THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE VICE-SECRETARY OF THE GEOLOGICAL SOCIETY.

VOLUME THE SECOND.

[illegible]

PART THE FIRST.

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:

LONGMAN, BROWN, GREEN, AND LONGMANS.

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SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.

MDCCCXLVI.

List

OF THE

OFFICERS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

ELECTED FEBRUARY 1846.

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VICE-SECRETARY.

Professor Ansted, M.A. F.R.S.

CURATOR AND LIBRARIAN.

Mr. J. De C. Sowerby, F.L.S

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ERRATA.

Page 227, line 31, for 39 read 68.
— 228, — 9, for "*b and d*" read *Strata No.* 2 *to* 6.
— 230, — 38, for *lævigata* read *lævigatus.*
— 231, — 1, for *group* read *division.*
— „ — 2, for 150 read *about* 120.
— „ — 7, for 150 read 70.
— „ — 33, for *No.* 60 read "57 *to* 61."
— 232, — 12, for 69 read 67.
— 234, — 3, cancel "*Hampshire basin*" over the 5th column of diagram, and extend over it the heading of the 4th column, viz. "*division of Cuvier, &c.*"
— „ — 8, for *lacustrine* read *lacustre.*
— 236, — 2, for *group* read *division.*
— „ — 1 and 11, for *c* read *No.* 3.
— 239, — 48, omit *but.*
— 243, — 9, for *therefore* read *probably.*
— 246, — 36, after "*following*" insert *which species, and also the greater part of those in the above list, are from the strata No.* 56 *to* 61 *of Headon Hill and Colwell Bay.*
— 247, — 9, insert *?* before *L.*
— „ — 13, place *M. buccinoidea* under *M. annularioides,* and not in the same line with it.
— 255, — 29, omit *north,* and for *side* read *and.*

CORRIGENDUM.

At page 69, in the abstract of a paper by the Rev. D. Williams, it is stated that "the soft and rotten condition of the Syenite has no doubt obtained for it the name of pottle stone, by which it is locally known, since it was formerly wrought for skins and other culinary vessels.' This does not give a proper view of the author's meaning. He intended only to infer from the name of 'pottle stone' locally applied to the rock in question, which is a free-working talcose or steatitic Syenite, that it might have been formerly worked for culinary purposes.

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GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 20, 1846.

REPORT OF THE COUNCIL.

The Council have the satisfaction of again calling the attention of the Members of the Geological Society to the prosperous state of its affairs, as shown by the increasing number of its Fellows. At the close of 1844 the numbers had been reduced by unusual mortality from 883 to 875; in the course of the past year the number of new admissions has greatly exceeded that of deaths and resignations. During that period 27 new Fellows have been elected, and 5 who had been elected in the preceding year have paid their entrance fees, making a total increase of 32. On the other hand, there have been 13 deaths, 4 resignations and 2 defaulters removed, leaving an increase of ordinary Fellows of 13. They have at the same time to announce the death of 2 Foreign Members and of 3 Honorary Members, and the election of 1 Foreign Member, thus causing a further reduction of 4, and reducing the total increase to 9.

This number however must be further diminished by 1 in consequence of the name of a distinguished transatlantic geologist being inserted twice; Prof. H. D. Rogers having been elected a Foreign Member when his name was already on the list as a non-resident Fellow. Thus at the close of 1845 the real increase of the Society was 8, and the total number of Fellows was again raised to 883 from 875.

The Council have further the satisfaction of stating that the excess of income over expenditure during the year 1845 amounted to the sum of 40*l.* 16*s.*

At the close of 1845 the number of living compounders was 123, and the amount received from them in lieu of annual contributions was 3874*l.* 10*s.* During the past year 8 newly-elected Fellows have compounded, 7 of whose compositions have been already invested, in accordance with the now-established practice of the Society, and added to its funded property, which thus received an increase of 220*l.* 10*s.*; but in consequence of the great fall in the price of Consols, from *par* (at the close of 1844) to 94 (at the close of last year), the estimated value of the funded property was only increased from 2896*l.* 11*s.* 3*d.* (the amount stated last year) to 2961*l.* 5*s.* 6*d.*

In consequence of Mr. Woodward, the Sub-Curator of the Museum, having received the appointment of Professor of Natural History at the Agricultural College of Cirencester, he resigned his office in this Society during the course of last year. The Council, in considering the arrangements to be made in filling up Mr. Woodward's place, and the necessity of obtaining the services of an efficient officer, resolved that a different distribution of the duties of the Vice-Secretary was desirable.

At the same time other changes were required in the manner in which the Journal was to be conducted, in consequence of which the Council resolved that the Vice-Secretary should be relieved from all superintendence of the Library and Museum, and that his duties at the Society should be confined, at a reduced salary, to the care of all papers communicated to the Society, and to editing the Transactions and Journal.

The Council have the satisfaction of stating that they have secured the services of Mr. J. De C. Sowerby as Curator and Librarian. Mr. Sowerby's attainments and skill in fossil conchology are too well known to require any remarks on this occasion; the appointment was subsequently confirmed by the General Meeting, to whom, in conformity with the bye-laws, it was submitted; and the Council look forward to seeing the Museum and Collections shortly rendered, through his labours, more available to the Fellows of the Society.

It was stated in the Annual Report of last year that an agreement had been made with Messrs. Longman and Co. for the regular publication of the Quarterly Journal of the Geological Society. This agreement was made for one year, renewable at the expiration of that period. At the end of the year however Messrs. Longman and Co. gave notice that they declined to continue the arrangement any longer, or to run any further risk. The Council, after full consideration, and being satisfied that under existing circumstances the Journal is the most advantageous form in which a large proportion of the papers read at the meetings can be published, determined to continue it on the Society's account for the ensuing year, the Vice-Secretary remaining the editor, under the superintendence of the President and Secretaries. A letter has been addressed by the Secretary to the Fellows, stating all particulars respecting the Journal, and also explaining the reasons why they have considered it expedient for the future, or at least during such period as the present form of an illustrated Journal shall be kept up, to discontinue the gratuitous distribution of these illustrated Proceedings to the Fellows, and not to publish them otherwise than in the Journal.

During the last year the seventh volume of the Transactions has been commenced, and that form of publication will be continued for those papers requiring illustration which cannot be adequately given in an octavo form. The Council have been induced to try the plan adopted by some Foreign Societies, of publishing the papers separately, each memoir constituting a part, which when there is a sufficient number will form a volume, and for which a title-page and index will be printed. The funds disposable for this purpose did not allow of more than one part being published at the Society's expense; but Mr. Warburton and Mr. Greenough, feeling the importance of an early publication of the discovery by Mr. Bain, with

Professor Owen's description, of fossil remains of bidental and other reptiles in South Africa, hitherto unknown, an opinion in which the Council entirely concurred, liberally supplied the funds for the publication of these communications.

The Council have further the satisfaction of stating that they have received information through the Earl of Lincoln, that the Government have awarded the sum of £200 to Mr. Geddes Bain, in consideration of the exertions he has made towards bringing to light the fossil remains of Southern Africa.

In conclusion, they have to announce that they have awarded the Wollaston Palladium Medal and the balance of the proceeds of the Donation Fund for the present year, amounting to £30 1*s.* 6*d.*, to William Lonsdale, Esq., F.G.S., for his many valuable contributions to Geological science, and more especially for his description of the Corals in the Silurian and Devonian rocks, for his late Report in the first volume of the Quarterly Journal of the Geological Society on the Corals from the Tertiary formations of North America, and for his description of the Corals from the Palæozoic formations of Russia.

Report of the Museum and Library Committee.

The Museum continues in nearly the same state as when the Report was made last year. In consequence of Mr. Woodward's engagements with the Journal and subsequent absence, no progress has been made in carrying out the former resolutions of the Council respecting it. Few specimens have been added during the last year: they consist of—

Tertiary.—Bones from the Eocene strata of Hordwell and Barton, presented by Thomas Falconer, Esq.

Specimens of Foraminifera from Charing, by W. Harris, Esq.

Chalk.—Chalk Fossils from Trimmingham, by Miss Gurney.

Spongeous Flint, by Mr. H. Ball.

Beryx radians, Maidstone, by E. H. Bunbury, Esq.

Kentish Rag,—Fossils from Maidstone, Mr. W. H. Bensted.

Wealden.—Unio Valdensis, Isle of Wight, Dr. Mantell.

Slab of Paludina, Weald, W. Harris, Esq.

Great Oolite.—Specimens from Kate's Cabin, Peterborough, by H. M. Lee, Esq.

Lias.—Part of the head of an Ichthyosaurus, of which the other portion is in the Society's collection; presented by the Earl of Enniskillen, Sir P. Egerton, Mr. Stokes, Mr. Murchison, Mr. Warburton, and Mr. Broderip.

Coal.—Calamites pachyderma, &c. from Oldham, by E. A. Wright, Esq.

Series of specimens of Shells, &c. from Coalbrook Dale, by W. Anstice, Esq.

Mountain Limestone.—Palates, Teeth, and Spines of Fish, from the limestone of Armagh, by Capt. Jones, R.N.

Specimen of Orthoceratite, Ireland, from W. Thompson, Esq.

Devonian System.—Polished Corals, Devonshire, presented by the Marquis of Northampton.

Pebbles from Schabar, by G. A. Mantell, LL.D.

Pholas clavata on Teak timber, by Capt. J. W. Symonds, R.N.

Foreign Specimens.

Fossils from the Azores, by C. Hunt, Esq.

Three Terebratulæ, by Baron Von Buch.

Specimens of Palæozoic Fossils from New South Wales, by the Rev. H. S. Clark.

Specimen of Gypsum, by Charles Stokes, Esq.

The Committee have ascertained that a resolution adopted last year by the Council, to the effect "that all specimens belonging to the Society, in the hands of Fellows, be immediately returned," has been only partially carried into effect.

Library.

The Vice-Secretary has been engaged in preparing a Catalogue of the Books and Maps, the first sheets of which are already printed, and the whole will be shortly completed. Donations of about 180 volumes and pamphlets have been received during the past year.

S. P. PRATT.
H. FALCONER, M.D.
ROBERT AUSTEN.

Comparative Statement of the Number of the Society at the close of the years 1844 *and* 1845.

	Dec. 31, 1844.		Dec. 31, 1845.	
Compounders		116		123
Residents		230		250
Non-residents		452		437
		798		810
Honorary Members	23		20	
Foreign Members	50		49	
Personages of Royal Blood	4	—77	4	—73
		875		883

General Statement Explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1844 *and* 1845.

Number of Fellows, Compounders, Contributors, and Non-residents, December 31, 1844			798
Add, Fellows elected during former years, and paid in 1845	Residents 3; Non-residents 2	5	
Fellows elected during 1845, and who paid	Residents 17; Non-residents 10	27	
			32
			830
Deduct, Compounder deceased		1	
Residents ,,		3	
Non-residents ,,		9	
Resigned		4	
Removed		2	
Non-resident, being also on the Foreign List		1	
			20
Total number of Fellows, 31st Dec. 1845, as above			810

Number of Honorary Members, Foreign Members, and Personages of Royal Blood, December 31, 1844		77
Add, Foreign Member elected		1
		78
Deduct, Honorary Members deceased	3	
Foreign Members ,,	2	
		5
Total as above		73

Number of Fellows liable to Annual Contribution at the close of 1845, *with the Alterations during the year.*

Number at the close of 1844		230
Add, Elected in former years and paid in 1845		3
Elected during 1845 and paid		17
Non-residents who became Residents		18
		268
Deduct, Deceased	3	
Resigned	3	
Compounded	8	
Removed	2	
Became Non-resident	2	
		18
Total as above		250

Deceased Fellows.

Compounders (1).

Edward Wood, Esq.

Residents (3).

John Backhouse, Esq.
R. C. Sale, Esq.
William Taylor, Esq.

Non-Residents (9).

R. T. Atkinson, Esq.
T. J. L. Baker, Esq.
Col. Edward Clive.
Sir C. H. Colville.
J. S. Duncan, Esq.
Hugh Edwards, Esq.
S. L. Kent, Esq.
Thomas Meade, Esq.
Lieut.-Col. M. Shaw.

Honorary Members (3).

Dr. J. MacDonnell.
J. A. MacKonochie, Esq.
James Oakes, Esq.

Foreign Members (2).

Cavaliere Monticelli.
Count Münster.

The following Persons were elected Fellows during the year 1845.

January 8th.—George Dawson, Esq., Birmingham.
January 22nd.—David Walker, Esq., M.A., Colchester.
February 5th.—Thomas Longman, Esq., 2 Hanover Terrace, Regent's Park; John Durancé George, Esq., 32 Old Burlington Street; and Capt. Barham Livius, Dover.
February 26th.—John Fowler, Esq., Stockton upon Tees.
March 12th.—Sir Robert Burdett, Bart., Ramsbury Park, Wilts; and Warrington W. Smyth, Esq., 3 Cheyne Walk, Chelsea.
April 2nd.—Waller Augustus Lewis, Esq., B.A., 18 Stratford Place; Capt. Washington, R.N., F.R.S.; Albemarle Bettington, Esq., 23 Hanover Square; Robert Stephenson, Esq., 15 Cambridge Square; George Stephenson, Esq., Tapton House, near Chesterfield; Lieut. Baird Smith, of the Engineers, Bengal Army; Capt. Thomas Hutton, of the Bengal Army; John MacClelland, Esq., of the Bengal Medical Service; and the Earl of Auckland, Eden Lodge, Kensington.
May 14th.—John Collis Nesbit, Esq., 38 Kennington Lane; Thomas Graham, Esq., M.A., Professor of Chemistry, University College, London; and Joseph Yelloly Watson, Esq., Malvern Cottage, St. Ann's Road, Brixton.

May 28th.—Captain Thomas E. Bigge, 19 Bryanstone Square; Matthew Bell, Esq., Bourne Court, Kent, and 4 Grosvenor Crescent; and John Alexander Hankey, Esq., 36 Brook Street.

June 11th.—Alexander Keith Johnston, Esq., Edinburgh; Brooke Cunliffe, jun., Esq., Erbistoch Hall, North Wales; The Earl of Lincoln, Chief Commissioner of Her Majesty's Woods and Forests; and Edward Solly, Esq., 38 Bedford Row.

December 3rd.—James Ashwell, Esq., B.A., St. Peter's College, Cambridge; and A. W. Jackson, Esq., Hoddesdon.

December 17.—John Morris, Esq., High Street, Kensington; and Dr. Edward Kelaart, of the Army Medical Staff.

The following Person was elected a Foreign Member.

March 12th.—M. Alcide d'Orbigny, Vice-President of the Geological Society of France.

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

British and Irish Specimens.

Specimens of the *Unio Valdensis* from the Wealden of the Isle of Wight; presented by G. A. Mantell, LL.D., F.G.S.

Slab of *Paludinæ* from the Weald at Pluckley, and Corals, Shells and Foraminifera from the Chalk of Charing, Kent; presented by Wm. Harris, Esq., F.G.S.

Fossils from the Great Oolite, Kate's Cabin in Peterborough; presented by H. M. Lee, Esq., F.G.S.

Gigantic Head of *Ichthyosaurus*, the remaining portion of a specimen already in the possession of the Society; presented by H. Warburton, Esq., M.P., the Earl of Enniskillen, R. I. Murchison, Esq., Sir Philip Egerton, Bart., M.P., Charles Stokes, Esq., and W. J. Broderip, Esq., F.G.S.

Series of Specimens from Coalbrook Dale; presented by W. Anstice, Esq., F.G.S.

Palates, Teeth and Spines of Fish from the Carboniferous Limestone of Armagh; presented by Capt. Jones, R.N., F.G.S.

Specimen of *Orthoceratite* from the Mountain Limestone of Ireland; presented by W. Thompson, Esq., F.G.S.

Polished sections of Corals from South Devon; presented by the Marquis of Northampton, F.G.S.

Specimen of Gypsum; presented by Charles Stokes, Esq., F.G.S.

Specimen of the *Pholas clavata* in Teak Timber; presented by Capt. Sir W. Symonds, R.N.

Calamites pachyderma and other Coal-plants from Glodwick Colliery, Oldham; presented by E. A. Wright, Esq.

London Clay from the bed of the Thames opposite Limehouse; presented by George Rennie, Esq.

Foreign Specimens.

Three species of *Terebratula*; presented by Baron Leopold Von Buch, For. Mem. G.S.
Specimens of Rocks and Palæozoic Fossils from New South Wales; presented by the Rev. W. B. Clarke, F.G.S.
Pebbles from Ichaboe; presented by G. A. Mantell, LL.D., F.G.S.

Charts and Maps.

Ordnance Townland Survey of the County of Cork, in 155 sheets; presented by Col. Colby, R.E., by direction of the Lord Lieutenant of Ireland.
The Charts published by the Admiralty during the year 1844; presented by Capt. Beaufort, R.N., by direction of the Lords Commissioners of the Admiralty.
Sheets 19 to 33, and 35 to 43 inclusive of the Geological Survey of Great Britain; presented by Sir H. T. De la Beche, For. S. G.S., by direction of the Chief Commissioner of Her Majesty's Woods and Forests.
Essai d'une Carte Géologique du Globe Terrestre, par M. A. Boué; presented by the Author.
Map of the Coal district eastward of Glasgow; presented by L. Horner, Esq., P.G.S.
Carte Géologique du Terrain entre le lac d'Orta et celui de Lugano, par M. Leopold de Buch; presented by the Author.
Croquis provisional de una Parte del Terreno Carbonifero de Asturias con la Indicacion de los, &c.; presented by the Asturian Mining Company.
Map of the Cape of Good Hope; presented by H. Warburton, Esq., F.G.S.

Lithographic Drawing of a Fossil Jaw; presented by W. K. Bridgeman, Esq.
Lithographic Drawing of a gigantic Ruminant; presented by Mr. Bettington.
Lithographic Drawing of an imprinted Slab from the New Red Sandstone at Weston, Cheshire; presented by Dr. James Black, F.G.S.
Portrait of the late Francis Baily, Esq., P. Ast. Soc.; presented by the Rev. Richard Sheepshanks, F.G.S.

Medallion of Mr. J. De Carle Sowerby; presented by Mr. J. De Carle Sowerby.

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.
Agassiz, Prof. L., For. Mem. G.S.
American Philosophical Society held at Philadelphia.
Ansted, Prof. D. T., F.G.S.
Anstice, W., Esq., F.G.S.
Asturian Mining Company.
Athenæum, Editor of the.

Benett, Miss.
Bettington, A., Esq., F.G.S.
Black, James, M.D., F.G.S.
Boston Society of Natural History.
Boué, Mons. A.
Braim, T. H., Esq.
Brayley, E. W., Esq., F.G.S.
Bridgeman, W. K., Esq.
British Association for the Advancement of Science.
Broderip, W. J., Esq., F.G.S.
Brodie, Rev. P. B., F.G.S.
Buckman, James, Esq., F.G.S.
Bunbury, E. H., Esq., F.G.S.

Cangiano, L., Esq.
Catullo, Prof. T. A.
Chemical Society of London.
Clarke, Rev. W. B., F.G.S.

Dana, J. D., Esq.
D'Aoust, M. V.
Daubeny, Prof., M.D., F.G.S.
De la Beche, Sir H. T., F.G.S.
Dépôt Générale de la Marine de France.
De Walterhausen, M.
Dufrésnoy, M., For. Mem. G.S.
Durocher, M. J.

Egerton, Sir. P., Bart., M.P., F.G.S.
Élie de Beaumont, M., For. Mem. G.S.
Enniskillen, Earl of, F.G.S.

Falconer, H., M.D., F.G.S.
Fox, R. W., Esq.
Franklin, Sir J., K.C.H., F.G.S.

Geological Society of Dublin.
Geological Society of France.
Gervais, M. P.
Gibbes, R. W., M.D.
Gregory, W., M.D.

Haarlem Société Hollandaise des Sciences.
Hall, James, Esq., F.G.S.
Harris, W., Esq., F.G.S.
Hausmann, Prof. J. F. L., For. Mem. G.S.
Helmerson, Herr G. von.
Horner, L., Esq., Pres. G.S.

Jackson, C. T., M.D.
Jones, Capt., R.N., M.P., F.G.S.

Kerigan, T., Esq.
King, W., Esq.

Lee, H. M., Esq.
Lyell, C., Esq., F.G.S.

Macaire, Prof.
Mackintosh, A. F., Esq., F.G.S.
Mantell, G. A., LL.D., F.G.S.
Michelin, H., Esq.
Modena Society.
Müller, Herr Joh.
Murchison, Sir R. I., F.G.S.
Museum of Natural History of Paris.

New York Dissector, Editor of.
Northampton, Marquis of.
Northumberland Natural History Society.
Nicol, James, Esq.
Nyst, M. P. H.

Ordnance, Master-General and Board of.

Philadelphia Academy of Natural Science.
Pictet, M. F. J.
Pilla, Herr L.

Quetelet, M. A.

Redfield, W. C., Esq.
Reeve, Mr. Lovell.
Rennie, G., Esq., F.G.S.
Royal Academy of Berlin.
Royal Academy of Brussels.
Royal Academy of Munich.
Royal Agricultural Society of England.
Royal Asiatic Society.
Royal Geographical Society.
Royal Irish Academy.
Royal Polytechnic Society of Cornwall.
Royal Society of Edinburgh.
Royal Society of London.

Sabine, Lieut.-Colonel, F.G.S.
Scacchi, Signor A.
Sheepshanks, Rev. R., F.G.S.
Silliman, Prof., M.D., For. Mem. G.S.
Simms, F. W., Esq., F.G.S.
Society of Arts.
Stockholm Academy.
Stokes, Charles, Esq., F.G.S.
Symonds, Capt. Sir W., R.N.

Taylor, Richard, Esq., F.G.S.
Taylor, R. C., Esq., F.G.S.
Tchihatcheff, M. P. de.
Thibert, F., M.D.
Thompson, W., Esq., F.G.S.

Von Buch, Baron, For. Mem. G.S.

Warburton, H., Esq., M.P., F.G.S.
Washington National Institution.
Wright, C. A., Esq.

Zoological Society.

List of PAPERS *read since the last Annual Meeting, February 21st,* 1845.

Feb. 26th.—On the Miocene Tertiary Strata of Maryland, Virginia, and North and South Carolina, by Charles Lyell, Esq., F.G.S.

——— On the White Limestone and Eocene Formations of Georgia and South Carolina, by Charles Lyell, Esq., F.G.S.

March 12th and Jan. 7th, 1846.—On the Comparative Classification of the Fossiliferous Slates of North Wales, Westmoreland and Lancashire, by the Rev. Adam Sedgwick, M.A., F.G.S., Woodwardian Professor in the University of Cambridge.

April 2nd.—On an Aërolite said to have fallen near Lymington, Hants, by R. A. C. Austen, Esq., F.G.S.

——— On the Junction of the Transition and Primary Rocks of Canada and Labrador, by Capt. Bayfield, R.N.

April 16th.—On the supposed evidences of the former existence of Glaciers in North Wales, by Angus Friend Mackintosh, Esq., F.G.S.

April 30th.—On the Palæozoic Deposits of Scandinavia and the Baltic Provinces of Russia, by Sir R. I. Murchison, V.P.G.S.

May 14th.—Extract of a Letter from Dr. A. Gesner, on the Gypsiferous Red Sandstone of Nova Scotia.

May 14th.—On the Coal Beds of Lower Normandy, by R. A. C. Austen, Esq., F.G.S.

——— Notes of a Microscopical Examination of the Chalk and Flint of the South-East of England, by G. A. Mantell, LL.D., F.G.S.

——— On some Specimens of Pterodactyle, recently found in the Lower Chalk of Kent, by J. S. Bowerbank, Esq., F.G.S.

May 28th.—On the Geology of Lycia, by Edward Forbes, Esq., F.G.S., Professor of Botany in King's College, London, and Lieut. Spratt, R.N., F.G.S.

——— On a new Family of Crinoidal Animals called *Cystideæ*, by Baron Leopold von Buch, For. Mem. G.S.

——— On the relation of the New Red Sandstone to the Carboniferous strata in Lancashire and Cheshire, by E. W. Binney, Esq.

June 4th.—On Dust falling on Vessels in the Atlantic Ocean, by Charles Darwin, Esq., F.G.S.

——— On Foraminifera in the Lias, by H. E. Strickland, Esq., F.G.S.

——— On Spirifers from the Lias, by James Buckman, Esq., F.G.S.

——— On Artificial Graphite, by William Brockedon, Esq.

——— On the Piræus at Athens, by the Rev. Robert Everest, F.G.S.

——— On an Elephant's Tusk found in the Gravel of Kent, by — Charlton, Esq.

——— On the Ear-bone of a Whale found in the Crag near Ipswich, by C. B. Rose, Esq., F.G.S.

——— On Scotch Boulders, by James Smith, Esq., F.G.S.

November 5th.—On Footsteps on a Slab of New Red Sandstone, by James Black, M.D., F.G.S.

——— On the Granite of Lundy Island, by the Rev. David Williams, F.G.S.

——— On the Geology of the neighbourhood of Tremadoc, by J. E. Davis, Esq., F.G.S.

November 19th.—On the Age of the newest Lava Current of Auvergne, and on Shells found in Gravel under the Lava, by Charles Lyell, Esq., F.G.S.

——— On the Geological position of the Bitumen used in Asphalte Pavements, by S. P. Pratt, Esq., F.G.S.

——— Letter from Capt. Cooper, announcing the Discovery of Coal, or Lignite, in the Island of Formosa.

December 3rd.—On Fossil Ferns from Maryland, by C. J. F. Bunbury, Esq., F.G.S.

——— On Bones of Iguanodon recently found in the Wealden strata of the Isle of Wight, by G. A. Mantell, LL.D., F.G.S.

December 17th.—On the supposed Fossil Bones of Birds from the Wealden, by Richard Owen, Esq., F.G.S., Hunterian Professor of Anatomy in the Royal College of Surgeons.

December 17th.—On Amber, and on the Organic Remains found in it, by Prof. Göppert of Breslau.

——— Extract from a Letter concerning a Depression lately produced in consequence of an Earthquake in Cutch, by Mrs. Derinzy.

——— On the occurrence of Nodules, commonly called Fossil Potatoes, on the shores of Lough Neagh, by the Very Rev. the Dean of Westminster, F.G.S.

January 7th, 1846.—On the Fossil Remains of Birds in the Wealden strata, by G. A. Mantell, LL.D., F.G.S.

January 21st.—Continuation of the Memoir on the Palæozoic Rocks of Cumberland, by the Rev. Adam Sedgwick, F.G.S., Woodwardian Professor in the University of Cambridge.

——— On the so-called "Jackstones" of Merthyr Tydvil, by Joseph Dickinson, Esq., F.G.S.

——— On the Coal-plants of Nova Scotia, by J. W. Dawson, Esq., and C. J. F. Bunbury, Esq., F.G.S.

February 4th.—On the Tertiary Formations of the Isle of Man, by the Rev. J. Cumming.

——— On Sternbergia, by J. S. Dawes, Esq., F.G.S.

Receipts.	£. s. d.	£. s. d.
Balance at Banker's, 1st January, 1845, on the Donation Fund		31 11 6
Balance at Banker's, Geological Map Fund		3 5 0
Received for Geological Map of England	53 15 0	
Dividends on Donation Fund of 1084*l.* 1*s.* 1*d.* Red. 3 per Cents.	31 11 6	
		85 6 6
		£120 3 0

Expenditure.	£. s. d.	£. s. d.
Cost of Medal awarded to Prof. Phillips	10 10 0	
Balance of Proceeds awarded to Mr. Bain	21 1 6	
		31 11 6
Paid on account of Geological Map		3 5 0
Balance at Banker's, Trust Account		85 6 6
		£120 3 0

Valuation *of the Society's Property; 31st December* 1845.

Property.	£. s. d.	£. s. d.
Balance in Banker's hands		338 5 2
Balance in Clerk's hands		8 7 8
Funded Property, 3150*l.* 5*s.* 11*d.* Consols, at 94		2961 4 8
Arrears of Admission Fees	33 12 0	
Arrears of Contributions prior to 1845, considered good	6 6 0	
Arrears of Contributions of 1845	44 2 0	
		84 0 0
Estimated value of unsold Transactions		1265 11 11
Estimated value of unsold Transactions, separate Memoirs		78 18 6
Estimated value of unsold Proceedings		100 0 0
[*N.B. The value of the Collections, Library and Furniture is not here included.*]		£4836 7 11

Debts.	£. s. d.
John Arrowsmith, account not yet obtained, but estimated at about	15 0 0
Balance in favour of the Society	4821 7 11
	£4836 7 11

Signed, J. L. PREVOST, Treasurer.

Feb. 2, 1846.

RECEIPTS.

	£.	s.	d.	£.	s.	d.
Arrears of Admission Fees	39	18	0			
Arrears of Annual Contributions	75	12	0			
				115	10	0
Admission Fees				212	2	0
Annual Contributions of 1845				740	15	6
Dividends on 3 per Cent. Consols				86	13	5
Sale of Transactions				69	19	6
Sale of Transactions in separate Memoirs				67	19	4
Sale of Proceedings				5	11	6
				£1298	11	3

	£.	s.	d.
Balance at Banker's, January 1, 1845	234	6	10
Balance in Clerk's hands	40	0	0
Compositions received	220	10	0
Composition received in December after Consols shut	31	10	0
Balance of Income over Expenditure as above	40	16	0
	£567	2	10

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

Signed, T. H. SHADWELL CLERKE, JOHN CARRICK MOORE, S. P. PRATT, } AUDITORS.

Feb. 2, 1846.

PAYMENTS.

	£.	s.	d.	£.	s.	d.
General Expenditure:						
House Repairs	5	12	1			
Furniture Repairs	23	14	6			
New Furniture	56	2	4			
Taxes and Rates	35	11	4			
Fire Insurance	9	0	0			
Fuel	45	17	0			
Light	24	9	8			
Miscellaneous House expenses, including Postages	46	14	1			
Stationery	35	6	7			
Miscellaneous Printing	33	11	3			
Tea for Meetings	25	18	8			
				341	17	6
Salaries and Wages:	£.	s.	d.			
Vice-Secretary	150	0	0			
Sub-Curator	93	15	0			
Clerk	100	0	0			
Porter	80	0	0			
House Maid	33	4	0			
Occasional Attendants	15	19	6			
Collector	28	7	0			
				501	5	6
Library				90	6	3
Museum				9	19	11
Diagrams at Meetings				1	5	8
Miscellaneous Scientific Expenditure				9	3	4
Publications:	£.	s.	d.			
Extra Charges on Journal	55	19	0			
Proceedings	155	9	8			
New Titles, &c. for the separate Memoirs of Transactions	31	9	2			
Transactions	60	19	3			
				303	17	1
Balance of Receipts over Expenditure				40	16	0
				£1298	11	3

	£.	s.	d.	£.	s.	d.
Compositions Funded				220	10	0
Balance at Banker's	306	15	2			
Balance Composition not Invested, to be Invested in January 1846	31	10	0			
Total Balance at Banker's, December 31, 1845				338	5	2
Balance in Clerk's hands				8	7	8
				£567	2	10

Estimates *for the year* 1846.

INCOME EXPECTED.

	£.	s.	d.	£.	s.	d.
Balance of 1845				40	16	0
Arrears (See Valuation-sheet)				84	0	0
Ordinary Income for 1846 estimated:						
Annual Contributions (250 Fellows)				787	10	0
Admission Fees, under the average of the last 5 years:						
Residents (15)	94	10	0			
Non-residents (14)	147	0	0			
				241	10	0
Dividends on 3 per Cent. Consols				90	0	0
Sale of Transactions and Proceedings				100	0	0
				£1343	16	0

Mem.:—

	£.	s.	d.
Balance at Banker's, 31 December, 1845	306	15	2
In the Clerk's hands	8	7	8

Signed, J. L. PREVOST, Treasurer.

Feb. 2, 1846.

EXPENDITURE ESTIMATED.

	£.	s.	d.	£.	s.	d.
General Expenditure:						
House Repairs	10	0	0			
Furniture Repairs	15	0	0			
New Furniture	25	0	0			
Taxes and Rates	35	11	4			
Fire Insurance	9	0	0			
Fuel	45	0	0			
Light	25	0	0			
Miscellaneous House Expenses	46	0	0			
Stationery	35	0	0			
Miscellaneous Printing	32	0	0			
Tea for Meetings	26	0	0			
				303	11	4
Salaries and Wages:						
Vice-Secretary	120	0	0			
Curator	130	0	0			
Clerk	100	0	0			
Porter	80	0	0			
Housemaid	33	4	0			
Occasional Attendants	16	0	0			
Collector's Poundage	30	0	0			
				509	4	0
Library:						
Catalogue	60	0	0			
Binding and Additions	50	0	0			
				110	0	0
Museum				25	0	0
Diagrams at Meetings				16	0	0
Miscellaneous Scientific Expenditure				15	0	0
Publications, Journal				200	0	0
,, Transactions				100	0	0
				1278	15	4
Balance over Expenditure				65	0	8
				£1343	16	0

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

May 14, 1845.

Joseph Yelloley Watson, Esq., Professor Thomas Graham, M.A., and John Collis Nesbit, Esq., were elected Fellows of the Society.

The following communications were read:—

1. *On the* Coal Beds *of* Lower Normandy. By R. A. C. Austen, Esq., B.A., F.G.S.

Several tours in Lower Normandy have enabled me to observe the geological structure of that district, and to trace the distribution of fossil forms through several groups of strata. It was my intention to have embodied these facts in two separate memoirs, of which one would have related to the Palæozoic group, and the other to the Cretaceous; but in the autumn of 1844 I revisited many parts of Belgium and Rhenish Prussia, and have, in consequence, been induced to alter my original plan of describing the Cotentin and part of Calvados separately; and instead of this I now propose to lay before the Society two *general memoirs* on those two groups, as they are developed in Western Europe. I have therefore detached the short notice of the Littry and Plessis coal-fields, which form the subject of the present communication, from the memoir of which it originally formed part.

My last visit to Lower Normandy was in the autumn of 1843. I had then expected to find that a line of section taken northwards from about Balleroy as far as the coal-mines of Littry would have given a good ascending section, and have exhibited the distinct relations of a true carboniferous series, to the older slate rocks of Calvados: such however was not the case. The road in this direction lies partly through the forest of Cerissy, across a tract which preserves a very uniform level, and which is covered superficially with accumulations of siliceous grits rounded into pebbles, mixed with sand, clay and fragments of slate; enough however is seen to satisfy one that the slate system, without any change in character, is carried on along the whole line of this section.

Previous to my last visit to this part of France, I had considered that the several small patches of coal, which have long been known to exist in the departments of Calvados and La Manche, belonged to the true carboniferous period. Considerations have since suggested themselves, which induce me to think that they may be of a subsequent age.

The strike of the slate rocks, in every place in which I could observe it, ranged steadily about east and west, whilst the apparent dip or bedding (for I must admit that it is most difficult to determine this) seemed northerly, and often highly inclined, as far as near Littry. The coal-mines at this place are not situated, as descriptions had led me to suppose, in a depression of the slate districts: it is true, they occupy a low position with relation to some of the adjacent country, but their real position is at the extreme boundary of the older rocks, and where the new red sandstone series abuts against them. M. Herault has fully described this coal-field in the ninth volume of the 'Annales des Mines,' and states that the works are conducted on one seam only, which is about three feet thick: this I had not any opportunity of verifying, but from the size of the blocks of coal which are raised, the thickness of the seam must be very considerable. The coal, or at least such as I saw, was of inferior quality, dull, earthy and pyritous, with occasional compact and shining seams in the plane of the bedding. My conviction is, that the beds with which this coal is associated form no part of the older group of strata (whether slates or siliceous grits), which are everywhere highly inclined, whilst the former are horizontal, or nearly so. M. Herault, in the memoir above alluded to, gives sections of several workings which appear to have been carried through the entire thickness of this small coal-field, according to which its component strata rest on the edges of highly inclined slates and grits, such as compose the district to the north, preserving their east and west strike beneath; so that the coal strata must evidently have been deposited subsequently to the elevation and disturbance of the older series. I think that it is unnecessary to establish for all this part of France any other division than that adopted by M. Dufrenoy; and as it is on the edges of the uppermost of the older beds that the carboniferous strata of Littry are found, the latter cannot be identified with the black carbonaceous slate of the department of La Manche, so rich in Orthocerata and Crinoidea, or with the Anthracites of Brittany, with which I thought at one time they might be contemporaneous*.

* M. Alex. Brongniart refers the coal of Littry to his anthracitic group. See *Tableau des Terrains*, p. 270.

The character and general aspect of beds associated with coal, of whatever age, from the oldest to the most recent, are so strikingly uniform, that it is a waste of time to attempt to define the age of any given deposit by means of such comparisons. All considerable masses of coal, of every period, seem to have been formed under like conditions; conditions which have been local, and only a little less so at the period of the true coal-measures, than at previous and subsequent ones.

But, although independent of the great mass of older rocks of this part of France, the coal strata of Littry might still belong to the true coal-measures. At the time when I first doubted the accuracy of this reference, I had no means of inquiring how far the evidence from the vegetable remains had fixed their age. This I have since been able to do, and the result is in strict accordance with that derived from other considerations. Remains of plants are certainly very rare at this place; but I did not expect to find that it had only afforded two species to M. A. Brongniart's great work on fossil plants, namely *Calamites Luckowii*, var. β. p. 124. pl. 16. f. 2, 4; and *Calamites cruciatus*, p. 128. f. 19.

On the other hand, as has been observed by M. Dufrenoy, coniferous wood is found in abundance,—a character which is very usual in the lower beds of the new red sandstone series, and one which I have frequently remarked in the west of England. But the numerous impressions of ferns, so characteristic and abundant in the shales of every true coal-field, are wanting, together with all the other usual forms,—*Lepidodendron*, *Stigmaria*, &c. &c. The new red sandstone of all this part of France is equally rich in fossil-wood, and M. de Gerville particularly pointed out to me that of Monteburg, to the east of Valognes, as containing large branched trees.

In the absence, then, of any direct evidence as to the age of the Littry coal-field, the position and mineral character of its associated beds are entitled to consideration. Now these correspond exactly with those of the new red sandstone group, beneath, and at the edge of which formation the mines are situated*. It has never been pretended that there was any want of conformity between the beds which surmount the coal and those which immediately contain it; on the contrary, they seem to form a consecutive series, and cannot be separated into true coal-measures, and overlying new red sandstone (as cases in this country might suggest), but belong entirely to the latter period, of which they form the base, the coal seam being a subordinate bed.

It is unnecessary to enter into like details with respect to the several other localities in which coal has been found or is now worked, in the departments of Calvados and La Manche; as for instance at Moon, a few miles west of Littry, and at Plessis, since the coal occurs everywhere under precisely similar circumstances of position

* M. Alex. Brongniart remarks on the resemblance of the beds which surmount the coal to his "psephite," or lower red sandstone, but adds, "ce rapprochement ne paroit pas différer de celui que M. Herault établit entre cette roche, et le grès rouge ancien."—*Tableau des Terrains*, p. 276.

and association as at Littry, being independent of the older strata, and connected with the new red sandstone. M. de Gerville states that the Plessis mine has afforded him about a dozen species of Ferns and Calamites, and these I had an opportunity of seeing in that gentleman's rich collection. The only plant quoted by M. A. Brongniart from the mines of Plessis is *Neuropteris rotundifolia*, and this has not hitherto been recognised in any other locality.

The circumstance which first suggested that the coal-beds of this part of France were distinct from the true coal-measures, was rather the relation which a peculiar porphyritic rock bears to the several deposits, than any considerations as to position, on which point a mere traveller through a district has hardly ever time to bestow sufficient investigation.

Every geologist of the present day is ready to admit that the great erupted masses of each distinct period preserve, over areas of considerable geographical extent, not only an identity in composition, but also certain obvious external characters by which they may be recognised at once, such as the porphyritic granites, for instance, or what is more particularly in point, the red quartziferous porphyry of Exeter, (and the porphyres quartzifères rouges) of Brittany and the Cotentin. Throughout the latter districts of France the eruption of these masses has taken place at some period subsequent to the consolidation of the palæozoic strata; so much so, that I believe MM. Dufrenoy and Elie de Beaumont connect this outbreak with the disturbance which closed that great period. This view is indeed founded on facts gathered in many parts of France, but the proofs of it are more direct and evident in the west of England than I found them elsewhere. An account of these porphyries may be seen in Sir H. De la Beche's "Report on Devon and Cornwall*," and in a memoir by myself already reported in the Geological Proceedings†. This red quartziferous porphyry occurs in association with the lower beds of the several coal-fields of Calvados and La Manche. M. Herault has particularly noticed it with respect to the Littry mines, and he also infers its greater antiquity from the fact that it has supplied the shingle which enters so largely into the beds of conglomerate which underlie the coal: at Littry the strata are horizontal, but at Plessis, where they are much broken, the disturbances have, I believe, been considered by some geologists to have arisen from the intrusion of the porphyry, just as we still find it stated occasionally that the eruption of the Exeter porphyries was the cause of the Devonshire conglomerates. At Plessis, as at the other places, the mechanical strata contain portions of the erupted rock, and consequently are subsequent to them. Now the precise period of the appearance of the red porphyries was at the close of the carboniferous series. Their mode of association with the lower beds of the Littry deposits is similar to that which has long been familiar to English geologists with respect to the west of England conglomerate, and thus these Littry beds must be referred without any doubt to the new red sandstone period. It is, however,

* Report, &c., p. 204. † Geol. Proc., vol. ii. p. 587.

with these strata that the coal seams of Littry, Moon, Plessis, &c. are associated, and they must therefore cease to be considered as of the true carboniferous epoch; and my own impression, after several visits, is, that no deposits of the latter period occur in this part of France.

The fossil plants of the Normandy coal at present known are,—

1. *Calamites Luckowii*, var. β. of Brong.

This variety, in the shortness of the articulations and in the distinct form of the tubercles, is very unlike the species known by that name from Belgium or Newcastle. Var. β, it must be remembered, is peculiar to Littry; so that should the species be the same, the constant habit of the Littry plant implies altered conditions affecting its growth.

2. *Calamites cruciatus*, Brong. p. 128. pl. 19.

Very like the preceding in the closeness of its articulations, but more finely ribbed. There seems some doubt as to the identity of this with Sternberg's species from Saarbruck, and there are reasons for considering it a true *Equisetum*.

3. *Neuropteris rotundifolia*, Ad. Br. 238. pl. 70. p. 1.

Peculiar to Plessis.

There remain also a few more species which are new and undescribed. This flora, as far as it goes, comes nearest to that of Saarbruck; but if I might venture on a comparison, it would be to refer the flora of the Normandy coal beds to that period which has lately been designated as *Permian* by Mr. Murchison.

To this account of the lower portion of the pœcilitic system of Normandy, may be added one observation respecting its uppermost beds. On descending the high lands of the older palæozoic strata which surround the town of Valognes, in the Cotentin, a belt of red sandstone and marl is first traversed, but the town itself is built on beds of a very different character. This deposit may be studied in numerous open quarries of building-stone, whose mineralogy has been accurately described by M. de Caumont; from mineral character it had been assigned to various parts of the oolitic system, most commonly to the Portland beds; but its real position was always maintained by M. de Gerville to be intermediate between the red marls and the lower lias. As to its lower limit, this may clearly be seen in the neighbourhood of Valognes, but at this place it is uncovered by higher deposits: at Osmanville, however, and other places, the superposition of the lias to the Valognes freestone is visible.

M. Alexandre Leymerie, in an able memoir on the base of the secondary system of deposits of the department of the Rhine, designates one part of the series under the local name of the Choin-bâtard, and compares it with the freestone of Valognes, adding, " If we were better acquainted with the fossils of the Valognes beds, we should probably find that a certain number were common to the two deposits." The list of the fossils of the Choin-bâtard contains but few species, and both in the Lyonnais and in Normandy the specimens are badly preserved; but I was fortunate in obtaining at

Valognes three specimens of the *Diadema globulus*, one of the most common fossils of the Choin-bâtard.

The next point of interest which attaches to these beds is, that they everywhere indicate a break in the continuity of the series of deposits before the commencement of the lias. In Normandy and the Lyonnais the freestone beds become compact, and appear to have been again broken up and furrowed, before the lias was thrown down upon them. There is nothing in common in the faunas of the two deposits; and we have also, as M. de Caumont observes, a distinctly marked interval of time separating them.

In this country the passage from the red marls to the white lias, and again to the lower lias marls, as seen on our southern coast, is not marked by any distinct break, and the most that can be deduced from the appearances thus exhibited is, that a change took place in the conditions under which certain beds were deposited as compared with others below them.

When a great disturbance has taken place in the earth's crust, the deposits next in succession must occur in every possible relation to those last accumulated, but part of them may remain in the same position as before, and be covered conformably by beds of like mineral character. Such was the case nearly with respect to the red marls and lias marls of other parts of England. In France and some parts of Germany the line of separation is broadly drawn, and in addition to this a change takes place in the infra-liassic strata, which clearly indicates a decrease of depth in the sea in which they were formed. This is very general in France, and Count Mandelslohe, when noticing some beds of this age in Wurtemberg, describes them as containing great numbers of undescribed littoral shells (*Ampullaria*, *Trochus*, *Turritella*).

The Valognes freestone however, and the equivalent strata elsewhere, are not without an exact representative in this country. Being some time since at Porlock for the purpose of looking at the curious outlying mass of secondary strata there, I came upon some large blocks of stone, which were being used in building some cottages, and found them composed to a great extent of broken shells, the smaller ones of which alone were perfect, but these in most beautiful preservation. The beds from which these stones had been taken I found to be intermediate between the upper red marl and the blue lias shales and limestones; and they indicate that for some time before the deposition of the lias marl, which is a deep-sea deposit, there existed at that spot conditions which favoured the accumulation of vast numbers of molluscous animals. The species are all new, chiefly gasteropodous.

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2. *Notes on a Microscopical Examination of the Chalk and Flint of the South-east of England, with remarks on the Animalcules of certain Tertiary and modern deposits.* By G. A. Mantell, Esq., LL.D., F.R.S., F.G.S.

[This paper was withdrawn by the author with the permission of the Council.]

3. *On a new Species of* PTERODACTYL *found in the Upper Chalk of* KENT. By J. S. BOWERBANK, Esq., F.R.S., F.G.S.

(PLATE I.)

I HAVE recently obtained from the upper chalk of Kent some remains of a large species of *Pterodactylus*. The bones consist of—

1. The fore part of the head as far as about the middle of the *cavitas narium*, with a corresponding portion of the under jaws,—many of the teeth remaining in their sockets. (See Plate, fig. 1.)
2. A fragment of a bone of the same animal, apparently a part of the coracoid. (Fig. 2.)
3. A portion of what appears to be one of the bones of the auricular digit, from a chalk-pit at Halling. (Fig. 3.)
4. A portion of a similar bone, from the same locality as No. 1. (Fig. 4.)
5. The head of a long bone, probably the tibia, belonging to the same animal as the head No. 1. (Fig. 5.)
6. A more perfect bone of the same description, not from the same animal, but found at Halling. (Fig. 6.)

The latter specimen appears to me to be the same description of bone as that described by Professor Owen in the Geological Transactions (2nd Ser. vol. vi. p. 411, and pl. 39. fig. 1). The mutilated condition of the figured specimen would not allow Professor Owen to speak of its identity with the bird tribe with great certainty, and he at the same time points out its discrepant characters.

From a comparison of the specimens Nos. 5 and 6 with the figure in the Transactions, and from my recollection of the original, I am very much disposed, with due deference to Professor Owen, to believe that it may ultimately prove to be the bone of a *Pterodactylus* instead of a bird; and this is the more probable, as the bone in question, and the head and bones of the animal now produced, are from the same pit at Burham in Kent.

[*Note by the author*, dated Dec. 1845.]—Since the above brief communication was made to the Society, I have had an opportunity, through the kindness of Professor Owen, of comparing the bone represented by fig. 6 in the annexed plate with the specimen belonging to the Earl of Enniskillen, which is figured in the Transactions of the Geological Society as a portion of the shaft of the humerus of a longipennate bird, and from the comparison thus made, I am the more inclined to believe that the latter is in truth the bone of a *Pterodactyl*. Although the two specimens differ greatly in size, there is so strong a resemblance between them in the form and degree of the angularity of the shaft, and in the comparative substance of the bony structure, as to render it exceedingly probable that they belong to the same class of animals.

It is true that the bone represented in fig. 6 is not part of the group of bones associated with the head, so as to be at once stamped as belonging to a *Pterodactyl*; but it is fortunate that among that group of bones there is one, fig. 5, which there is every reason to believe is the head of a bone corresponding with that represented by fig. 6, but having the opposite side exposed to view; thus connecting the latter with the former in such a manner as to leave no reasonable doubt of their both having belonged to the same class of animals.

In my communication to the Society in May last, I have stated that I believed it probable that these bones were parts of a tibia, but on a more careful comparison with the figures of *Pterodactylus* by Goldfuss, I am inclined to believe they are more likely to be portions of the ulna.

It is unfortunate for the comparison of the specimens that the bone belonging to Lord Enniskillen is deficient in that end in which mine is most perfect, and that the bone in my possession wants the end in which the former is nearly perfect, so that in reality the whole weight of the comparison is dependent upon the similarity existing in the shafts of the two bones.

The flat side of the bone described by Professor Owen is rather more rounded at that portion exhibited by cutting away the chalk beneath it, but it gradually becomes less convex as we pass towards the same relative portion that is exposed in my specimen; and the expansion towards the large extremity of the bone, represented by fig. 6, corresponds, as nearly as can be determined by the mutilated condition of the specimen, with the large extremity of the bone belonging to the Earl of Enniskillen.

If the part of the head in my possession (see fig. 1) be supposed similar in its proportions to that of *Pterodactylus crassirostris*,—and there appears but little difference in that respect,—it would indicate an animal of comparatively enormous size.

The length of the head from the tip of the nose to the basal extremity of the skull of *P. crassirostris* is about $4\frac{5}{8}$ inches, while my specimen would be, as nearly as can be estimated, $9\frac{1}{8}$ inches.

According to the restoration of the animal by Goldfuss, *P. crassirostris* would measure as nearly as possible three feet from tip to tip of the wings, and it is probable that the species now described would measure at least six feet from one extremity of the expanded wings to the other; but if it should hereafter prove that the bone described and figured by Professor Owen belongs to a *Pterodactyl*, the probable expansion of the wings would reach to at least eight or nine feet.

Under these circumstances, I propose that the species described above shall be designated *Pterodactylus giganteus*.

May 28, 1845.

J. A. Hankey, Esq., and M. Bell, Esq., were elected Fellows of the Society.

The following communications were read :—

1. *On the Geology of* Lycia. By Professor Edward Forbes, F.R.S., and Lieut. T. A. B. Spratt, R.N., of H.M.S. Beacon.

The district explored by the authors extends over two degrees of longitude and one of latitude. It is chiefly occupied by a series of alpine plains and mountain ridges, broken up by four great valleys,

del. et Zinc.

PTERODACTYLUS GIGANTEUS _ *BOWERBANK.*

which open seawards. The mountain mass of Cragus rises to 7500 feet, that of the Lycian Taurus to 7000 feet, that of Massicytus to 10,000, Soosoos-Dagh to 7000, and Mount Solyma to 7000. The plains or *yailahs* which these mountain ridges wall in, vary in elevation from 2000 to 6000 feet above the sea. They have no outlets; the rivers which water them pour into caverns, and reappear again at the bases of the mountains in the low country near the sea. Geologically, they appear to be valleys of elevation.

Sedimentary rocks.—The oldest stratified rock in Lycia is the *Scaglia* or *Apennine limestone*, usually referred to the cretaceous epoch. It forms the great mass of the country and the highest mountains, 10,000 feet above the sea; it is usually a cream-coloured compact limestone, sometimes a gray or pink stone of looser texture, and in places brecciated. In Milyas it degenerates into a soft chalky limestone, resembling chalk, and difficult to distinguish from the freshwater tertiary limestones. Near Lake Caralitis the harder and softer beds of the scaglia are interstratified: the more compact scaglia is usually very thick-bedded. The strata dip at all possible angles, and are often much disturbed and contorted: the dip is generally from the axis of the mountain chains. Fossils are very scarce. *Nummulites*, *Pectens*, and corals of the genus *Astræa* were found in it. Strata of greenish sandstone or shale (macigno?) rest upon the scaglia, in most cases conformably: they contain traces of vegetable impressions. A coarse green gravelly sandstone near Almalee, apparently of the same age with the shales, contains Nummulites.

Marine tertiary beds are met with at four localities in Lycia, viz. Saaret near Antiphellus, Gendevar, Armoutlee, and near Arsa. They are probably all of the same age, and contain numerous fossils: they consist of marls, shales and conglomerates. Thirty-four species of mollusca were collected in these beds, of which twelve were identical with or nearly allied to Bordeaux species, three or four were Sicilian, and two identical with Touraine fossils in Mr. Lyell's collection. The beds at Saaret are elevated 2500 feet above the sea, those at Gendevar 2700, those at Armootlee 6000, and those at Arsa between 2000 and 3000 feet. The authors regard these marine tertiaries as belonging to the miocene period.

Freshwater tertiaries are extensively developed in Lycia, especially in the great valleys. They consist of beds of white marl and limestone, usually capped by conglomerate; they are often 300 to 400 feet thick; fossils are found in them in the valley of the Xanthus and near Cibyra. A *Limneus*, identical with the *Adelina elegans* of Cantraine, another species allied to *L. longiscatus*, an undescribed *Paludina*, a *Planorbis* and some species of *Unio*, were the principal forms observed. In these tertiary basins the beds are horizontal in the centre, and inclined towards the sides; they are regarded by the authors (from a comparison with the other freshwater tertiaries of Asia Minor) as subsequent to the marine beds, and probably of the older pliocene period.

Extensive deposits of more recent origin also occur. The great plain of Pamphylia is composed of travertine, resting probably on marine tertiaries, and forming cliffs from twenty to eighty feet high.

Igneous rocks are not unfrequent, and their presence is evidently connected with the disturbances of the mountain masses. Around the Gulf of Macri hills of schistose serpentine occur, rising up amidst the scaglia, and probably of older date. This rock extends far into Caria. A serpentine, apparently newer and disturbing the scaglia, is seen among the mountain passes on the confines of Phrygia and near Cibyra. A serpentine, apparently of the same age with the last, appears near Olympus, and bears up masses of the scaglia. At the junction of the two rocks is the Yanar, a stream of inflammable gas, famous as the Chimæra of the ancients, and first discovered in modern times by Captain Beaufort. Greenstones, porphyries and amygdaloids are seen in many localities around Mount Solyma, some of them more recent than the newest serpentines, of which they contain included fragments.

The authors draw the following conclusions from their examination of the geology of Lycia :—

The first epoch indicated is that of the formation of the scaglia, which was probably deposited as very fine sediment in a deep sea. This we infer from the mineral character of the rock, its uniformity, the extreme scarcity of fossils in it, and when organic remains are present from those being mostly foraminifera, such as the Nummulites, especially such species as from their thin, flat, wafer-like forms and large size were not adapted for shallow water. The scaglia is usually referred to the cretaceous æra ; but, judging from the singular assemblages of fossils found in some parts of it, as at Mount Lebanon, and from its great thickness, extent and uniformity of mineral character, it is not improbable that it was a formation, the deposition of which went on without interruption in the depths of a great ocean during the whole of the secondary epoch.

The history of the sandy beds which rest upon the scaglia is more difficult to understand, unless we suppose a considerable and sudden change of level of the sea-bed previous to their deposition, and before the conversion of the cretaceous sea into land, which we must suppose to have happened before its depression to form the bed of the miocene sea in which the marine tertiaries of Lycia were deposited. At this time we have certain evidence that the higher peaks and ranges of the Lycian Taurus and Massicytus were above water. The elevation of the miocene marks the epoch of greatest disturbance. From 2000 to 6000 feet of the Massicytus were raised above water, and the forms of the mountain summits must have undergone material change. The next great event was the formation of the great lakes, in which freshwater tertiaries were deposited. The draining of these lakes, the thickness of the deposits formed in which indicates the long and tranquil period of their existence, was effected without any great disturbance of their beds, though considerable barriers must have been destroyed.

Since then movements of elevation and depression have been going on, even during the historical period, as is proved by examination of the monuments on the coast of Lycia. The formation of the great Pamphylian plain may also be regarded as one of the latest, though one of the most important events in the geological history of this part of Asia Minor.

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2. *Notice of a New Family of Crinoidal Animals, called* Cystidea. By Baron Leopold von Buch, For. Memb. G.S. &c.

The Crinoidea are provided with long arms, penetrating plates, which together form a kind of cup containing the viscera of the animal. These arms, according to the discoveries of Mr. Thompson, which have since been fully confirmed by M. Müller of Berlin, in his beautiful analysis of the *Platycrinus*, have the ovaries placed at the base of pinnules attached to the arms. An ovarian orifice in the cup would therefore have been useless, and is not present.

In the most ancient formations there exist, however, bodies *without arms*, and generally of a nearly spherical form. These bodies, of which the cup closely resembles in all respects that of the Crinoidea, are always provided with an ovarian orifice, and further, they also have an anus by the side of the mouth. This is an organization different from that of the Crinoidea, and it will be useful to collect the various species into a group under a distinct name.

The Cystidea are distinguished,—

1. By having the mouth constantly at the apex and in the centre, which is rarely the case in the Crinoidea.

2. By being provided with an ovarian orifice, generally situated in the upper part of the body or cup. This orifice is almost always formed by five valves, pierced at their summit with a small hole.

3. By having an anus not far from the mouth, and always on the right of the ovarian orifice.

The description of the various species forms the subject of a memoir in the Transactions of the Berlin Academy not yet published.

The figures of *Caryocrinus ornatus** are intended to exhibit the admirable symmetry of these bodies. Two large plates and two small ones form the base. If from the intersection of the large ones, each of which is composed of two small ones confluent and soldered together, we draw an imaginary line to the summit, it is found to pass through a lateral plate, having an angle at its apex, and not truncated as the rest: beyond which and in the same direction is placed the mouth.

We have therefore here a bilateral arrangement—a right and left side—distinctly shown ; and this arrangement exists in almost all the Crinoidea, especially in such as have unequal basal plates, such as *Platycrinus*, &c.

* The figures of most of the species are given, together with a complete translation of M. von Buch's memoir, among the miscellaneous articles in the present number of the Journal.—Ed.

The *Caryocrinus* exhibits the first rudiments of these striæ passing from one plate to another, which in several species are prominent, forming a network which effectually conceals the intersection of the plates, and deceives us as to their structure and arrangement. It is these striæ which are so often observable on the *Marsupites* of the chalk, and it is very much to be desired that their nature and use could be made out.

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3. *On the relation of the New Red Sandstone to the Carboniferous Strata in* LANCASHIRE *and* CHESHIRE. By E. W. BINNEY, Esq.

LATTERLY much attention has been devoted by English geologists in endeavouring to trace the upper boundary of the carboniferous strata, and to show the connexion of the latter with the beds of the overlying new red sandstone formation. This subject, although it has often been treated upon, still possesses great interest, as by it alone can we obtain certain information with regard to the probable extent of our valuable coal-fields, all of which, on their dip, disappear under the new red sandstone.

At the Manchester meeting I had the pleasure of showing to some of the members of the British Association an excavation exhibiting the lower new red sandstone in contact with the coal-measures. In the present paper it is my intention to describe all the similar sections that I have met with in the counties of Lancaster and Chester. Before doing this, however, it will be desirable to give a general sketch of both the new red sandstone and carboniferous groups on the west of the *penine* chain. The new red sandstone formation occupies nearly the whole of the county of Chester, and a considerable portion of Lancashire.

It may be conveniently divided into—

	Thickness. Feet.	
1. Upper red marls, comprising (according to Mr. Ormerod*) a. Red and variegated marls of	unascertained	Mr. Murchison's Trias.
b. Gypseous and saliferous marls	800	
c. Waterstones	440	
2. *Bunter sandstein* (upper new red) proved to be	600	
3. *Red and variegated marls*, containing thin beds of limestone, full of magnesian limestone fossils, maximum	210	Permian.
4. *Lower new red sandstone*, maximum	120	

The deposits marked *a* and *b*, so far as they are yet known, have been found to be conformable to each other, but there is reason for believing that the latter deposit is not always conformable to the underlying waterstones. The last-named beds also are conformable to the upper new red sandstone, and can be seen at several places

* Report of the Council of the Manchester Geological Society for 1842–1843.

gradually passing into that rock, which in its turn is sometimes seen passing successively into the magnesian limestones and lower new red sandstone, where these deposits have been met with, but is more frequently found resting on the carboniferous strata without their intervention. The thickness of the two lower members of this formation is extremely variable.

The dip of the new red sandstone is nearly to all points of the compass at different places, but in the east of South Lancashire and Cheshire the main dip is towards the south-west. On the west side of the same counties it is to the south-east and north-east. Although at present no perfect synclinal axes can be traced, owing to the numerous lines of fault that traverse the new red sandstone plains, scarce any one can examine the dips of the strata without being convinced that all the forces which elevated the coal-fields of Lancashire and Flintshire in latter times have materially affected the position of the new red sandstone formation.

General description of the Lancashire coal-field.—The carboniferous strata commonly known by the name of the Lancashire coal-field occupies the chief part of the southern division of the county of Lancaster, and extends into adjoining portions of the counties of Chester, Derby and York. Coals have been worked from near Macclesfield to Colne, a distance of about forty-six miles north and south, and from Tarbock to Todmorden, about forty miles in a line from W.S.W. to E.S.E. The latter however is by far the greatest width of the field, and much exceeds its average, for in the southern part there is not more than a mile in horizontal distance from the upper new red sandstone to the millstone grit. The area of the field might indeed be extended over considerable portions of the moorlands of Cheshire, Derbyshire, Yorkshire and Lancashire, occupied by millstone grits, but I have only noticed the country lying between points where collieries are now or have been in operation, not including the two small seams of coal which sometimes, but not always, occur between the first and second millstone grits. The last-named deposit is the lowest rock of what in this coal-field may be truly termed the carboniferous (coal-bearing) strata, and can be conveniently assumed as their lowest boundary, although it is well known that elsewhere in England, as well as in Scotland and Ireland, coals are found lying at great depths below them. The limestone shales of Roecross, Tintwistle beyond Mottram, and those of Pendle Hill near Burnley, are taken as the base of the deposit, and full 6600 feet of strata, terminating with the red clays lying above the limestones of Ardwick near Manchester, and containing about 120 different seams of coal, have been ascertained. How much more lies under the new red sandstone remains yet to be proved. This outline shows the coal-field in question to be the most perfectly developed of any in England, and therefore admirably adapted for investigating the true upper boundary of the carboniferous strata.

This coal-field may be divided into three groups, namely the upper, middle and lower.

The first is assumed, for the sake of convenience, to include all the carboniferous strata lying above the red measures of the limestones of Ardwick down to the floor of the four-feet mine of Bradford, Patricroft and Worsley*. It is 1560 feet in thickness, and contains five workable seams of coal, the highest that have been wrought in England.

The second commences from the floor of the four-feet mine, and terminates with the floor of the coal distinguished as the Riley mine of Oldham, the Daubhill mine of Bolton, and the Arley mine of Wigan, well-known as the last thick seam. In this division lie the main coals. It is 2910 feet in thickness, and contains, according to the testimony of Mr. Andrew Knowles† (probably the oldest and most extensive coal proprietor in Lancashire), twenty seams, which I think may be termed workable ones.

The third division includes all the strata lying between the floor of the Riley mine and the limestone shales, and comprises all the mountain mines. It is 2130 feet in thickness, and contains six seams that have been worked.

The upper field is best seen at Ardwick, where it can be traced to within about 100 yards of the upper new red sandstone. In most parts of the district it is not seen, being covered up by the upper new red sandstone. Hitherto no passage of one formation into the other has been observed. Its seams of coal and rocks, with the exception of the beds of limestone, are variable and difficult to trace for any considerable distance.

The coals and rocks in the middle field alter much in their characters‡, and are with difficulty identified at different points in the county; but the last thick seam, known by the respective names of the Lower Woodley, Riley, Dogshaw, Daubhill, Arley and Orrell mines, is well-known and easily identified.

All the rocks and coals of the lower field are far more constant than those of the other two, and there is little difficulty in tracing them through the whole country, and identifying them at the most distant places.

Most persons on inspecting the Lancashire coal-field are surprised at the long narrow tongues of upper new red sandstone which run into it. These are generally deep down-throws of the coal-measures, which have been filled up with sandstone. Their direction is most frequently towards the north and north-west, but there is one at Collyhurst near Manchester which runs a little east of north. These faults, in the language of miners, "cut off" the coals; but they are in fact down-throws; and whenever they are found on the rise of the mine, it may be taken as a general rule that the measures have been thrown down, although the sides of the fault, from

* In a former communication I included all the Manchester coal-field in the upper division, but I now consider that the four-feet coal is a much more convenient line for dividing the upper from the middle field. See Proceedings of the British Association for Manchester Meeting (1842), Trans. of Sections, p. 49.

† Memoirs of the Literary and Philosophical Society of Manchester, New Series, vol. vi. p. 452.

‡ Proceedings of the British Association, *antè cit.* p. 50.

having been long acted upon by the water which deposited the new red sandstone, give no indication as to whether or not the dislocation was up or down.

Connexion of the Lancashire Coal-field with other Coal-fields.

No positive evidence has yet been obtained to prove the continuity of the Lancashire seams with those of Flint or the Dee, but judging from the dips of the two coal-fields, and the similarity of their respective strata, there can be little doubt of their extending under the new red sandstone formation of Cheshire, and being connected. The coals at Neston, Northop and Bagilt appear to be identical with the thick coals of the lower part of the middle division of the Lancashire coal-field. Unfortunately the great upthrow of the mountain limestone of Halkin has cut off the coals on the rise, and we are deprived of the sight of the lower coal-field, which is so generally the most useful part of the deposit when we wish to identify one coal-field with another.

With regard to the Yorkshire and Derbyshire coal-field*, there is no doubt of its identity with that of Lancashire, the millstone grit which forms the lower part of both fields being continuous over the hills along the line of the Manchester and Sheffield Railway, by the Huddersfield Canal, Blackstone Edge and Todmorden, the limestone shales being sometimes seen under them in the valleys. In addition to this, all the seams and rocks of the lower coal-field, with their beds of *Pecten*, *Goniatites*, &c., in the neighbourhood of Staleybridge and Marple, can be as well identified with those of Deepcar and other places in the valley of the Don and Brampton near Chesterfield, as they can with those of Harrock Hill and Newburgh near Ormskirk.

The deposits in the middle of the coal-field, it has been already stated, cannot be well identified even in Lancashire at distant points, owing to the change in the seams of coal and the variability of their accompanying rocks; and it is therefore scarcely to be expected that they can be better compared with beds in a different field. But the black shale coal of Sheffield and Chesterfield—the last thick seam—can be identified with the Riley mine, the last bed in the middle division of the Lancashire coal-field. This bed of coal in each field is generally of great value, both for its thickness and quality, and lies immediately above about 200 yards of barren shales and sandstones which occur over the lower coals. These strata have become well-known in both districts, owing to the fruitless searches which have been made in them for workable seams of coal, and they constitute a good line of boundary to separate the middle from the lower coal-field.

Having thus obtained some evidence of the identity of a seam of coal in the two fields, there is little difficulty in learning how far each field is developed, and what portions of each remain under the new red sandstone formation. Probably the best way to ascertain

* Transactions of the Manchester Geological Society, vol. i. pp. 78, 80.

the upper boundaries of the carboniferous strata is to compare one coal-field with another; for, so far as I am aware, no one in England has yet seen coal-measures fairly graduate and pass into the lower new red sandstone formation. In Lancashire about 1490 yards of strata, terminating upwards with the red measures of Ardwick, have been found above the Riley or Daubhill mine. Now what is the case in Yorkshire and Derbyshire? In the measures occurring between the black shale coal of Bromley, proved to be identical with that of Sheffield and the Worth Wood coal, formerly worked by the proprietors of the Swinton Pottery, only 633 yards of strata have been met with. This distance is taken from the borings made some years ago at the expense of Earl Fitzwilliam in and near to his Wentworth estate. And in Derbyshire I know of no more than 600 yards of measures having been found to exist above the same coal, so that if the two coal-fields have been formerly one, we have evidence that 837 yards more of the coal-measures have been exposed in Lancashire than in Yorkshire and Derbyshire, and in such case they exist in all probability covered up by the new red sandstone formation.

In the limestones and red shales of Ardwick*, we find both the remains of large sauroid and other fishes, and an abundance of fossil plants; but the former, as they are of little value in identifying particular coal-measures, it will not be necessary to mention. But with regard to the latter, some, as *Neuropteris cordata*, a *Lycopodites*, a small *Sphenopteris*, an undescribed *Pecopteris*, a *Lepidophyllum*, and two *Asterophyllites*, not yet figured, are of considerable importance. These plants, especially the first-named, have been met with in the high coal-measures of Le Botwood and Uffington, and in the Burdiehouse strata near Edinburgh (the true position of which, some geologists contend, belongs to the upper and not to the lower part of the field as first supposed†), and some of them also have been pointed out to me by Mr. Lyell among the fossils brought by that geologist from the upper part of the coal-fields of North America and from Autun in France. In Yorkshire and Derbyshire I have not been able to discover any of these plants, notwithstanding that most of the specimens of the fossil flora are common to both coal-fields. Although, generally speaking, these fossils alone may not be sufficient to identify strata at different points, still their absence in some measure tends to confirm the opinion that the upper portion of the Yorkshire and Derbyshire coal-field is not exposed.

The Lancashire coal-field having been compared with that of Yorkshire and Derbyshire, and having been proved to be continuous with it, we are justified in concluding from analogy, that not only is the North Welch deposit similarly connected, but that those of Shropshire, Staffordshire and Leicestershire, as well as that of

* Murchison's 'Silurian System,' p. 86.

† If fossil organic remains are of any evidence in identifying strata at different places, the Salopian, Lancastrian and Scotch deposits must be considered as being of the same age.

Cumberland, are but the outcrops of one vast coal-field lying under the new red sandstone formation.

Previous to describing the sections, it will be as well to remark, that there is great difficulty in distinguishing the lower new red sandstone from some of the rocks of the upper part of the carboniferous series, for which it has no doubt often been taken. In Lancashire no fossils have hitherto been found in the first-named rock. This is also the case with several of the upper sandstones of the coal-field. The lower sandstone is however generally composed of particles of silica with some few pieces of a mineral resembling jasper, much more feebly cemented together and having far more of a conglomerate character than any sandstone in the upper coal-field. Its grains also have a slighter coating of oxide of iron around them, are larger and much more angular, and contain amongst them few, if any, of the large rounded pebbles so common in the upper new red sandstone. It varies greatly in colour, being sometimes of a deep red, but occasionally dirty green or dull brown, and its thickness can never be estimated with any certainty for a considerable distance.

The red and variegated marls with limestones*, representing the magnesian limestones of Yorkshire and Derbyshire, can generally be well-determined by their characteristic fossils. The beds of limestone contain little, if any, magnesia, and in their appearance and organic remains much resemble the lowest beds of Bolsover, described by Professor Sedgwick in his most valuable paper on the magnesian limestone, published in the Transactions of the Geological Society†. The bed in Derbyshire is provincially called the Fox Bed, and is used for agricultural purposes from the circumstance of its containing little, if any, magnesia.

The upper new red sandstone varies much in colour, hardness and grain, but on the whole it must be considered as one thick bed, since no lines of demarcation, except a few slight partings of red and variegated clays, can at present be drawn between its upper and lower beds, so as to determine which part of it should be classed with the upper portion of the Permian system, and which with the lower division of the Trias, a separation which Mr. Murchison and M. E. de Verneuil have shown to exist in other countries ‡.

With these observations, I shall proceed to describe the sections, and show the relations which exist between the three lower members of the new red sandstone and the underlying coal-measures.

In several geological maps, especially that lately published by the Society for the Diffusion of Useful Knowledge, the lower new red sandstone and the representative of the magnesian limestone are laid down in continuous lines skirting the coal-fields with great regularity. Now these deposits have never yet been met with, so far as I am aware, except at the points mentioned in the following sections:—

* Transactions of the Manchester Geological Society, vol. i. p. 44.
† Second series, vol. iii. p. 81.
‡ Quarterly Journal of the Geological Society, vol. i. p. 81.

(1.) *The Norbury Section* *.

Little evidence of the relation which exists between the coal-measures and the new red sandstone strata is to be found in the country lying between Macclesfield and Stockport, the drift enveloping the district so as to prevent the beds from being seen. In the brook-course at Norbury, about three miles south of Stockport, there was a good section a few years ago, but it has lately been covered up. On proceeding up the stream from the Macclesfield turnpike-road to the cottage below the mill, the upper new red sandstone was seen dipping to the south-west at angles varying from 10° to 20°. Under it were two yards of red clays (5), which were laminated and contained small plates of mica. I found no organic remains in this deposit, but from the position of the beds they were probably the representatives of the magnesian limestone. Immediately under these marls was a bed of coarse sandstone (4), five feet three inches in thickness. Its colour was different from that of the upper new red sandstone, and it was composed of nearly incoherent sand of much larger and sharper grains than the upper rock. The colour of it was a dirty brown. In all its characters it resembled the lower new red sandstone, and I have therefore described it as such. Under the last-named deposit was a bed of reddish-coloured clays (3), about four yards in thickness and containing no organic remains. These appeared to belong to the lower new red sandstone rather than to the coal-measures, as the latter are seen dipping under them at a much greater angle, namely at about 40°. The coal-measures belong to the middle division of the field.

(2.) *Fog Brook Section.*

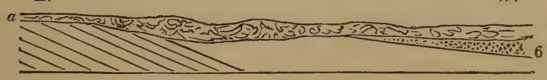
This is seen in the stream known by the above name (Fog Brook) in Offerton, about three miles south-east of Stockport. In it the upper new red sandstone appears well-developed, dipping at an angle of 15° to the S.S.W., but further down the brook it dips at 25°, and ter-

* In this and the following sections, illustrating the present memoir, the references will be as follows :—

6. Upper new red sandstone.
5. Red marls and limestone.
4. Lower red sandstone.
3. Red clays.
2. Upper coal-measures.
1. Middle coal-measures.

minates in two singular rounded projections, which have evidently been pushed up by the underlying strata. It is succeeded by about one yard of red clays, which bear evidence of considerable pressure having been exerted upon them. Then come regular coal-measures, dipping S.S.W. at angles varying from 80° to 70°. These last-named strata are in the lower part of the middle coal-field; the whole of the thick beds of this valuable deposit being here covered up by the upper new red sandstone, and I am not aware that any attempt has been made to follow them under this rock.

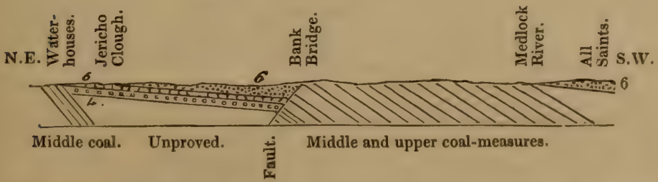
(3.) *Beet Bank Bridge Section.*



a. Drift.

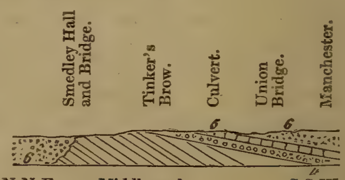
This is seen on the banks of the Tame, about three miles north-east of Stockport. The upper new red sandstone (6) runs up the valley from Reddish Mills, skirting coal-measures on its northern side. It dips at a moderate angle nearly due west. Its absolute point of contact with the coal-measures cannot be seen, owing to a thick covering of drift, which hides the section for about fifty yards; but when the measures do appear they are seen dipping to the west, at an angle of 19°. Their position is about the upper part of the middle field. No traces of the two lowest members of the new red sandstone formation have here been seen; but the late Mr. Fletcher's trustees, in working their 'little coal' to the north-west by the footway leading to Reddish Mills, drove their levels for a distance of 100 yards under the sandstone without perceiving the slightest disarrangement of the measures, thus clearly proving that the latter there run quite regular under the sandstone, and are not cut off, as local miners have hitherto supposed.

(4.) *Manchester Section.*



Under the site of All Saints Church in Chorlton-upon-Medlock, a thin bed of red marls was found lying upon the upper new red sandstone. The latter rock occupies the whole of the distance between that place and Mr. Schofield's chapel in Every Street. It dips to the south-west at an angle of about 10°. From the chapel to the river Medlock, near 100 yards of strata are covered with drift so as not to be visible; therefore it is not known whether the two lower members of the new red sandstone or the higher coal-measures crop out in that space. In the turn of the river Medlock, red and variegated clays, parted by thin bands of gritstone, make their appearance. These are succeeded by similar deposits, containing the limestones and thin coals of Ardwick, and afterwards all the coal-measures of Bradford and Clayton, comprising the whole of the known part of the upper and the higher part of the middle division of the coal-field. The dip is nearly south-west, at angles varying from 18° to 25°. The coal-measures at Bank Bridge have been thrown down by a fault to an unknown depth, and are covered by upper new red sandstone for a distance of about three miles. The last-named formation crops out near Jericho Clough, and the coal-measures of the middle field are afterwards seen in the river-course at Waterhouses dipping westwards, at an angle of about 60°. The strata of Ardwick are the highest members of the coal-field that I have met with; but whether they constitute the termination of the field, and none other are to be met with on their dip, yet remains to be proved.

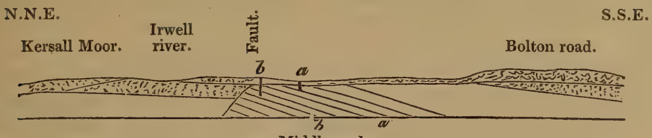
(5.) *Collyhurst Section.*



This section is one mile north of Manchester, and shows the three lower members of the new red sandstone formation, successively outcropping and graduating into each other. The shell marls and lower new red sandstone are in great force, and the last-named rock rests unconformably on the coal-measures of the middle field.

This section has been fully described by me, and the description is published in the volume of the Transactions of the British Association for 1844, and in the first volume of the Transactions of the Manchester Geological Society. But there is one circumstance not fully described in either of those papers. It is, that at the turn in the river Irk, where the lower new red sandstone can be seen gradually passing into red clays containing numerous circular impressions, and immediately above the clays, there occurs a bed of conglomerate sandstone of a brownish colour, with sharp angular grains and pebbles sometimes reaching to the bulk of a common marble. This conglomerate presents more of the usual characters of the lower new red sandstone than the thick rock of Collyhurst, the grains of which are all well-rounded, and never, I believe, attain the size of a small pea. In my section it is classed with the magnesian limestone, but I now consider that it ought to be grouped with the lower new red sandstone. Immediately above this conglomerate are red and variegated clays, amongst which are nodules of a fine-grained reddish stone containing a considerable amount of iron and lime.

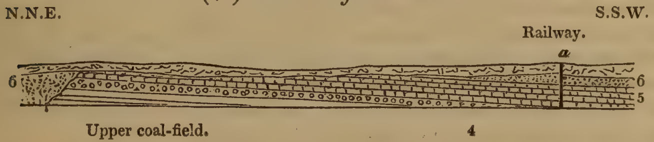
(6.) *Pendleton Section.*



a, b, Sinkings to two seams of coal worked by Mr. Fitzgerald.

The Pendleton section occurs two miles north-west of Manchester. It exhibits the upper new red sandstone at Oatbank near the Eccles new road, dipping to the south-west at a moderate angle. Drift covers up the country under the higher part of Pendleton, but in the valley of the Irwell Mr. Fitzgerald has worked seams both in the upper and middle coal-fields. These dip at an angle of about 18° to the S.S.W., and outcrop against the upper new red sandstone, which there lies in a deep downthrow of the coal-measures of full 1000 yards in extent. The absolute thickness of the upper new red sandstone at this fault is unknown, but it must be near 300 yards. At a depth of 450 yards, red clays are met with in driving a level from the deep pit through the fault. The sides of the fault exhibit every appearance of the former action of water upon them. The upper new red sandstone lying in the fault dips at a moderate angle to the south-west.

(7.) *Patricroft Section.*



a. Messrs. Lancaster's deep shaft.

The Patricroft section is about four miles west of Manchester. This is one of the most interesting sections that I have yet met with, being the result of the first successful attempt to sink through three members of the new red sandstone formation in search of coal in a district where all the practical miners asserted that it did not exist. In other parts of England, no doubt, coals have been obtained by sinking through some of the lower members of the new red sandstone formation, but I am not aware of any other instance than the present in which all the three lower members of this group have been sunk through and coals profitably worked under them. The merit of this enterprising mining operation is due to Messrs. Lancaster, who have with the most persevering industry and skilful management surmounted difficulties by which most men would have been overwhelmed.

The shaft of the Patricroft Colliery (*a*, see diagram) is near the station on the line of the Liverpool and Manchester Railway:

it is 440 yards in depth. In sinking it, the following section, for the copy of which I am indebted to the proprietors of the colliery, was met with:—

	yds.	ft.	in.	
Till	5	0	0	
White sandstone		2	0	Lower part of the Bunter sandstein.
Red clays		2	0	
Red sandstone	5	0	0	
Red marls	2	0	0	Shell marls and limestones.
Red stone		1	6	
Red marls	1	1	0	
White sandstone		1	0	
Red marls	3	0	0	
Limestone			10	
Red marls		1	6	
Limestone		1	3	
Red marls		2	0	
Limestone		1	0	
Red marls		1	0	
Red marls with several thin beds of limestone		2	6	
Red marls		1	10	
Limestone		2	0	
Red marls	12	0	0	
Lower new red sandstone resting on the higher part of the upper coal-field	7	0	0	

The three members of the new red sandstone dip nearly due south at an angle of about 6°. The upper new red rock soon crops out, but the limestones and marls and lower new red sandstone, as well as the coal-measures, abut against the upper new red sandstone which is here found lying in a fault similar to that at Pendleton in the last section. The coal-measures comprise 398 yards of the upper field, and dip to the south at an angle of about 8°. They have been examined up to the fault, and there exhibit every appearance of having been long subjected to the action of water. The side of the fault slopes at an angle of about 20° towards the north.

(8.) *Atherton Section.*

N.N.E. S.S.W.

Middle coal. 4 5

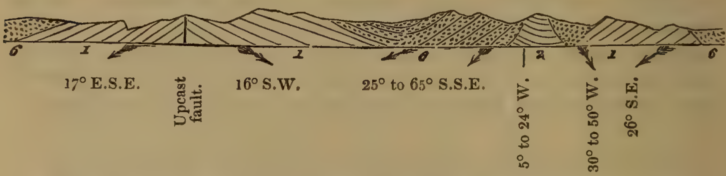
This section is near Leigh, and is exposed in the small brook-course which enters the land, formerly part of the park, from the north. On the banks of this stream, up to and a little past the small bridge, the upper new red sandstone appears dipping at an angle of about 8° or 10° to the south. It is seen gradually passing first into beds of red marl containing thin beds of hard gritstone, and afterwards into deposits of red laminated marls containing numerous beds of limestone. The largest of these, I was informed, is about one foot eight inches in thickness, and there are several beds of from two to four inches, besides others of less dimensions. All these limestones and marls are full of the usual magnesian limestone fossils, similar to those found at Newtown, and figured in the first volume of the Transactions of the Manchester Geological Society; but the first-named strata do not contain a trace of magnesia. By the kindness of Mr. H. Blair, I am enabled to give the following analysis, made by Mr. Hugh Watson, chemist, of Bolton, of a specimen of this limestone from Bedfrid, the adjoining parish to Atherton :—

Carbonate of lime	56·5
Aluminous and siliceous earths	38·5
Oxides of manganese and iron	2·5
Water	2·5
	100·0

The dip of these strata is to the south, at an angle similar to that of the upper new red sandstone. In proceeding up the brook-course towards the mill, however, their dip becomes greater, reaching to an angle of 16°, and is to the south-west instead of to the south. They are succeeded by the lower new red sandstone, seven yards in thickness. This rock dips to the south-west at an angle of 25°, which gradually diminishes to 16° as it approaches the coal-measures. The last-named strata cannot be traced for a few feet to the north-east, but when they are seen they incline to a little north of west, at an angle varying from 12° to 15°. As you proceed further towards the mill, however, they are found not to have been so much affected by the fault, and recover their regular dip to the south-west at an angle of 16°. The fault which has thrown up the lower new red sandstone runs from south-east to the north-west, and has, no doubt, considerably disturbed both the new red sandstone and carboniferous strata in its neighbourhood.

The condition of the lower new red sandstone in one part of the rock is very remarkable, and exhibits every appearance of having been subjected to great heat and pressure. Part of it is converted into a hard crystalline rock, which displays scarcely any trace of the nearly incoherent sand of which it is usually composed, while other portions of it seem to have had a metallic matter resembling iron pyrites injected into it. The rock also presents numerous slides or polished surfaces, so frequently met with near faults. However, there is one bed left which retains all the usual characters both as to colour and grain of the rock, and clearly identifies it with the lower new red sandstone. After examining the rock, scarce any one can doubt that it has been subjected to great heat; still there is no visible trace of any trap dyke near it; so probably the alteration of the stone has been produced by heat developed on the upheaving of the strata, and is due to friction alone. The sides of many faults far removed from igneous rocks often give evidence of the action of intense heat upon them, which in my opinion can only be accounted for by the great heat developed by the violent friction of some parts of the rocks against other parts.

(9.) *Liverpool and Manchester Railway Section south of St. Helens.*



N.B. The arrows denote the direction of the dip at the places where its amount is quoted.

Sutton.

The upper new red sandstone is seen on the west of the branch leading from the Liverpool and Manchester Railway to St. Helens, and there dips at a moderate angle to the east; but it cannot be traced to the variegated and red measures seen in the Sutton brook, which appear again on their rise on the inclined plane. These beds of clay contain thin bands of gritstone and some smooth laminated light-coloured strata resembling the upper beds of magnesian limestone of Brotherton in Yorkshire, but they do not effervesce on being treated with acids. Their appearance on the whole, although resembling some of the lower deposits of the new red sandstone formation, has induced me to colour them as part of the upper coal-field,—as high as, or even higher in the series than, the red measures seen at Ardwick. No fossil organic remains have as yet been found in them. The dip of the strata east of the Workhouse Bridge is 17° to the E.S.E.; on the west of the bridge is seen a fault, with a hard crystalline rock apparently much altered by heat lying in it, and regular coal-measures of the middle field dipping to the S.S.W. at an angle of 16°. An anticlinal axis is thus formed. The coal-measures continue for some distance, and become nearly level before they are covered up by the drift. The upper new red sandstone is not seen on the railway, owing to there being no cuttings; but at Thatto Heath, a little to the north of the line, it occurs as a strong conglomerate, dipping westwards, and continues as far as the railway station at Kenrick's Cross.

Whiston.

Proceeding towards Liverpool, after leaving the station at Kenrick's Cross, the upper new red sandstone is soon seen taking a moderate dip to the south-east. Near the Wooden Bridge at Whiston, it dips at an angle of 25°, is much discoloured, and traversed by joints filled with a substance resembling oxide of manganese. The dip increases to an angle of 65° east of the bridge, and then ninety-eight yards of coal-measures are seen protruded through the sandstone. These measures are of the upper coal-field, and consist of red clays containing a bed of limestone about two feet in thickness, resembling that found at Ardwick, and a rock of reddish gritstone on the east of the bridge. These strata dip to the west at an angle of 24°, which gradually diminishes as you proceed westwards until they reach the upper new red sandstone, where it is only about 5°; three or four inches of soft red clay intervene betwixt the coal-measures and the upper new red sandstone. The last-named rock when it appears is much discoloured. At first its angle of dip is 50° to the west, but this soon lessens to 30°; and it then, in the distance of a few hundred yards, disappears, and is succeeded by the Halsnead and Huyton coal-field.

Huyton.

After the disappearance of the upper new red sandstone in the last section, some of the higher portions of the Halsnead coal-measures are seen on the railway dipping eastwards, but no good section appears until you reach the cutting at Huyton Quarry. The flag-rock there seen is one well known in the neighbourhood of Bury and Rochdale as the upper flag, or old Lawrence rock, and is always found to overlie the upper portion of the lower coals. It dips to the south-east at an angle of 26°, and some of its lowest beds on their rise abut against the upper new red sandstone lying in the valley below, and extending from that point to beyond Liverpool without interruption. The occurrence of the last-named rock on the rise of the coal-measures seems to indicate a great downthrow of the latter filled up with sandstone. Where the coals come up again to the west remains yet to be proved. The upper new red sandstone, when again seen on the railway near Broad Green, dips eastwards.

The last three sections afford us valuable information as to the different characters of the dislocations which have broken up the coal-field. The first two of them exhibit anticlinal axes of upper new red sandstone, without any traces of the marls and limestones and lower new red sandstone. They are, beyond doubt, elevations and protrusions of coal-measures fairly through the upper new red sandstone, effected since the deposition of the latter rock; and if the two lower members of the new red sandstone had there existed, some traces of them would in all probability have appeared. But the coal-measures of Halsnead and Huyton were evidently elevated before the upper new red sandstone was deposited on their western flanks. This last-named rock overlies a great mass of these deposits between Huyton and Liverpool. Between Liverpool and the Irish Sea, few, if any, searches for coal have been made; but if the upper new red sandstone can be found cropping out to the west, there is every reason to believe that coals will be met with under it. On the other hand, if the sandstone west of Liverpool is found dipping westward, the coals will be at a great depth.

Conclusion.

After having observed the facts detailed in the foregoing paper, the author has arrived at the following conclusions:—

1st. That although the Lancashire coal-field is 6600 feet in thickness, and is probably the most perfectly developed coal-field in England, still it has never been seen to graduate upwards into the new red sandstone, and, consequently, that its upper boundary must be considered as unascertained.

2nd. That on comparing the Lancashire coal-field with that of the south-west of Yorkshire and Derbyshire, the latter exhibits a deficiency of 837 yards of the middle and upper measures.

3rd. That the new red sandstone formation is found resting upon coal-measures of all ages, and scarcely ever at different places on rocks of the same age, so that it cannot with propriety be said to bound, but only to cover them.

4th. That where coal-measures have been found on their rise outcropping against the new red sandstone, the latter bed, so far as has been yet proved, always indicates that the coal-measures exist beneath it, but that the dislocation is of great extent.

5th. That in all cases where seams of coal have been followed on their dip under the new red sandstone, they have been found to continue under it without any perceptible difference either in their inclination or quality.

6th. That the dislocations in the coal-field may be classed under two heads, namely the older ones, produced before the deposition of the upper new red sandstone, and the newer ones which have been produced since, but that the former have been in some degree affected by the movements which produced the latter.

7th. That the new red sandstone formation is very irregularly deposited over the underlying carboniferous strata, and that its two lower members are frequently either very slightly developed or altogether wanting, which seems to indicate that these lower members repose in great troughs and hollows of the coal-field, which had an irregular surface, over which the waters of the new red sandstone sea flowed and deposited the various beds.

June 4, 1845.

The following communications were read:—

1. *An account of the* Fine Dust *which often falls on Vessels in the* Atlantic Ocean. By Charles Darwin, Esq., F.R.S., F.G.S.

Many scattered accounts have appeared concerning the dust which has fallen in considerable quantities on vessels on the African side of the Atlantic Ocean. It has appeared to me desirable to collect these accounts, more especially since Professor Ehrenberg's remarkable discovery that the dust consists in considerable part of Infusoria and

Phytolitharia. I have found fifteen distinct statements of dust having fallen; and several of these refer to a period of more than one day, and some to a considerably longer time. Other less distinct accounts have also appeared. At the end of this paper I will give the particular cases, and will here only refer to the more striking ones and make a few general remarks.

The phænomenon has been most frequently observed in the neighbourhood of the Cape Verd Archipelago. The most southern point at which dust is recorded to have fallen is noticed by Capt. Hayward (1), on whose vessel it fell whilst sailing from lat. 10° N. to 2° 56′ N.; the distance from the nearest of the Cape Verd Islands being between 450 and 850 miles. Respecting the northern limit, the water for a great distance on both sides of C. Noon (in lat. 28° 45′) is discoloured, owing in part, according to Lieut. Arlett (2), to the quantities of falling dust. Hence the phænomenon has been observed over a space of at least 1600 miles of latitude. This dust has several times fallen on vessels when between 300 and 600 miles from the coast of Africa: it fell, in May 1840, on the Princess Louise (3) (in lat. 14° 21′ N. and long. 35° 24′ W.) when 1030 miles from Cape Verd, the nearest point of the continent, and therefore half-way between Cayenne in S. America and the dry country north of the Senegal in Africa.

On the 16th of January (1833), when the Beagle was ten miles off the N.W. end of St. Jago, some very fine dust was found adhering to the under side of the horizontal wind-vane at the mast-head; it appeared to have been filtered by the gauze from the air, as the ship lay inclined to the wind. The wind had been for twenty-four hours previously E.N.E., and hence, from the position of the ship, the dust probably came from the coast of Africa. The atmosphere was so hazy that the visible horizon was only one mile distant. During our stay of three weeks at St. Jago (to February 8th) the wind was N.E., as is always the case during this time of the year; the atmosphere was often hazy, and very fine dust was almost constantly falling, so that the astronomical instruments were roughened and a little injured. The dust collected on the Beagle was excessively fine-grained, and of a reddish brown colour; it does not effervesce with acids; it easily fuses under the blowpipe into a black or gray bead.

In 1838, from the 7th to the 10th of March, whilst Lieut. James in H.M.S. Spey was sailing, at the distance of from 330 to 380 miles from the continent, between lat. 21° 10′ N., long. 22° 14′ W., and lat. 17° 43′ N., long. 25° 54′ W., considerable quantities of dust fell on his vessel, four packets of which, together with a written communication, I owe to the kindness of Mr. Lyell. The dust which fell on the first day (or the 7th) was preceded by a thick haze, and it is coarser than that which fell on the succeeding days: it contains numerous irregular, transparent, variously coloured particles of stone about the $\frac{1}{1000}$th of an inch square, with some few a little larger, and much fine matter. The fact of particles of this size having been brought at least 330 miles from the land is interesting, as bearing on the distribution of the sporules of cryptogamic plants and the ovules of Infusoria. The dust which fell on the three succeeding days resembles in appearance and in its action under the blowpipe that collected by myself off St. Jago, and is so excessively fine, that Lieut. James was obliged to collect it with a sponge moistened with fresh water. As the wind continued nearly in the same direction during the four above-mentioned days, and the distance from the land was only a little increased after the first day, it would appear probable that the coarser dust was raised by a squall with which the breezes on this coast so often begin blowing.

With respect to the direction of the wind during the falls of dust, in every instance where recorded it has been between N.E. and S.E.; generally between N.E. and E. In the case however given by the Rev.W. Clarke (4), a hazy wind which had blown for some time from E. and S.E. first fell calm, and was succeeded for a few hours by a S.W. wind, and then returned strongly to the east; during this whole time dust fell. With respect to the time of year, the falls have always occurred in the months of January, February, March and April; but in the case of the Princess Louise in 1840, as late as on the 9th of May. In the one year of 1839, it has chanced that dust has been recorded as having fallen in the Atlantic (as may be seen in the references) on the 14th and 15th of January, and on the 2nd, 4th, 9th, 10th, 11th, 12th and 13th of February. I may add, that Baron Roussin (5), during his survey of the north-western African coast, found, that whilst the wind keeps parallel to the shore, the haze and dust extend seaward only a short distance; but when during the above four specified months the harmattan blows from the N.E. and E.N.E., accompanied by tornados, the dust is blown far out, and is raised on high, so that stars and all other objects within 30° of the horizon are hidden.

From the several recorded accounts (6) it appears that the quantity of dust which falls on vessels in the open Atlantic is considerable, and that the atmosphere is often rendered quite hazy; but nearer to the African coast the quantity is still more considerable. Vessels have several times run on shore owing to the haziness of the air: and Horsburgh (7) recommends all vessels, for this reason, to avoid the passage between the Cape Verd Archipelago and the main-land. Roussin also, during his survey, was thus much impeded. Lieut. Arlett found the water so discoloured (8), that the track left by his ship was visible for a long time; and he attributes this in part to the fine sand blown from the deserts, "with which everything on board soon becomes perfectly caked."

Professor Ehrenberg * has examined the dust collected by Lieut. James and myself; and he finds that it is in considerable part composed of Infusoria, including no less than sixty-seven different forms. These consist of 32 species of siliceous-shielded *Polygastrica*; of 34 forms of *Phytolitharia*, or the siliceous tissues of plants; and of one

* These microscopic organized bodies have been described in the 'Monatsberichten der Berlin Akad. der Wissens. Mai 1844; u. 27 Februar 1845.' In the latter paper a full list of the names is given: the column marked St. Jago includes those collected by myself.

Polythalamia. The little packet of dust collected by myself would not have filled a quarter of a tea-spoon, yet it contains seventeen forms. Professor Ehrenberg remarks, that as 37 species are common to several of the packets, the dust collected by myself, and on four successive days by Lieut. James, must certainly have come from the same quarter; yet mine was brought by a E.N.E. wind, and Lieut. James's by a S.E. and E.S.E. wind. The Infusoria are all old known species, excepting one allied to a Hungarian fossil; and they are of freshwater origin with the exception of two (*Grammatophora oceanica* and *Textilaria globulosa*), which are certainly marine. Prof. Ehrenberg could not detect any of the soft parts of the Infusoria, as if they had been quickly dried up, and hence it would appear that they must have been caught up by the wind some time after having been dead. The greater number of the species are of wide or mundane distribution; four species are common to Senegambia and S. America, and two are peculiar to the latter country: moreover it is a very singular fact, that out of the many forms known to Professor Ehrenberg as characteristic of Africa, and more especially of the Sahara and Senegambian regions, none were found in the dust. From these facts one might at first doubt whether the dust came from Africa; but considering that it has invariably fallen with the wind between N.E. and S.E., that is, directly from the coast of Africa; that the first commencement of the haze has been seen to come on with these winds; that coarser particles have first fallen; that the dust and hazy atmosphere is more common near the African coast than further in the Atlantic; and lastly, that the months during which it falls coincide with those when the harmattan blows from the continent, and when it is known that clouds of dust and sand are raised by it, I think there can be no doubt that the dust which falls in the Atlantic does come from Africa. How to explain the enigma of the absence of characteristic African forms and of the presence of two species from S. America, I will not pretend to conjecture. Finally I may remark, that the circumstance of such quantities of dust being periodically blown, year after year, over so immense an area in the Atlantic Ocean, is interesting, as showing by how apparently inefficient a cause a widely extended deposit may be in process of formation; and this deposit, it appears from the researches of Prof. Ehrenberg, will in chief part consist of freshwater Polygastrica and of Phytolitharia.

List of References.

(1) Nautical Magazine, 1839, p. 364. The dust fell from the 9th to the 13th of February 1839, whilst sailing from (lat. 10° N., long. 29° 59′) to (lat. 2° 56′ N., long. 26° 30′ W.). The wind on the 9th was E.N.E., on the 10th N.E. by E., and on the three succeeding days N.E.

(2) Geographical Journal, vol. vi. p. 296. "Survey of some of the Canary Islands and part of the coast of Africa, by Lieut. W. Arlett, R.N."

(3) Edinburgh New Phil. Journal, vol. xxxii. p. 134. The account is taken from Berghaus' Almanack of the dust which fell on the Princess Louise on Jan. 14th and 15th, 1839, between (lat. 24° 20′ N., long. 26° 42′ W.) and (lat. 23° 05′ N., and long. 28° 18′ W.): and again in 1840 from the 6th to the 9th of May, whilst between (lat. 10° 29′ N., long. 32° 19′ W.) and (lat. 16° 44′ N., long. 36° 37′ W.). During the

voyage of a vessel of the same name, in which Dr. Meyen was a passenger (Reise um Erde, Th. i. s. 54) on the 27th of October 1830, the sails were observed to be stained by a powder, which Dr. Meyen considered to be a minute Cryptogamic plant: the date would lead me to believe that in this case the phænomenon was different from that of the dust described in this paper.

(4) Proceedings of the Geolog. Soc. vol. iv. p. 145. The dust described by the Rev. W. Clarke fell February 2nd to the 4th, 1839, when between (lat. 21° 14′ N., long. 25° 6′ W.), and nearly (lat. 12° 36′ N., long. 24° 13′ W.). The direction of the wind has been already given in the paper; as it also has been, when the dust was collected by Lieut. James and myself. Mr. Clarke has since written a communication on the subject for the 'Tasmanian Journal' (vol. i. p. 321), to which I am indebted for two references.

(5) Nautical Magazine, 1838, p. 824.

(6) Nautical Magazine, 1837, p. 291. Mr. Burnett, on February 12th to 15th, in sailing from (lat. 4° 20′ N., long. 23° 20′ W.) to (lat. 8° N., long. 27° 20′ W.), a distance of 300 miles, with the wind N.E., preceded by a S.E. squall which veered to E.S.E. and then to N.E., had the sails, rigging and mast covered with red dust. The dust began to fall as soon as the wind became N.E.: the atmosphere was very hazy. The nearest land was 600 miles distant. The same phænomenon was observed by Mr. Burnett in April 1836.

Mr. Forbes gives an account (Sharon Turner's S. Hist. of the World, p. 149) of dust which fell on a ship when 600 miles from the coast, between C. Verd and the R. Gambia: the wind all the previous night had been N.E.

In the Edinb. New Phil. Journal (vol. vii. p. 402) there is another account of dust which fell in considerable quantities on March 29th, 1821, in lat. 11° 3′ N., when 300 miles from the nearest part of Africa.

In Howard Malcolm's Travels (vol. ii. p. 200) there is a similar account of dust which fell during several days in February on a ship north of the equator, when more than 1000 miles from the coast of Africa: the wind was N.E.

(7) Horsburgh's East Indian Directory, p. 11.

(8) In Tuckey's Narrative of the Congo Expedition (p. 10), a discoloured sea and a hazy atmosphere are described on the 9th of April in lat. 22° N. and long. 19° 9′ W., when 32 leagues from the main-land.

It may be worth here recording that Sir A. Burnes (Travels in Cabool, p. 223), in describing Khoten, a region of Upper Asia, adds, "it is said that its productiveness depends upon clouds of red dust, which always fall or are blown in this part of Asia." But he thinks that the statement requires confirmation.

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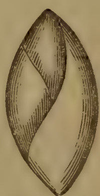
2. *On two Species of* Microscopic Shells *found in the* Lias. By H. E. Strickland, Esq., M.A., F.G.S.

a

b



a. Orbis infimus, Strickland. *b. Polymorphina liassica*, Strickland.

N.B. The figures are greatly magnified, the small dot beneath the letters being the natural size.

The shells of the microscopic order *Foraminifera*, which occur so abundantly in the cretaceous and tertiary series, are found much more rarely as we descend through the secondary formations. Examples of them have indeed occurred both in the oolitic and the palæozoic series, but I believe that these fossils have not hitherto been met with in the lias.

The Rev. P. B. Brodie, while pursuing his interesting and successful researches into the fossil insects of the lower lias, was the first to discover these minute objects. In a bed of yellowish shaly stone, a few feet above the "insect limestone" of Wainlode Cliff, Gloucestershire, he detected small white dots about $\frac{1}{50}$th of an inch in diameter, which when examined by a powerful microscope prove to be discoid spiral shells, apparently unattached, with five or six smooth, rounded, narrow volutions, devoid of striations or any other distinctive characters. As there are no traces of concamerations, we perhaps ought to refer them to the *Serpulidæ* rather than to the *Foraminifera*, although their extreme minuteness would point to the latter family as a more probable clue to their affinities. It has been suggested to me that their characters resemble those of the genus *Orbis* of Lea, and I will therefore denominate the fossil provisionally *Orbis infimus* (see figure *a*). These fossils also occur in a similar bed of shaly limestone near the base of the lias at Cleeve Bank, between Evesham and Bidford. Along with them I here obtained one specimen of an equally minute fossil, which exhibits more decidedly the characters of the group *Foraminifera*, and is referable to the family *Stichostega*. It is an oval body, pointed at both ends, smooth and glossy, convex, divided into three concamerations, the largest of which extends all the length of the shell. As the aperture is not visible, it cannot be referred with certainty to any of the known genera of *Foraminifera*, but in general form it approaches sufficiently to the genus *Polymorphina* of M. d'Orbigny, and we will therefore denominate it *Polymorphina liassica* (see figure *b*).

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3. *On* SPIRIFERS *from the* LIAS. By JAMES BUCKMAN, Esq., F.G.S.

[Notice of this paper is postponed.]

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4. *On a Method of forming the Dust of* GRAPHITE *into a solid Mass.* By W. BROCKEDON, Esq.

THE *graphite*, or black-lead of commerce, of sufficiently good quality to be used for pencils, has become very scarce, only a small quantity being now raised in the Borrodale mines, and that of inferior quality, so that what has been sold lately is part of a large supply obtained forty years ago. This quantity having been picked over and over again, the former reputation of the Cumberland graphite is now no longer sustained, and its impurity is detected by artists in consequence of the grit which it often contains.

The author of this paper has contrived a method by which the fine dust of the best parts of the graphite may be recomposed into a mass as dense and compact, and of as close a texture as the best quality found in the mine. To effect this, the dust obtained from sawing graphite into thin plates and veneers, to be enclosed in the cedar, is carefully washed and ground, and by repeated operations is rendered pure and free from grit, being finally sifted through spaces less than $\frac{1}{50000}$th part of a square inch.

Thus prepared, the powder is placed under a powerful press on a strong die or bed of steel with air-tight fittings. The air is then pumped from the dust, and while thus free from air a plunger descends upon it, and it becomes solidified. The power employed to perform the operation is estimated at 1000 tons, several blows having been given, each of this power.

Specimens of graphite, prepared by this process from the dust of the best Cumberland black-lead, were exhibited; one of them a block in a condition to be cut into thin plates for pencils; another a broken piece, showing the same smooth surface on both sides of the line of fracture, an appearance often observed in native graphite.

The author considers it a legitimate inference to be drawn from this process, that the fine sediment deposited from the detritus of rocks may be again converted into solid stone by mere pressure.

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5. *Remarks on the Level of the* PIRÆUS HARBOUR *near* ATHENS, *and of the country adjacent.* By the Rev. ROBERT EVEREST, F.G.S.

THE author in this paper directs attention to certain appearances which he considers afford evidence of a depression of land along certain portions of the Mediterranean coast. These appearances consist of the foundations of some ancient buildings now observed to be below the water-line, and of sarcophagi now also below the sea-level.

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6. *Notice of the Discovery of the Tusk of an* ELEPHANT *in the* GRAVEL *near* ROCHESTER. By Mr. W. J. CHARLTON.

IN this notice the author mentioned the fact, that many specimens of the bones and tusks of elephants have been found in the gravel near Rochester, about two furlongs from the banks of the Medway. The fragment in question was about three feet in length, and measured ten inches across at the larger and nine inches at the smaller end.

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7. *On the Occurrence of a Fossil Petro-tympanic Bone of a* WHALE *from the* CRAG *near* IPSWICH. By C. B. ROSE, Esq., F.G.S.

DURING a visit to the Crag district of Suffolk in July 1844, while travelling up the Orwell towards Ipswich, and at a short distance below Holywells, a celebrated Crag locality, I observed a patch of crag on the upper part of a somewhat lofty portion of the bank of the river, and went ashore to examine it. I had not long searched the mass, which consisted chiefly of broken shells, ere I found a heavy nodule, which I soon recognised as the tympanic bone of a Cetacean. It is nearly perfect, having only a portion about an inch in length broken from one end of it. Its fractured extremity exhibits the following characters:—The central portion is of the colour of ferruginous clay; there is next a band of dark ferruginous stain, and exterior to the last a layer of an ochrey colour, somewhat darker than the central portion, and which is easily chipped from the dark-coloured layer; innumerable minute indentations are visible upon its surface, more particularly upon the involuted portion. The colour of the different layers observed in my specimen is undoubtedly derived from a ferruginous infiltration; the texture is that of exceedingly dense bone,—a solidity appropriate to the function of the organ to which it belongs, and very unlike the texture of some coprolitic (?) bodies I possess from the Crag, which exhibit somewhat similar concentric bands, but a decidedly *crystalline* fracture, particularly in the dark-coloured bands.

The long diameter of my fossil is three and a quarter inches, the short diameter two inches, and its average thickness at the fractured extremity is three-quarters of an inch. On comparing my specimen with the description of similar fossils by Professor Owen, in his Appendix* to Professor Henslow's paper, read before the Society Dec. 13, 1843, I have no hesitation in deciding that it is the tympanic bone of *Balæna definita.*

Professor Henslow, in the paper above referred to, says, "It seems to me not a little remarkable that all these specimens should have been procured within a very narrow compass, for I found none beyond the limits of two contiguous indentations in the cliff, a short distance to the north of Felixstow." I have therefore forwarded this communication to the Society, merely for the purpose of contributing a new locality in which a cetacean remain has been met with.

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8. *On the Scratched Boulders and Rocks of the Coal-field of Scotland.* By James Smith, Esq., F.G.S., of Jordan Hill.

The phænomenon of scratched boulders has of late attracted attention from its supposed connexion with glacial action; but before the researches of Professor Agassiz had excited so much interest on the subject, it had been but little attended to. When he visited Scotland in 1840, with the object of searching for proofs of the former existence of glaciers in that country, and their connexion with the erratic blocks and the so-called diluvium or till, his attention was immediately arrested by the striæ which were observed upon some of the blocks. He however admitted to me then, as he has since done in

* Quarterly Journal of the Geological Society, vol. i. p. 38.

his paper on the subject, that the deposit in which these boulders occurred "was not produced by true glaciers, although intimately connected with the phænomena of ice." He also states, in the above-quoted paper, that "the erratic blocks in Switzerland are always angular," which is just what might have been expected if they were transported by ice, whether upon glaciers or icebergs. The erratic blocks in Scotland, on the other hand, are rounded, and we have two problems to solve,—how have they been rounded? and how have they been scratched? Before attempting to answer these questions, it is necessary that we should be made acquainted with all the circumstances under which these blocks are found; we can then compare the facts with proposed solutions, and by excluding those which are inconsistent with well-established facts, be driven at last to that solution which explains them all.

Every person has seen pebbles ground on one side for the purpose of exhibiting their polish or structure; and the commonest observer cannot fail to draw the following conclusions:—

1. That the stone has undergone two different kinds of attrition since it has been separated from its native rock, totally distinct and unconnected with each other.

2. The rounding process must have preceded the grinding one.

3. The stone must have been at liberty to roll in the one case, but must have been held fast in the other.

4. The rounding has been caused by the action of water.

The case of the boulders is precisely that of the pebble, and my present object is to show how they have been held fast. I think it right to observe, that the great mass of boulders at Bell's Hill, near Glasgow, where M. Agassiz first observed this phænomenon, and to which he has since repeatedly alluded in his writings, although most satisfactory on many points, threw no light upon this; the boulders were not *in situ*; a hill, composed of till, in which they were imbedded, had been levelled, and they were left in heaps. There was therefore no means of knowing whether the cause, whatever it was, acted in a certain and uniform direction,—a point of great consequence in this question.

Some late observations, which I have had an opportunity of making, convince me that the cause which has produced the furrows upon the boulders is identical with that which has produced the similar effect upon rocks *in situ*, and that they are posterior to the deposition of the till, or at least to the deposition of the older till or boulder clay, if it shall be established that there have been at least two deposits of this nature.

There are three positions in which boulders may be found in the till:—They may be altogether buried in it; they may be partially buried in it, with their upper surface exposed; or they may rest on the surface. Rocks *in situ* may be covered with the till, or part of their surface may be exposed. This distinction is an important one, because if the striæ on rocks occur below the till, they have probably been caused by its deposition. If however they are only found on the exposed surface, we may infer that they are posterior to it; and in like manner, if the striæ upon boulders are only found upon their exposed surfaces, we may draw the same conclusion.

On my last visit to Scotland, I observed on the shore of the Gare Loch, about twenty-five miles from Glasgow, two boulders of considerable magnitude half-buried in the till, with their upper surfaces scratched. They were near enough to enable me to observe that the striæ were perfectly parallel, and in the same direction in both stones; and near the foot of the Campsie range of hills, I observed the same phænomenon on the exposed surface of a trap rock. The direction was the same in all the three cases, viz. from the north of west to the south of east. This coincidence can scarcely be accidental, particularly as it agrees with the observations of others.

Colonel Imrie, in his account of the geology of the Campsie Hills *, notices the striated surface of the trap rocks, and their direction from west to east, "except where turns in vales had partially influenced the course of the current." He also notices that some of the boulders had scratched surfaces, in a position which indicated they had come from the west. Mr. David Milne, in his paper on the Lothian coal-field, in the 'Transactions of the Royal Society of Edinburgh †,' states, respecting the boulders of the till in that district, "Though these boulders are generally smooth, some of them have ruts or scratches on their upper sides, which have been apparently produced by the passage over them of harder bodies. I have more particularly observed these scratches on blocks of limestone, sandstone and greenstone. It is an object of some importance to ascertain the direction of these ruts, but it is in very few places in the district where this can be ascertained. The direction of the ruts can be very distinctly seen along the shore at Joppa, near Portobello, and at Seafield, near Leith. They appear at both places between west and west-south-west by compass, but the most general direction is west-half-south. A great many boulders have lately been dug out of this deposit in the excavations for the Newhaven and Edinburgh railway; the direction of the scratches upon them is west-half-north."

I have never observed any furrowed surfaces below the till ‡; on the contrary, whenever I have seen it in contact with the subjacent rock, it exhibits marks of violent action, fracture and denudation. Mr. John Craig of Glasgow, whose pursuits as a mineral surveyor render him familiar with this, informs me that he has observed the same thing. But if the mode of deposition has been a violent one, the cause must have been a transient one, otherwise the smaller broken fragments would in all cases have been removed; but the contrary is the case; by far the greatest number of fragments are those of the subjacent rock, more or less rounded according to the distances from which they have been brought.

* Memoirs of the Wernerian Society, vol. ii. p. 35.

† Vol. xiv. p. 310.

‡ There is a furrowed, scratched and polished surface of the sandstone below the till at the great stone-quarries of Craig Leith, of a part of which plaster casts were taken by Captain Basil Hall. [Note by Referee.—Ed.]

The melting of ice has been suggested as the cause of debacles capable of transporting boulders; but the melting of ice could never produce a debacle in the rigid sense of the word—I mean such a debacle as would be produced by the bursting of a waterspout, or the head of a reservoir, or an earthquake wave; the laws of matter prevent it. The conversion of sensible into latent heat is necessarily a work of time: floods, possibly of great violence, might result from such a cause, capable of moving the greatest masses; but their action would be continuous, and they would necessarily separate the larger from the smaller fragments, and all of them from the clay in which they are imbedded; they would be arranged both according to their size and their gravity; but neither of these is the case, and I must conclude, with Sir James Hall, that such effects are "inexplicable by any diurnal cause." But even if this difficulty could be got rid of, a more insuperable one meets us; such floods must necessarily run down the hills, and into the natural lines of drainage of the country. In the west of Scotland the great line of drainage is marked by the course of the river Clyde, and floods poured from the contiguous mountains must inevitably follow its course to the sea; but the very reverse of this is the case. I never yet saw or heard of an erratic block in the valley of the Clyde, where its course could be traced, that did not come in an opposite direction to the flow of the river. We can trace their course, not from the mountains to the sea, but from the sea to the mountains. Mr. Milne, in another paper on the geology of Roxburghshire*, after noticing "that the parent rocks were in all cases to the westward of the boulders," contends that they could not be transported by glaciers; and after noticing the line of drift, he adds, "A glacier which transported (boulders) from Criffel to the hills of Liddesdale, besides being forty miles long, must have crossed the valleys of the Nith, Annan, Esk and Tarras rivers, as well as the high ridges separating them; it must have done so without having any lateral barriers to retain and guide it; and lastly, it must have moved *up* the valley of the Liddel for at least fifteen miles of its course." If this argument is good against the action of glaciers in transporting boulders, it is still better when applied to the case of boulders assumed to have been transported by glacial floods. It appears to me to be perfectly conclusive against both hypotheses.

I am very far from contesting the former existence of glaciers in Scotland; on the contrary, I consider it in the highest degree probable that they did exist; and when we find scratches on the vertical faces of rocks not following a definite course, but having the same direction as that of the valleys, and when we find boulders arranged as they are in moraines, then the action of glaciers affords a natural and satisfactory solution; but these are exceptional cases, and after many years' study of this deposit, I have never met with any. The action of icebergs has also been suggested; here also I have no difficulty in admitting the probability of their former existence, and there is proof that much of

* Transactions of the Royal Society of Edinburgh, vol. xv. p. 480.

this deposit was permanently submerged about the period to which we must refer these phænomena, viz. about the end of the tertiary period. These icebergs however must have obeyed every impulse of wind and tide ; and when we find angular masses transported from a distance resting on the surface or imbedded in marine strata, we may infer with great probability that they were dropped from icebergs : this also is an exceptional case, of which I have never met an instance. But even if such phænomena were much more frequent than we find them to be, they would throw no light whatever on the origin of the boulder clay. The explanation which is attended with fewest difficulties is that propounded by Sir James Hall, and by one and all of the early Scotch observers, and maintained with great ability and knowledge of detail by Mr. Milne, in his valuable papers already referred to, the first of which indeed has no reference to the glacial theory, which was not then propounded, at least in this country. This explanation, modified by later discoveries, is as follows :—A rush of water, such as that produced by earthquake waves of sufficient violence to tear up not only the pre-existing unconsolidated cover, but considerable portions of the subjacent rocks, and perhaps obliterate the inequalities caused by disturbances in the coal-measures, passed over the island from west to east, or rather from the north-west, depositing the whole in a confused mass on the surface. In that part which was under the sea, beds of gravel, sand and clay were deposited. In process of time a second debacle again swept over the island in the same direction, but with much less violence than the first; the stratified beds, perhaps of no great thickness, were swept away, leaving however occasional patches, sufficient to attest their existence, and also part of the pre-existing diluvium, reducing the inequalities and grinding the exposed surfaces of the rocks and boulders ; for it is to this second debacle I ascribe the scratching of the rocks and boulders ; and here I think ice acted an important part, and was probably the principal agent in grinding down the substances over which it passed : a colder climate and a north-west direction both point to a frozen ocean which was perhaps broken up by the convulsion which caused the diluvial wave, and the ice of which was swept over the land in the same direction. That there are two separate deposits of till, I have no doubt ; the newer is finer, lighter in the colour, and with fewer and smaller boulders than the older, and when seen in contact the junction is well-defined ; such a junction may be seen in the cover of Gilmour Hill quarry, near Glasgow. Mr. Craig informs me that he found the femur of the fossil elephant in stratified beds between these separate deposits ; and Mr. Milne describes them under the names of the " upper covering of gravel and boulders," and the " lowest boulder clay," enumerating four stratified beds between them. M. d'Archiac, in his account of the Geology of the Department de l'Aisne, also notices two unstratified deposits, both of which he ascribes to *diluvial* action.

June 11, 1845.

E. Solly, Esq., F.R.S., F.L.S.; Alexander Keith Johnston, Esq.; the Earl of Lincoln, and B. Cunliffe, Esq., were elected Fellows of the Society.

The following communications were read:—

1. *On the Palæozoic Rocks of the* Isle of Man. By the Rev. J. G. Cumming, M.A.

[This paper is postponed for the present.]

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2. *Description of* Footmarks *and other Imprints on a slab of* New Red Sandstone, *from* Turner's Falls, Massachusetts, U.S., collected by Dr. James Deane of Greenfield, U.S. By Gideon Algernon Mantell, Esq., LL.D., F.R.S., F.L.S.

Having recently received from Dr. James Deane a small slab of stone covered with Ornithichnites belonging to two species, and some of these imprints exhibiting the character of the surface of the dermal integument more distinctly than any other specimen brought to this country, I am desirous of submitting it to the examination of the Society, with the following description which accompanied it.

The slab is about two feet in diameter and half an inch in thickness. On the upper surface there are two rows of small elegant footmarks, of the species termed by Professor Hitchcock *Ornithichnites gracillima*; one row consists of five, and the other of six consecutive impressions. There is also a row of four footprints of a much larger species, the *O. fulicoides* (so named from their resemblance to the footmarks of the recent cinereous coot, *Fulica Americana*). These are arranged around the circumference of the slab, and their alternate order proves that they have been impressed by the same individual. "There is a rare peculiarity displayed in these larger impressions that adds greatly to their interest: it is the markings of the papillæ, and folds of the cutaneous integument, which are very distinct; and this character," says Dr. Deane, "I have only observed in two other examples. The papillæ may be seen most distinct in the first, second, and fourth footstep; particularly in the last of the series, on the top of the slab." The three rows of footprints above-described embrace fifteen impressions, and exhibit the articulations of the toes perfectly. The surface of the stone is pitted by rain-drops, from a shower which must have fallen before the birds walked over the soft mud and made the footprints. There are also indistinct traces of the trails of worms, and of an Annelide.

On the reverse of the slab there are the casts of four consecutive impressions of *Ornithichnites gracillima*; and a row of two, of dimensions intermediate between those of the preceding varieties.

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3. *On the Geology of the Island of* St. Mary's, *one of the* Azores. By T. Carew Hunt, Esq., Her Majesty's Consul for the Azores.

The island of St. Mary's, the easternmost of the Azores, is about seven miles in length from east to west, and five in breadth from north to south, and is divided naturally into a plain and an elevated district, which, taken together, mark its aspect from the sea. The plain occupies about one-third part on the west side of the island, the other part being formed of an elevated ridge running from north-west to south-east, which rises to a double peak (Pico Alto) 1889 feet above the sea, and of which the sides decline on the north, east and south to mural cliffs of considerable height.

The base appears to be a dark blue compact basalt, containing minute crystals of olivine. This basalt has in some parts assumed a contorted columnar structure and near the town of Villa do Porto a distinct prismatic character. Above this bed is a coarse red wacké, passing to a cellular brown amygdaloid, its softer parts thickly imbedded with splendent crystals of augite, and the cells of the harder mostly filled with arragonite in three varieties of crystallization, and carbonate of lime. In both are occasional imperfect crystals of hornblende. This would seem to be the second bed of the island, and to it succeed deposits of marine shells of variable thickness, in which the most conspicuous shells are the lesser and greater scallop, mixed in parts with an arenaceous cement and rounded nodules of basalt, breccia and amygdaloid, and interstratified with films and layers of semicrystalline carbonate of lime. This calcareous bed is of extreme hardness, except where its sections have been exposed to and rendered brittle by the spray of the sea. On the surface is a strong grayish argillaceous earth mixed and covered with small decomposing basaltic pellets of a concentric laminated structure, which, with beds of tufa of different degrees of coarseness, completes the constitution of the plain district.

The lower beds of the second or elevated district (marked B) are probably a continuation of those described, overlaid by the mass of brown, compact, and sometimes amygdaloidal porphyry, which has formed the chain of heights. At St. Lorenzo is a detached cavernous rock of basalt veined with carbonate of lime, whose interior is filled with stalactites,—a variation of base which occurs in other parts of the island, and extends to the Formigas rocks, distant twenty miles to the north-east.

The general conclusion will perhaps be, that the two lower beds of basalt and amygdaloid were of successive submarine formation; that the lapse of many ages allowed them to be covered with a thick layer of marine shells and sand; that a new eruption covered this layer and partly fused it; and that the island was completed by the formation of Pico Alto. It will be a question, whether its emergence preceded, accompanied or followed the last convulsion, and also at what relative period a small hill called the Pico do Facho, near Villa do Porto (connected apparently with some neighbouring basaltic dykes), was formed.

It will perhaps be thought that the nature of the organic remains of this island throws light on the antiquity of the whole archipelago, as the westernmost island of Flores contains calcareous beds which may have been formed like those of St. Mary's, while the volcanic character of the intermediate island constitutes a general chain of connexion between them. And if those remains be found to be the same with the fossils of Sicily, the Azores may perhaps be assumed to be of the age of that and neighbouring parts of the land of the Mediterranean.

PROCEEDINGS,

ETC.

POSTPONED PAPERS.

On the Geology of GIBRALTAR. By JAMES SMITH, Esq., of Jordan Hill, F.G.S.*

[Read Nov. 20, 1844.]

THE continent of Europe is terminated on the south and that of Africa on the north by a secondary formation of considerable extent, which is cut into two by the Straits of Gibraltar. The prevailing rock on both sides is siliceous sandstone, generally of a yellowish brown colour, which is associated with limestone and shale in different states of induration, and also with subordinate beds of chert and coal. Judging from external character I should pronounce it to belong to the true coal-measures, but the indications furnished by organic remains point rather to the Jurassic group. The evidence however is by no means conclusive; fossils are of such rare occurrence and in such an imperfect state, that no certain inference can, in the present state of our knowledge of its organic remains, be drawn from them. The Gibraltar limestone contains casts of marine shells, chiefly Terebratulæ, one of which appears to be the *T. fimbria* and the other the *T. concinna* of the 'Mineral Conchology,' both belonging to the lower oolite. A coal-pit has lately been opened about four miles to the north of Gibraltar, but hitherto with no other success than the discovery of a bed of arenaceous shale, with thin flakes of highly crystalline coal. The late Mr. Drummond Hay, the British consul at Tangier, informed me that there are also indications of coal on the African side of the Straits.

The hills round the Bay of Gibraltar rise to an elevation of between 2000 and 3000 feet, and at their base there is a series of low swelling hills of tertiary limestone, which, as I have elsewhere shown, belong to the great miocene formation of the south of Europe†.

The mountain or rock of Gibraltar, as it is usually called, forms an oblong peninsula, extending two miles and a half from north to

* See Quarterly Journal of the Geological Society, vol. i. p. 298.
† Ibid, vol. i. p. 235.

south, and three-quarters of a mile in breadth. It is terminated on the north by a perpendicular cliff 1250 feet in height; its greatest elevation is 1470 feet, and its southern extremity is marked by a triple series of cliffs and terraces. The elevated part of the rock which occupies the northern half of the peninsula is divided into three distinct eminences by gaps in the summit and ravines at the sides. The most northerly eminence is called by the Spaniards 'Salto de Lobos,' and 'Wolf's Crag' by the English; the precipice is called the North Front, and the height above it the Rock-gun, from the gun perched on its summit. The hill in the centre is called Middle Hill or the Signal Station, and the southern height 'Pan d'Assucar' or the Sugar-loaf, but more commonly O'Hara's Tower. To the south of this there is a plain called Windmill-hill Flats, about 400 feet above the level of the sea. This is bounded by an escarpment and succeeded by a second and lower plateau called Europa Flats; and at the southern extremity of the promontory there is, or rather was, a third terrace separated by a sea-worn cliff from the Europa Flats; but the cliff is now concealed by fortifications, and the terrace by a glacis.

1.

In the above diagram is represented the general appearance of the western face of the rock. The beds of limestone in the elevated part dip to the west, but from Windmill-hill Flats, southwards, they dip to the east. About halfway up the western side of the elevated part, there is a precipice parallel to the ridge on the summit or axis of the rock; at the base of this precipice there is a plain of stratified siliceous sand, called the red sands, upon which the town is built and the esplanade and Alameda or public garden formed. On the shore at the western base of the rock, and parallel to its axis, there is a series of beds of highly indurated shale; these are nearly vertical, and separated as they are from the stratified limestone beds by sands or breccia, it is impossible to determine whether they lie over or under them. The same may be said of beds of secondary sandstone which also occur on the west side of the rock, but are not seen in contact with the limestone: this however is not a point of any geological consequence, as they all evidently belong to the same formation.

No rocks of the miocene tertiary period, although these are so largely developed in the immediate neighbourhood, occur in the promontory of Gibraltar; neither are there any newer tertiary deposits, unless we call the breccia, in which the bones of the cave-bear and fossil elephant have been found, tertiary. The post-tertiary rocks are numerous, and of great geological interest from the light they throw upon the former changes which the rock must have undergone subsequently to its first upheaval. The most important of these is a red sandstone containing recent marine shells: on the south-east it attains a thickness of not less than 300 feet: it is formed of water-worn grains of quartz cemented by the calcareous matter deposited by the water which percolates through the superincumbent rock; it is extremely hard and tough, and is used in preference to the secondary limestone for lining the embrasures. The next in importance is the breccia which covers the flanks of the mountain. It is chiefly composed of great and small fragments of the limestone cemented in the same manner as the sandstone. We also find masses of soil and mud similarly cemented, and in these the bones and shells of land animals have been found. They form the well-known bone-breccia of Gibraltar, some part of which must be of great antiquity, as it contains the bones of extinct animals; other parts of it are so modern as to contain the remains of man and works of art. The bone-breccia has been discovered in various parts of the rock, but the principal locality in which it occurs is a fissure in the face of the cliff at Rosia Bay. In scarping the rock for the purpose of making it more inaccessible, much of the bone-breccia has been removed, but enough remains to show its origin. It is lodged in a fissure which has evidently been connected with a cavern, the habitation of carnivorous animals; the floor, like that of the present open caves, has been formed by the dust of vegetable soil, blown into them during the dry season: this has become mixed up with fragments and minute splinters of bone—the remains of the prey of its former inhabitants. A land-flood has swept this bony mud in a semi-fluid state into the fissure, where it is now found. The direction of the flow can be distinctly traced. The splinters, instead of being arranged horizontally, are generally vertical, or rather parallel to the sides of the fissure; the mud has in time been indurated into breccia by calcareous infiltration, and afterwards cracked across by some of the numberless shocks to which the rock has been exposed while this transverse fissure has in its turn been filled with stalagmite. Major Imrie, who has described the geology of Gibraltar in the Transactions of the Royal Society of Edinburgh, observed this circumstance, and inferred from the septa or divisions thus formed that the fissure had been filled at different periods. This however is not the case; for not only is the flow uninterrupted, but a pebble has been cracked across, one half of which is above and the other below the division. There are larger fragments mixed with the splinters, upon one of which I observed the marks of the teeth of some animal. The cave which has furnished the bony matter no longer exists, but this can excite no surprise where so many causes of ruin have occurred, and in point of fact this locality forms part of the great landslip to be afterwards described. I have no additions to make to the list of animals whose bones have been found in this breccia, except those of the cave-bear and the fossil elephant. By permission of the Governor I made an excavation in Martin's Cave, but with no other success than the discovery of rude fragments of pottery, a piece of melted lead, and the bones of recent animals.

The subordinate beds of chert present no peculiarity which requires to be noticed, and there has been no coal found *in situ* upon the rock itself. I shall now proceed to inquire into the geological causes to which the rock owes its present configuration.

Its geological history is instructive as an example of the extraordinary number as well as complicated nature of the movements which have caused the irregularities on the surface of the earth. We are apt to ascribe the presence of marine remains in elevated situations to some great convulsion by which they have been raised from the bottom of the sea, and to suppose that they have remained subjected to no changes but such as are caused by the diurnal action of the elements; but an examination of the mountain of Gibraltar forces us to admit that it must have undergone not one but many movements both of elevation and depression, some of them attended with rupture and dislocation of the strata, others with mere changes of level; to these must be added the effects of chemical agents, landslips, blown sands, and the wasting action of the sea. Some of the disturbances must have obliterated every trace of preceding ones; but although we cannot hope to be able to describe all the changes which have taken place, enough of evidence remains to attest the existence of many of them, and to furnish a clue by which we can in some measure decipher the order of their occurrence.

We know from the marine remains contained in them that the beds of limestone must have been formed at the bottom of the sea during the secondary period in a position nearly horizontal, and that they must have been lifted up to an angle with the horizon by some force acting from below, doubtless of an igneous nature. Whatever it was it must have been deep-seated, and there are no igneous rocks in the neighbourhood.

A force sufficient to rend the superincumbent beds would tilt them upwards on one or both sides of the rent, and if any part of them stood above the surface it would assume the form of a three-sided prism, one of whose sides coincided with the planes of the beds, another with their truncated edges; the third side, or apparent base, would be formed by the surface of the sea, whilst the ends of the prism would be nearly perpendicular. It would appear in the case of Gibraltar that the rent or fissure caused by the subterranean force ran south and north; that the beds gave way on one side of the rent (the west) and were lifted up to an angle of about 19°. From the natural tendency which hard flat bodies have to break across at right angles, the inclination of one of the slopes being 19°, that on the opposite side of the ridge would be about 71°, the complement of the right angle, whilst the ends would be perpendicular.

If we raise the front edges of an octavo volume about an inch and a half off a table, leaving the back resting upon it, and suppose it nearly submerged in water, the part above the surface would afford a tolerably correct model of what the rock must have been after its first upheaval. The boards would be found to form an angle of about 19° with the surface, the front edges 71°, whilst the ends would be vertical.

This, if not the original form, is at all events the most ancient form of the rock of which any evidence remains. In its northern extremity we have the ruins of what must have been one of the ends of the great prism, and in the stupendous escarpment of the North Front its vertical termination.

The earliest epoch in the history of the rock is that in which its beds were deposited at the bottom of the secondary ocean. The second is that which followed the first upheaval, in which it took the form already described. In this position fresh beds would be deposited round its base composed of the disintegrated matter of the rock itself and that of the neighbouring shores.

2.

a. Elevated limestone rock. *b.* Sea forming new deposits at its base.

Accordingly we find in different parts of the rock, and chiefly in the presence of raised marine deposits which must have been deposited subsequently to the first upheaval, but anterior to the second, proofs not only of the changes of level which it must have undergone during this period, but also of the long duration of the period. In process of time however a second upheaval has taken place which tilted up the beds 19° more than they were at first: this disturbance however did not extend to the whole peninsula, the northern part being left in its original position: the rock must therefore have been broken across, and the line of fracture must be that which separates the beds in the original position with a dip of 19° from that part which has been elevated 19° more, and is consequently at an angle of 38°. This separating line is well-marked by the gap in the summit and ravines on the sides which separate the Middle Hill from that on the north or Rock-gun Height (see first diagram in page 42).

The consequence of this movement has been to place the oldest or limestone beds at the inclination of 38°, in which we find them at Middle Hill, and the new beds subsequently formed at an angle of 19°, or sloping inwards to the hill, as may be observed at its base. During the long continuance of the preceding epoch, the wasting action of the sea had scooped out a cliff and terrace: upon this terrace horizontal beds of sand had been deposited, and upon these, again, newer beds have been deposited unconformably or sloping outwards. Finally, in one of the numerous changes of level to which the rock has been subjected, and of which proof will be afterwards offered, the whole of these beds have been lifted up and covered with the blown sands of Catalan Bay on the east side. These sands slope against the face of the cliff at an angle of 30°, at which inclination they are kept by the winds from the east, which are the only ones which reach them.

3.

In the above diagram (3), which represents a section from west to east of Middle Hill, *a* is the limestone; *b*, thin beds of sandstone resting unconformably upon it at an angle of 19°; *c c*, beds of sandstone and sand formed subsequently to the second upheaval, but when the sea-level was different; *d d*, the present beaches; *e*, blown sands. With the exception of the limestone, the mineral composition of all these beds is the same, consisting of comminuted particles of limestone and quartz. *b* and *c* have been indurated into thin crumbling strata; they contain fragments of sea-shells, but although I have found none sufficiently entire to ascertain the species, they have all the appearance of being recent.

A third upheaval in the same direction, but still further to the south, has again tilted up the beds in that part of the rock about 19°, leaving the northern and middle hills in their former position, but inclining the strata to the south to 57°; the line of division is marked by an indentation to the south of the signal-post, called in Spanish *La Quebrada*, or broken ground. We are now arrived at the fourth epoch in the history of the rock; and in this locality we find deposits belonging to each. At one spot a little to the east of Martin's Cave, and looking towards it, the whole of them may be seen in juxtaposition.

4.

O'Hara's Tower.

In the diagram marked (4), which represents a section from west to east of the third or O'Hara's Tower height, the secondary limestone (*a*), originally level, has been lifted up by repeated upheavals to an angle of 57°; the beds (*b*) formed at the base of the rock subsequently to the first upheaval, have been lifted up by the second and third upheaval to an angle of 32°. As the two preceding movements were of 19° each, had the beds at *b* been originally horizontal, the angle would have been 38°; they must therefore have sloped outwards 6°, which is about the inclination of the present sands on the eastern beach. In mineral structure they are precisely the same as those forming at the present day, except that they are hardened into stone by the percolation of calcareous water, and tinged of a reddish colour by the oxide of iron: the separate beds at this particular point are but a fraction of an inch in thickness, but the mass composed of them is nearly 100 feet thick.

In the same diagram (*c*) represents beds formed during the preceding period, and these must have been horizontal, as their slope inwards is exactly the amount of the third upheaval. At (*d*) are other beds formed subsequently to the last upheaval, but when the sea-level was different: at this locality they form the floor of an ancient sea-worn cave, and contain marine remains. The only species I have been able to make out, the *Patella ferruginea*, is still to be found recent in the Mediterranean. This last bed I ascertained by barometrical measurement to be nearly 600 feet above the present sea-level. The rough ground on the left represents an extensive landslip, of great antiquity.

Above this series we come to Martin's Cave; the floor of it slopes inwards 11°; it is evidently sea-worn, and must have been formed during the preceding period, or that between the second and third upheavals, when it must have sloped outwards 8°, an angle corresponding with the present shore, which varies from 8° to 4°. To this period also belong beds of modern sandstone, which are about 100 feet higher, or 700 feet above the present sea-level, and which also dip inwards 11°; these last contain marine shells, apparently recent; they occur near the mouth of two sea-worn caves, which however belong to the subsequent epoch, as their floors are horizontal.

Still further to the south other disturbances must have taken place; but we want the evidence furnished by inclined modern deposits to ascertain their number and amount. I am inclined to think that one or more upheavals raised up the beds till they became vertical, and then overset them, because we find the beds at the south end of the elevated part of the rock nearly vertical, whilst further to the south they dip in an opposite direction, or to the east; we have evidence of at least one upheaval subsequent to the last-mentioned. Immediately under that part of the rock where the beds are vertical, there is a sea-worn cave (Flint's) elevated about fifty feet above the sea, with beds of sandstone below it dipping inwards 11°; this indicates that the movement has been in the same direction as those which preceded it, that is, giving the beds a dip to the westward: thus, by a series of consecutive upheavals, the beds have been raised from their original horizontality till they became vertical; beyond this they dip in an opposite direction; but whether they have been thrown down from the vertical, or raised up from the horizontal position, is a point concerning which I have no evidence to offer. The inclination of the beds of shale on the west side, and the precipice or cliff already described, were perhaps caused by or connected with the upheavals, of which we have such distinct traces on the eastern side. But this part of the rock is so much obscured by sands, breccia and vegetable soil, as to prevent any satisfactory conclusions being arrived at.

The next class of movements to which the rock has been subjected is that producing general change of level. No such change has taken place during the historical, or probably the human period. Ancient geographers describe it as almost surrounded by the sea; the ruins of Carteia, a city of antiquity in the time of the Roman republic, can be traced to the level of the sea; and ancient graves, containing stone hatchets and daggers, have recently been discovered not more than ten feet above it.

The sandy plain immediately to the north of the Fortress appears to have belonged to the period of stationary level which immediately preceded the present: it is full of marine shells. On the British side of the Spanish lines the ground has been much disturbed by the operations of the different sieges, but beyond them it is in its natural state, and affords a most perfect example of a raised shallow sea-bottom. On the west side it is buried under sand-hills, but on the east, where it is exposed to the winds from the Mediterranean, the sands have been blown away, leaving the deserted shells on the surface in such numbers, that when seen from the summit of the rock the ground is absolutely white with them. Notwithstanding their numbers, however, on my first examination I could not find more than five or six species, and these exclusively bivalves, the most numerous of which were the *Cardium tuberculare*, *Pectunculus pilosus*, *Donax trunculus*, and a Venus allied to *Venus gallina*, the *V. senilis* of Philippi. An examination of the sandy bottom of the bay by the dredge showed that it also was the exclusive habitation of gregarious bivalves. The Spanish boats dredge for shell-fish in the adjoining bay in about two-fathoms water: in examining the cargo of one of the boats, I found but one univalve, which contained a hermit crab, as if to prove that it was a straggler. The species were the same as those of the raised deposit; the only difference I could observe was, that the thick and strong shells, the *Cardium* and *Pectunculus*, were more abundant in proportion than in the ancient deposit; but this is easily accounted for, since these shells live in agitated water, and though they abound on the Mediterranean side of the neck of land, they are rare on the shores of the bay side; but when it was covered by the sea it was unsheltered, and naturally contained both kinds of mollusks. Nothing, indeed, can be more perfect than the resemblance of this ancient sea-bottom to that of the present bay, or, rather, to the appearance which it would present if raised above the sea, since the eastwardly winds from the Mediterranean would then blow the sands to the west side, and leave the shells on the surface. As the boats dredge in two-fathoms water, and this shelly deposit is raised about two fathoms, the difference or amount of the change must have been about 24 feet. Now it is remarkable that exactly 24 feet above the present littoral zone an ancient one was discovered, in which the resemblance was, if possible, still more perfect than in the corresponding sea-bottoms. The rocky shores on the east side of the rock, between high and low water, are perforated by Lithodomi, and covered with Balani and numerous clusters of the rock mussel (*Mytilus arcuatus*). In the elevated deposit the Balani were still adherent, the shells of the Pholades in their holes, and the clusters of mussels in the most perfect state. These fossils were found in a crevice, and their preservation is owing to a thin coating of stalagmite. From the state of the shells, with both valves adhering, the animals must have been alive when the elevation took place: I infer therefore that it was instantaneous. This deposit was discovered in a quarry at the North Front. In scarping the ancient sea-cliff at Europa Point, a raised beach was found at the height of 50 feet, and another 20 feet higher; in this last the molar tooth of the fossil elephant was found with sea-shells adhering to it: from these deposits I collected nearly 100 species, all recent; the cliff in which they were found is about 80 feet high. Above this is the extensive sea-worn plateau of the Europa Flats; its surface is almost entirely composed of bare water-worn rock, but there are notwithstanding patches of the indurated sand, in which I found imbedded a valve of the *Pecten maximus* and other fragments of shells. This plateau is backed by a second range of cliffs, in the front of which, at the height of 170 feet above the sea, there is an oyster-bed; and in the same cliff, but 94 feet higher, in scarping the rock, there was discovered another recent shelly deposit. On the east side of the rock, just above the third Europa advance battery, there is a bed of bivalves (*Pectunculi*), corresponding in height with the oyster-bed; and on the same side of the rock the hard modern sandstone, already mentioned, occurs in beds of great thickness, with occasional sea-shells, all recent. At the height of 600 feet I found, as formerly noticed, a similar bed with recent shells. All the deposits hitherto mentioned are in their natural position, and are consequently newer than the upheavals attended by dislocation and change of position. But although 600 feet is the highest point at which we have the evidence of organic remains to prove these more recent changes of level, yet, as the whole surface of the rock is sea-worn, and I find no break in the continuity of the surface, and as also many of the sea-worn caves, at much higher levels, are in their natural position, I infer that the whole mountain up to its summit, a height of 1470 feet, has been submerged subsequently to the last of the disturbances.

We cannot account for the phænomena which present themselves without supposing movements of depression as well as of elevation; but such movements are always difficult of proof, because the sea washes away and re-arranges the loose unconsolidated beds: hence vegetable deposits, such as submarine and subterranean forests, are exceptional cases of rare occurrence; but where petrifaction has taken place, the sea does not destroy the rocks. Beds formed of vegetable soil and mud, and containing nothing but the remains of land animals, converted into breccia by calcareous water, must have been formed on land; and as we find at Gibraltar such beds passing under the sea, we must admit a depression of the land since they were formed. I am satisfied however that the formation of every variety of the Gibraltar breccia is a subaërial process; the rain-water, percolating through the fissures which everywhere intersect the rock, dissolves a certain quantity, but as the largest portion of the water is evaporated before it reaches the sea, it deposits the calcareous matter upon whatever it comes in contact with, and unites the whole into breccia, a process which cannot take place under water; but if we admit that the breccia has been formed upon land, we must also admit many and extensive movements of depression, for we everywhere find it sea-worn. When the beds are marine, they must have been elevated before they were cemented into breccia, again depressed before they were water-worn and scooped into sea-caves, and after that elevated many hundred feet above the sea, as we find them near Martin's Cave.

The next class of causes which have acted upon the rock of Gibraltar are of a chemical nature, and to one of these I have ascribed the formation of the breccia, namely the solvent quality of water combined with a certain portion of carbonic acid; and when we consider the extraordinary quantity of breccia which everywhere covers the flanks of the mountain, and the quantity of calcareous matter required to cement it, which has been abstracted from its internal recesses, we can have no difficulty in accounting for the number and extent of its caverns. Several of these, as formerly noticed, are external, and have been scooped out by the sea; yet even these, when we examine them, are generally found to be pre-existing fissures widened. The sea-worn caves are horizontal and at right angles with the line of coast; the internal ones are vertical and branch out in every direction: one of these, the well-known cave of St. Michael, is of unknown extent, and from the recent researches of Lieutenant Risk, R.N., appears to communicate with both sides of the mountain; on the east side, which is not obscured by vegetation, may be seen in inaccessible situations the openings of many such caverns.

The great mass of the breccia is composed of the fragments of limestone, which have been thrown down or fallen to the base of the rock; the next in quantity is composed of the marine sandstone. It is to be observed, that where these beds are not in a position to receive the water from the limestone rock, they have not been converted into breccia. This is the case with the extensive beds of sand on the west side; the water which falls upon them does not pass over the rock, and they are still unconsolidated.

Landslips.—At the base of the southern eminence we have proofs of an extensive landslip; the rock which has given way is limestone breccia; the sides of the ravines are water-worn, showing change of level since it took place. At the base of the North Front there has been another landslip, also previous to the present sea-level, as the mass of rock which has fallen down has been hollowed out all round by the action of the sea.

The inland cliffs and terraces at the southern extremity, as well as the littoral caverns, which are numerous, and occur at every elevation from the present shore to near the summit, are evidently the result of the long-continued action of the sea.

In conclusion, I have to observe that these disturbances, of which we have such clear proofs, form but a portion of those to which the rock has been subjected; they give us in chronological order the geological history of the elevated part, but throw no light on the relative antiquity of those disturbances which have lifted up the beds at its western base to a vertical position, or elevated those at the south with an inclination opposite to that of those at the north, or caused the great escarpment of the western slope of the mountain.

With regard to the period in which the upheavals attended with rupture and dislocation of the strata took place, we have scarcely any evidence; those shells which were deposited before they ceased have the appearance of being recent, but the number of species is too few in the beds deposited before the last of these disturbances to afford any certain inferences as to their age. On the other hand, we have ample evidence to prove, that, since the testaceous fauna was the same as at present, many movements both of elevation and depression must have taken place.

Description of some Fossil Fruits from the Chalk Formation of the South-east of England. By Gideon Algernon Mantell, LL.D., F.R.S. &c.

[Read January 18, 1843.]

Plate II.

The small number of plants hitherto discovered in the Chalk formation of England renders any addition to the Cretaceous flora important; I am therefore induced to lay before the Society descriptions and figures of three fruits from the Chalk and Lower greensand of Kent and Sussex, that an authentic record may be preserved of these unique and interesting relics.

1. Zamia Sussexiensis, Mantell. Plate II. fig. 1.
From the lower greensand at Selmeston, Sussex.

More than twenty years since I discovered a deposit of calcareous wood in the strata of greensand near Willingdon, a village about three miles to the north-west of Eastbourn, in the county of Sussex: a similar accumulation of fossil wood occurs in a sand-bank in the adjacent parish of Selmeston, at the junction of the lower greensand with the gault, and is described in my 'Fossils of the South Downs' (p. 76). The specimens collected from these localities consist of waterworn fragments of stems and branches, which are generally more or less perforated by boring mollusca.

The structure of the wood is decidedly coniferous; transverse sections present concentric circles and medullary rays, and a reticulated surface composed of distinct cellules, varying in form from the circular to the elliptical. In a longitudinal division the tubes or woody fibres are seen to be uniform, and to have their walls studded with nearly circular discs or areolæ disposed in double rows, the discs being irregularly alternate, as in the recent *Araucaria*. In a few examples spiral vessels are discernible. The cone here delineated (fig. 1) was found among the wood at Selmeston about two years since, and is the only known specimen. It is five and a half inches long, and at the greatest circumference measures six inches. M. Adolphe Brongniart, to whom I transmitted a model and description of this fossil, observes, "Le modèle en plâtre du cone que vous m'avez envoyé est assez difficile à juger sans avoir vu l'échantillon lui-même, et par conséquent mon opinion ne peut être que fort hasardé, mais je serai plutôt porté à penser que c'est une jeune tige de Cycadée qu'un fruit de conifère. Ce pourrait aussi être *un fruit de Zamia*; mais l'examen de l'échantillon en nature, et surtout sa coupe transversale, serait nécessaire pour avoir une opinion positive."

But although at first sight this fossil, as M. Brongniart remarks, might be taken for the stem of a young cycadeous plant, the situation and small size of the stalk at the base (fig. 1. *a*), and the appearance of the scales seem to warrant the conclusion that it is the fruit of a *Zamia*. This opinion is supported by its analogy to the beautiful cone from Kent, figured in the 'Fossil Flora of Great Britain' as *Zamia macrocephala* (Foss. Flor. plate 125). From this specimen the Sussex fossil differs, however, in its form, and in the number, size and shape of its scales, which are more numerous, smaller and more oblong than those of *Z. macrocephala*. The specimen has fallen into the possession of another, or I should have made a transverse section of it, as suggested by M. Adolphe Brongniart.

2. Abies Benstedi, Mantell. Plate II. fig. 2. *a*, *b*, *c*.
From the lower greensand near Maidstone, Kent.

This beautiful cone was found by Mr. W. H. Bensted in the quarry of Kentish rag near Maidstone, in which the remains of the Iguanodon were discovered in 1834. In my late communication on *molluskite*, or the carbonized remains of the soft parts of mollusca, a bed of drift wood is described, which occurs in the quarry above-mentioned, associated with marine shells. It was in this deposit that the fossil cone was found, a collocation which throws some light on its nature and origin. The vegetable remains from Mr. Bensted's quarry are referable to the *acotyledonous*, *monocotyledonous*, and *dicotyledonous* classes. They consist of *Fucus Targionii* and some indeterminable species of the same genus; of stems, and apparently traces of the foliage, of endogenous trees allied to the *Dracæna**, and of trunks and branches of Coniferæ. The wood occurs both in a calcareous and siliceous state. I have a portion of a small stem eight inches long, which is converted into black flint

* *Dracæna Benstedi* of Mr. König; the specimens are now in the British Museum.

to the extent of six or seven inches, while the remainder is a friable carbonate of lime: the general aspect of this specimen, and the indications of eight irregular branches, prove at once its exogenous character. Transverse sections of the silicified part exhibit a small central pith, faint concentric circles, medullary rays, and a reticulated surface of very fine, unequal, elongated cellules, resembling the wood figured by Mr. Witham, fig. 3. pl. 5. (Foss. Vegetables, Edinburgh, 1831). Longitudinal slices viewed with a high power display on the walls of the tubes single rows of very minute discs or areolæ: the coniferous nature of the specimens is thus placed beyond all doubt. The cone found associated with this wood is in every respect such a fruit as a tree with the structure above described might be expected to produce. It bears a close resemblance to a fossil from the greensand of Dorsetshire discovered by Dr. Buckland, and figured in the 'Fossil Flora of Great Britain' under the name of *Abies oblonga* (Fossil Flora, p. 137). In its general form, and in the shape of the scales and seeds, the Maidstone specimen is decidedly distinct. Unfortunately the outer surface is so much worn that the external figure of the scales cannot be accurately defined, but the sections show their proportionate thickness, and as *Abies* is distinguished from *Pinus* by the thinness of the ends of the scales, the affinity of the fossil is clearly pointed out. There is an opening at the base of the cone occasioned by the removal of the stalk (see Pl. II. fig. 2.), and an accidental oblique fracture exhibits the internal structure. In the longitudinal section thus exposed (fig. 2. *a*) the scales are seen to be rounded and broad at their base, and to rise gradually and become thin at their outer terminations. The seeds are oblong, and one seed is imbedded within the base of each scale; in some instances there appear to be the remains of the embryo (Pl. II. fig. 2. *b*). Mr. Morris, upon inspecting this specimen, remarked, "that it has a great affinity to *Abies oblonga* of Lindley and Hutton, but is more spherical, and the scales are smaller, more regular and numerous." As the fracture is oblique the central axis is not displayed, but it appears to have been thicker than in *A. oblonga* (see fig. 2. *d*). There are about twenty-three seeds observable in the sections.

The cones above-described are entirely different from those figured by Dr. Fitton in his memoir on the strata below the chalk (Geological Transactions, 2nd Series, vol. iv. pl. 22).

3. CARPOLITHES SMITHIÆ*, Mantell. Plate II. fig. 3. *a*, *b*, *c*, *d*.
From the white chalk of Kent.

Among the fossils discovered in the Sussex chalk before the publication of my 'Illustrations of the Geology of Sussex,' was a specimen of so equivocal a nature as to render it doubtful whether it belonged to the animal or vegetable kingdom. The late Mr. Parkinson, to whom I showed this fossil, after much hesitation pro-

* The specific name is in honour of Mrs. Smith of Tunbridge Wells, whose choice collection of chalk fossils is well known.

nounced it to be a compressed fruit, and the following notice was accordingly inserted in the work above-named: "A fruit has lately been found in the lower chalk near Lewes; it is of a reddish brown colour, and of a flattened ovate form; about two inches in length and an inch and a half in breadth. The surface exhibits a fibrous appearance, and the surrounding chalk is tinged with a bituminous stain."

A short time since I detected in the cabinet of Mrs. Smith the only other specimen I have seen. A slight inspection was sufficient to determine its vegetable origin, for several seeds were imbedded in its substance, and others had been detached in clearing it from the chalk. I am indebted to Dr. Robert Brown for the careful examination of this fossil, and he informed me that he knew of no fruit to which it bore any near affinity, but suggested that the original was probably a succulent compound berry, the seeds appearing to have been imbedded in a pulpy substance, like the fruit of the mulberry, which is a spurious compound berry, formed by a partial union of the enlarged and fleshy calyces, each enclosing a dry membranous pericarp.

I despair of arriving at more satisfactory conclusions as to the nature of the original until other examples of this curious fossil shall be discovered, and have therefore placed it in the provisional genus *Carpolithes*.

The specimen and the detached seeds have been drawn by M. Dinkel with scrupulous fidelity, and these delineations will convey a more correct idea of the originals than any detailed description.

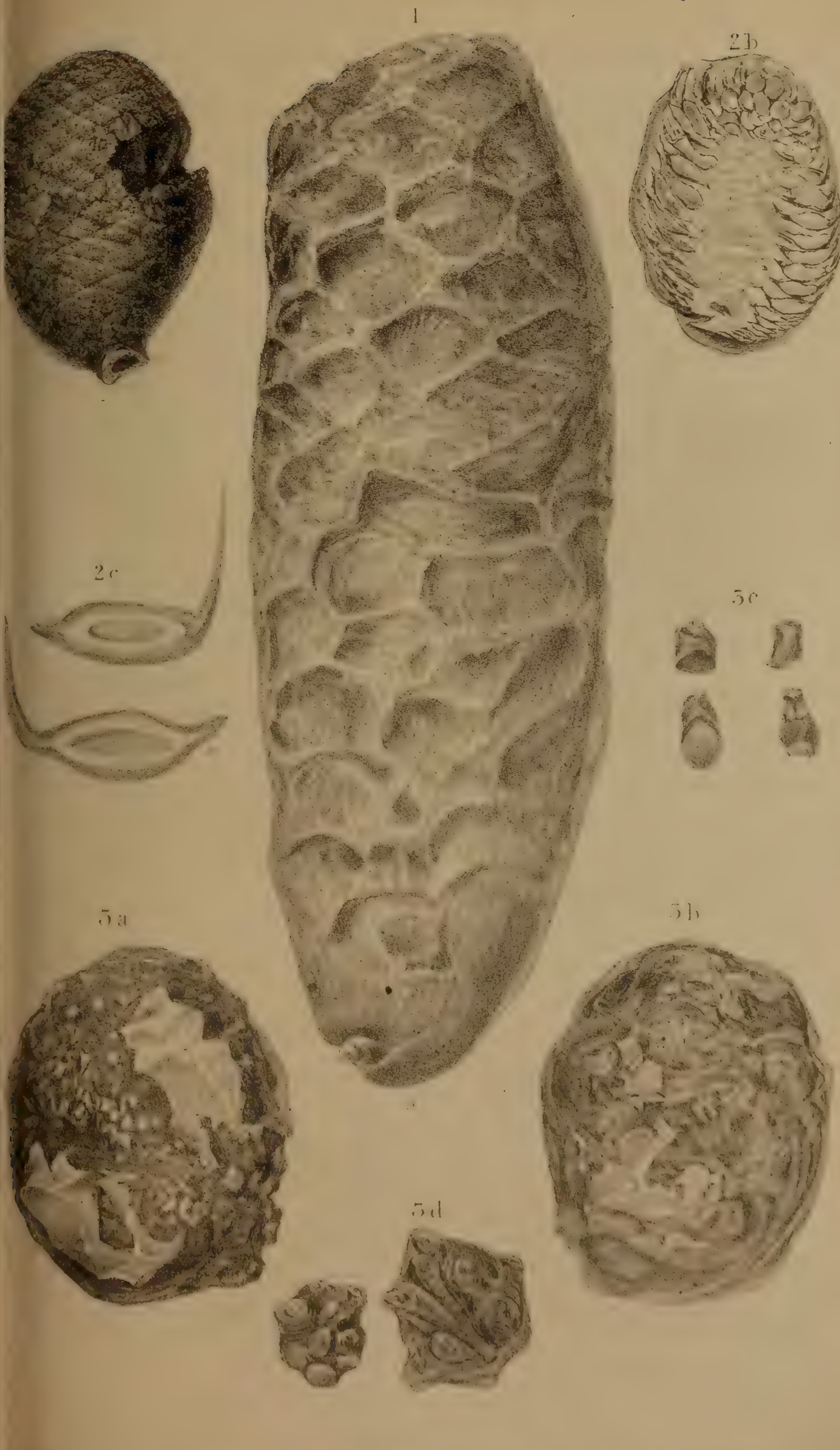
I will conclude this brief communication with the remark, that the occurrence of the fruit and foliage of coniferous plants in the Wealden, and the collocation of the cones and wood above-described with numerous remains of the reptiles peculiar to that formation, indicate that these terrestrial vegetables were also drifted into the chalk ocean from the country of the Iguanodon.

DESCRIPTION OF THE PLATE.

Fig. 1. *Zamia Sussexiensis*, n. sp. from the lower greensand, Selmeston, Sussex.
a. The remains of the stalk.

Fig. 2. *Abies Benstedi*, n. sp. from the lower greensand, Maidstone, Kent.
2 *a*. External surface of the cone: the hole at the base is occasioned by the removal of the stalk.
2 *b*. Longitudinal section, showing the seeds imbedded in the bases of the scales.
2 *c*. Enlarged views of sections of two scales, each containing a seed.

Fig. 3. *Carpolithes Smithiæ*, n. sp. from the white chalk, Kent. In the cabinet of Mrs. Smith of Tunbridge Wells.
3 *a*, 3 *b*. Views of the external surface in two different aspects.
3 *c*. Four detached seeds.
3 *d*. Portions of the pericarp detached, with several seeds imbedded.



Aldous Lith.

FOSSIL FRUITS, FROM THE
Cretaceous Formation

A Stratigraphical Account of the Section from Atherfield *to* Rocken-end *in the* Isle of Wight. By Wm. H. Fitton, M.D., F.R.S. &c.*

[Read January 22, 1845.]

The south coast of the Isle of Wight, it is well known, exhibits the whole series of deposits from the chalk down to the Wealden; the section, especially of the lower greensand near Atherfield, being of greater thickness than any other in England, while it is continuously exposed and accessible in all its parts. The object of the present communication is to describe this remarkable section anew; the author stating, that from the time and labour recently employed in extending his collection of the fossils, he believes it to be the most complete that has yet been brought together. The description is illustrated by a sectional drawing, and by a tabular list of the strata and of the fossils, so arranged that the succession of the beds and stratigraphical place or places of every species may be seen at one view. Such a document being a picture of nature, and representing only what has been actually observed, suggests of itself various general views respecting the order and distribution of the fossils, and may be employed as a test of the soundness of speculations connected with them; and it is shown that some of the opinions expressed in former numbers of this Journal derive support from the more extensive series of facts thus displayed.

The fossils here enumerated contain a very large number of those considered as characteristic of the corresponding groups on the continent of Europe, to which, in Switzerland and France, the name of 'Neocomian' has been applied; but with these are several species not hitherto found except in England. Among the former some of the most remarkable (as *Perna Mulleti*, &c. &c.) abound, especially in the very lowest beds of the lower greensand, but are there accompanied by several others, among which the genera *Thetis* and *Gervillia* may be mentioned, which range to a great height in this deposit. In mineral composition, the abundance of small-grained oolitic iron ore throughout a large space in the section furnishes a point of correspondence with the equivalent groups of the continent, which had not previously been noticed. And among the vegetable remains Mr. Morris has discovered *Lonchopteris Mantelli*, hitherto confined to the Wealden strata, in so many beds, that the general diffusion here of that fossil species is not improbable.

To the account of the section at Atherfield is subjoined a comparison with the three other sections of the same groups visible in the Isle of Wight,—at Compton, near Shanklin, and in Sandown Bay: and it is stated that the lowest beds in all those places contain many of the same remarkable fossils, *Perna Mulleti* especially having been thus obtained in great perfection.

Finally, a brief account is given of the corresponding portions of

* Ordered for publication, *in extenso*, in the Transactions of the Geological Society.

the subcretaceous series near Vassy, on the south-east of Paris, and near Auxerre; where the general relations of the series and many of the fossils agree with those of England: and some reasons are mentioned for supposing that traces even of the Wealden group may be found to exist in France, between the lower greensand and the Portland strata, which there appear in a very distinct form.

DONATIONS

TO THE

GEOLOGICAL SOCIETY

DURING THE YEAR 1845*.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

AGRICULTURAL Society of England, Journal. Vol. v. part 2, and vol. vi. part 1.

American Philosophical Society, Proceedings. Vol. iv. nos. 30, 31.

———, A Public Discourse in commemoration of P. S. du Ponceau, LL.D.

——— Journal of Science. Vol. xlviii. nos. 1 and 2, and vol. xlix. nos. 1 and 2.

——— Quarterly Journal. Vol. i. no. 1.

Arts, Society of, Transactions. Vol. lv.

———, Premiums for the Sessions 1845–46 and 1846–47.

Asiatic Society of Great Britain and Ireland, Journal. No. 16, part 1.

Athenæum Journal for the year 1845.

Berlin Academy, Abhandlungen, for 1843.

——— Bericht, July to December 1844, and January to June 1845.

* It is intended that this list shall be continued quarterly. The Donations, since the list published in Vol. vi. Part II. of the Society's Transactions, up to the end of the year 1844 will be given with the Title, Index, &c. of the fourth volume of the Proceedings.

Boston Journal of Natural History. Vol. iv. no. 4, and vol. v. no. 1.

British Association, Report of the Fourteenth Meeting (at York) in September 1844.

Chemical Society, Memoirs and Proceedings. Parts 10, 11, 12, 13, 14 and 15.

Cornwall Geological Society, Thirty-first Annual Report, 1844.

Cornwall Polytechnic Society, Tenth, Eleventh and Twelfth Annual Reports.

Dublin Geological Society, Annual Address, 1845.

Edinburgh, Royal Society of, Transactions. Vol. xvi. part 1, and vol. xvii. part 1.

———, Proceedings. Vol. ii. nos. 25 and 26.

France, Geological Society of, Memoirs. Vol. iii. part 1.

———, Bulletin. 2nd Ser. vol. ii. sheets 1–36 and 39–55.

Geneva Natural History Society, Memoirs. Vol. x. part 2.

Geographical Society, Journal. Vol. xiii. part 2; vol. xiv. part 2; vol. xv. parts 1 and 2.

Royal Irish Academy, Transactions. Vol. xx.

Linnean Society, Transactions. Vol. xix. part 4.

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———, List for 1845.

Modena Society, Memoirs. Part *Fisica*, vol. xxiii.

Munich Academy, Abhandlungen. Vol. iv. part 1.

———, Bulletin. Nos. 56 to 64, 1843, and nos. 1 to 50, 1844.

———, Almanach for 1844.

New York Dissector, a Quarterly Journal of Medicine. Vol. ii. no. 3.

Northumberland Natural History Society, Annual Reports for 1842, 1843, 1844 and 1845.

Paris Academy of Sciences, Comptes Rendus. Vol. xix. nos. 1 to 29, and vol. xx. nos. 1 to 26.

———, Archives du Muséum. Vol. iv. parts 1 and 2.

Philadelphia Academy of Natural Sciences, Proceedings. Vol. ii. no. 7.

Philosophical Magazine for the year. *From R. Taylor, Esq., F.G.S.*

Royal Society, Philosophical Transactions. Part 2 for the year 1844, and part 1 for 1845.

Scarborough Philosophical Society. Fifteenth Annual Report, 1845.

Tasmanian Journal. Vol. ii. no. 8. *From Sir J. Franklin, K.C.H., F.G.S.*

Washington National Institute, Proceedings. Third Bulletin.

Zoological Society, Proceedings. Nos. 131 to 147.

———, Reports of the Council and Auditors, 1845.

II. GEOLOGICAL BOOKS AND MEMOIRS.

The works of which the Author's name is printed in italics were presented by the respective Authors.

Accum, Frederick. Elements of Crystallography. *From A. F. Mackintosh, Esq., F.G.S.*

Ansted, D. T. The Geologist's Text-book.

———. Geology as a Branch of Education.

Brodie, Rev. P. B. A History of the Fossil Insects in the Secondary Rocks of England.

Buch, Leopold von. Uber Cystideen, eingeleitet durch die Entwicklung der Eigenthümlichkeiten von Caryocrinus ornatus, Say.

Buckman, James, and *H. E. Strickland.* A new edition of Mr. Murchison's Outline of the Geology of the neighbourhood of Cheltenham.

Glaciers and Icebergs in Scotland in Ancient times. *From the author.*

Catullo, T. A. Memoria sulle Caverne delle Province Venete.

Dana, J. D. Origin of the Constituent and Adventitious Minerals of Trap and the allied rocks.

——— Notice of Dr. Blum's Treatise on Pseudomorphous Minerals.

Dufrénoy, P. A., and Elie de Beaumont. Mémoires pour servir à une Déscription Géologique de la France.

Emmons, E. The Taconic System.

Explanations: A sequel to "Vestiges of the Natural History of Creation." *From the author of that work.*

Fox, R. Were. On certain Pseudomorphous Crystals of Quartz.

Gervais, Paul. Remarques sur les Oiseaux Fossiles.

Gibbes, R. W., M.D. Description of the Teeth of a new Fossil Animal found in the Greensand of South Carolina.

Hall, James. Geology of New York. Part 4.

Hausmann, J. F. L. Geologische Bemerkungen über die Gegend von Baden bei Rastadt.

— ——— Handbuch der Mineralogie. 2 parts.

Helmersen, G. von. Ueber die geognostischen Beschaffenheit des Ust-urt und insbesondere dessen östlichen Abfalles zum Aral-See.

Jackson, C. T., M.D. Final Report on the Geology and Mineralogy of the State of New Hampshire.

King, William. On the Genus Sigillaria.

Koninck, L. de. Déscription des Animaux Fossiles des Terrains Anthraxifères de la Belgique.

Lyell, Charles. Travels in North America; with Geological Observations on the United States. 2 vols.

Mantell, G. A., LL.D. On the Geological Structure of the County seen from Leith hill in the County of Surrey.

Müller, Joh. Ueber den Bau und die Grenzen der Ganoïden, und über das natürliche system der Fische.

Murchison, R. I., E. De Verneuil, and Count A. von Keyserling. The Geology of Russia in Europe and the Ural Mountains. From R. I. Murchison, Esq., V.P.G.S.

Nicol, James. On the Geology of Peebleshire.

Nyst, P. H. Déscription des Coquilles et des Polypiers Fossiles des Terrains Tertiaires de la Belgique. Liv. 1, 2 et 3.

Parkinson, James. An Introduction to the Study of Fossil Organic Remains. *From A. F. Mackintosh, Esq., F.G.S.*

Pictet, F. J. Traité Élémentaire de Paléontologie, ou Histoire Naturelle des Animaux Fossiles. Tomes 1, 2 et 3.

Pilla, Leopold. Sopra la Produzione delle Fiamme né Vulcani e sopra le consequenze che se ne possono tirare.

——— Application de la Théorie des Cratères de Soulèvement au Volcan de Rocca Monfina dans la Campanie.

——— E dissertatione Nicolai Stenonis.

——— Ricerche intorno alla vera posizione geologica del Terreno del Macigno.

Raulin, Victor. Géologie de la France.

——— Notice explicatoire de la Carte Géognostique du Plateau Tertiaire Parisien.

——— Réponses aux Objections faites par M. Pisses à la Notice sur la Disposition des Terrains Tertiaires des plaines de l'Altier et de la Loire.

Scacchi, A. Osservazioni Critiche sulla Maniera come fu Seppellita l'Antica Pompei.

——— Notizie Geologiche dei Vulcani della Campania estratte delle Lezioni di Geologia.

Taylor, R. C. Reports on the Washington Silver Mine in Davidson County, N. Carolina, U. S.

Tchihatcheff, P. de. Rapport sur un Mémoire de M. P. de Tchihatcheff, relatif à la Constitution Géologique de l'Altai.

Thomson, Thomas. Outlines of Mineralogy, Geology and Mineral Analysis. 2 vols. *From A. F. Mackintosh, Esq., F.G.S.*

Virlet d'Aoust. Notes sur quelques phénomènes de déplacements moléculaires qui se sont opérés dans les roches postérieurement à leur dépôt.

——— Mémoire sur les Filons en général.

Waltershausen, Baron von. Atlas de l'Etna.

III. MISCELLANEOUS BOOKS, &c.

Agassiz, Prof. L. Nomenclator Zoologicus. Fas. 7 and 8.

Calderini, C. J. La Nuova Illuminazione a Gas in Milano.

Observations made at the Magnetical and Meteorological Observatory at Toronto in Canada. Vol. i. 1840, 1841 and 1842. *From Lieut.-Col. Sabine, by direction of the British Government.*

College of Surgeons, Royal. Descriptive and Illustrated Catalogue of the Fossil Organic Remains of Mammalia and Aves contained in the Museum.

Daubeny, Charles, M.D. On the Rotation of Crops.

Gregory, William, M.D. Outlines of Chemistry, for the use of Students. Parts 1 and 2.

Herschel, Sir J. F. W. Memoir of Francis Baily, Esq.

Kerigan, Thomas. A Practical Treatise on the Eclipses of the Sun and Moon.

Law, Society for promoting the Amendment of. 2nd Annual Report. *From the Society.*

Macaire, Prof. Notice sur la Vie et les Écrits de Théodore de Saussure.

Michelin, Hardouin. Notice lue à la Société Géologique de France, à l'occasion du décès de M. Huot, l'un des membres fondateurs.

Morton, S. G., M.D. On a supposed new species of Hippopotamus.

Nattali's Annual Catalogue of Books for 1845.

Pilote Française. Instructions Nautiques—Environs de Cherbourg. *From the Dépôt Générale de la Marine.*

Redfield, W. C. On Ice in the North Atlantic.

Rees, Abraham, D.D. The Cyclopædia of Arts, Sciences and Literature, in 45 volumes. *From the late Miss E. Benett.*

Reeve, Lovell. Conchologia Iconica. Monographs of the Genera Corbula, Crassatella, Glauconome, Pectunculus, Cardium, and Mitra.

——— The Conchologist's Nomenclator.

Robson, T. C. A Treatise on Marine Surveying. *From F. W. Simms, Esq., F.G.S.*

Thibert, Felix. Catalogue of the Collection of Models of Pathological Anatomy.

Virlet d'Aoust. Notes sur la Géographie Ancienne.

Wiley and Putnam's List of New Publications, with a specimen of the United States Exploring Expedition.

IV. MAPS, CHARTS, &c.

1. *Geological Maps.*

Essai d'une Carte Géologique du Globe Terrestre, par M. A. Boué. *From the Author.*

Map of the Coal district eastward of Glasgow. *From Leonard Horner, Esq., P.G.S.*

Carte Géologique du Terrain entre le lac d'Orta et celui de Lugano, par M. Leopold de Buch. *From the Author.*

Croquis provisional de una Parte del Terreno Carbonifero de Asturias con la Indicacion de los. *From the Asturian Mining Company.*

2. *Miscellaneous Maps and Charts.*

The Charts published by the Admiralty during the year 1844. *Presented by Capt. Beaufort, R N., by direction of the Lords Commissioners of the Admiralty.*

The Ordnance Maps of the County of Cork (the Six-inch Survey), in 155 sheets. *Presented by Col. Colby, R.E., by Direction of the Lord Lieutenant of Ireland.*

Asia Minor. Three Maps.
Cape of Good Hope. One Map.
Australia. Three Maps.
} *From H. Warburton, Esq., M.P., F.G.S.*

3. *Geological Illustrations.*

Lithographic Drawing of a Fossil Jaw. *From W. K. Bridgeman, Esq.*

Lithographic Drawing of a gigantic Ruminant. *From Mr. Bettington.*

Lithographic Drawing of an imprinted Slab, from the New Red Sandstone at Weston, Cheshire. *From Dr. Black, F.G.S.*

Portrait of the late Francis Baily, Esq., P. Ast. Soc. *From the Rev. Richard Sheepshanks, M.A., F.G.S.*

Medallion of Mr. J. De Carle Sowerby. *From Mr. J. De Carle Sowerby.*

V. SPECIMENS.

Tertiary Fossils from the Azores. *From T. Carew Hunt, Esq.*

Bones from the Eocene strata of Hordle and Barton. *From R. Falconer, F.G.S.*

Chalk with Fossils, from Trimmingham, Norfolk. *From Miss Gurney.*

Spongeous Flint from the Chalk. *From Mr. Henry Ball.*

Specimens of *Beryx radians*, from the Chalk, Maidstone. *From E. H. Bunbury, Esq., F.G.S.*

Fossils from the Kentish rag, Maidstone. *From Mr. W. H. Bensted.*

Specimens of the *Unio Valdensis*, from the Wealden of the Isle of Wight. *From Dr. Mantell, F.G.S.*

Slab of Paludinæ from the Weald at Pluckley, and specimens of Foraminifera from the Chalk of Charing in Kent. *From Wm. Harris, Esq., F.G.S.*

Fossils from the Great Oolite, Kate's Cabin, in Peterborough. *From H. M. Lee, Esq., F.G.S.*

Three species of Terebratula. *From Baron Leopold von Buch, For.M.G.S.*

Gigantic Head of Ichthyosaurus, the remaining portion of a specimen already in the possession of the Society. *From H. Warburton, Esq., M.P., the Earl of Enniskillen, R. I. Murchison, Esq., Sir Philip Egerton, Bart., M.P., Charles Stokes, Esq., and W. J. Broderip, Esq.*

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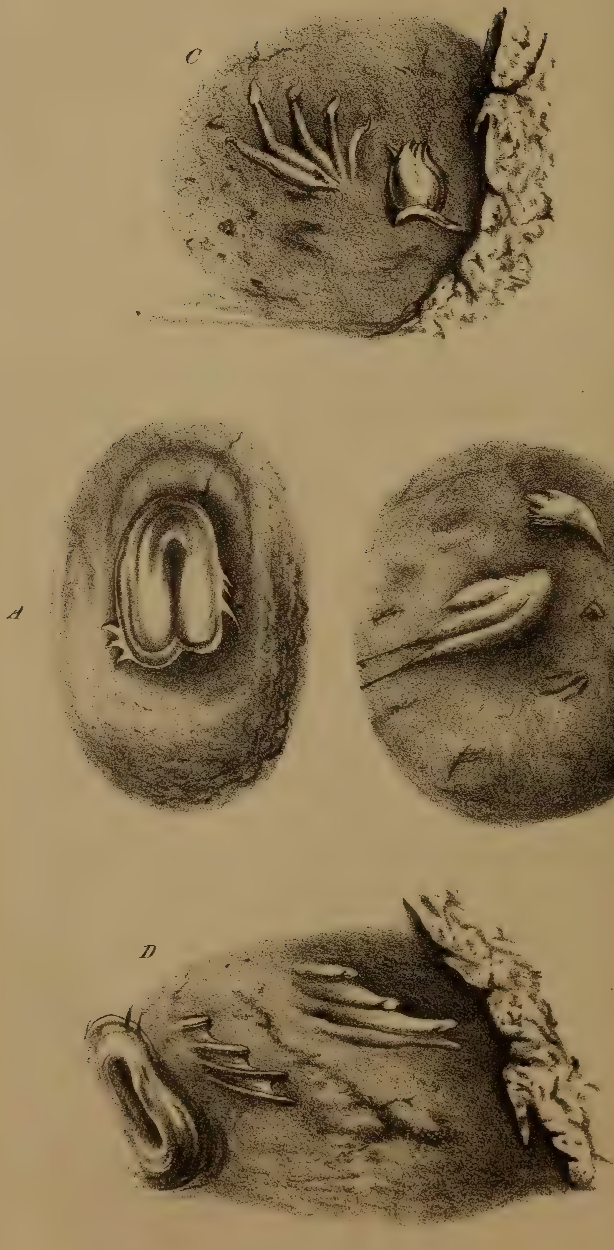

Reeve, imp:

Footmarks in New Red Sandstone.

(Dr. Black.)

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 5, 1845.

The following communications were read:—

1. *Observations on a Slab of New Red Sandstone from the Quarries at* Weston, *near* Runcorn, Cheshire, *containing the* Impressions *of* Footsteps *and other markings.* By J. Black, Esq., M.D., F.G.S.

Plate V.

The notices of fossil impressions of footsteps in the New red sandstone are now sufficiently numerous, as well in Warwickshire and Shropshire as in Cheshire, to take away the interest of novelty from any discovery of this nature; yet I consider the slab about to be described sufficiently new to justify my laying the following account of it before the Geological Society.

The summit of the quarry of New red sandstone whence this specimen was extracted by Mr. Feraday Smith is about 100 feet above the level of the Mersey at Weston. The rock is here worked perpendicularly to about fifty feet from the top, and the seams which contain the impressions are two in number and are nearly three feet apart, the higher being twenty-four feet from the top. Both these seams consist of from half to three-quarters of an inch of reddish silty clay, upon which when soft the impressions have been made, and the lower series has larger and better-defined marks than the other. The beds dip to the south-west at an angle of about 10°, and are of a red colour and coarse grain.

The slab in question is seven feet long by three and a half feet broad. It contains none of the footprints of the so-called *Chirotherium* (*Labyrinthodon*, Owen), but is full of those of smaller reptiles, apparently both Emydian and Batrachian, besides others which may have been made by birds. It is remarkable for the singular complication of cracks it presents, these forming a net-work more elaborate than I have noticed in other specimens*. It will readily be seen from an examination of the slab that the cracks took place after the footmarks had been impressed on the marly silt, which must first of all have been slowly and quietly deposited on the firm sand beneath.

It would also appear from this slab, that after the deposition of this thin coherent bed, which would not originally have exceeded an inch in thickness, the waters must have retired for a time without reflux, and that during this time many kinds of animals, terrestrial as well as amphibious, walked over the surface, while a continued process of drying was contracting the whole surface and thus forming a net-work of cracks over it. After this process had gone on until the drying was complete, another deposit of arenaceous sediment took place, filling up the cracks and depressions of the surface and forming one homogeneous mass of sandstone.

On carefully examining the reversed impressions seen in relief on the slab, we may recognise at least four separate and well-defined kinds, besides several others which either from their minuteness or indistinctness are not easily characterized. There are also two sweeping mouldings of slight elevation that traverse the face of the specimens in oblique directions. Owing to the cracks that have taken place, the marks are often divided and sometimes are shifted laterally. This is also the case with the lateral moulding.

Of the larger footprints, there are about twenty running principally in one direction. They are disposed in parallel rows, with a distance of nine inches from the tip of one toe to that of the other in each row, while each print in the one row is placed opposite the middle point between the two others in the corresponding row. The impressions, or rather the moulds, rise above the plane of the slab for about three-eighths of an inch. The length of each footmark is two inches, and the breadth an inch and a half. The highest point in the mould (the deepest impression therefore) seems to correspond with the heel, which in several cases appears to have penetrated through the soft clayey mass to the hard sand. On each side of several of the footprints there are impressions of short toes or claws, while round the front of each there is a semicircular and shallow groove or waved hollow, such as might be occasioned by the soft mud being pressed forwards and raised by the weight of the foot.

The larger impressions (Pl. V. fig. A.) seem to be intimately connected with the two moulded tracks that sweep over the face of the slab, for these tracks run parallel and midway between the two rows of footmarks, and were evidently formed before the clay had dried.

* The slab from Hessberg, figured in Dr. Buckland's Bridgewater Treatise, offers the nearest resemblance in this respect, but is not so completely covered with the reticulations.

Of the two tracks also, one was formed before the other, since one of the footmarks in the longer track has obliterated part of the track of the other, while the longer track is seen to have intersected and to be deeper than the other.

Similar tracks seen in relief have been attributed to the tails of animals dragging over the surface of soft silt or clay, and in the present case this explanation seems satisfactory.

As to the nature and form of the animals which have left these footprints, we can perceive that they had a strong resemblance to recent Emydians in their mode of progression and in the form of the foot; and from the fulness of the relief observed, the animal must have been of considerable weight in comparison with the length of the foot. From the perfect definition of the tracks which appear to have been caused by the tail, this organ would seem to have been rather firm and short, and not long and pliant.

The second class of well-defined impressions are marked (B) in the accompanying plate. They consist of eight pairs running across the breadth of the slab without interruption; and there are also some others whose connection cannot so easily be traced. The pairs of these impressions, seemingly those of the fore and hind feet, run in an alternate and oblique direction with respect to each of the other pairs: only three toes can be readily made out in them, and they belong to the larger and most probably the hinder feet. In some places it appears that these hinder feet were not raised freely from the ground at every step, for there are slight mouldings running from the extremities of the longest toe as if it had been dragged over the soft surface. These footsteps seem to have belonged to some small species of land tortoise, and they exhibit neither the impressions of a web nor of claws.

The third class (C) exhibits six larger impressions, each accompanied by a smaller and more obscure one, and they run in one direction across the end of the slab. There are also some others of the same kind detached on other parts of the surface. These prints, like the former set, are alternate and placed diagonally towards each other. On a first inspection the larger of them resemble the impressions of the feet of some birds, the toes being free and each terminated by the well-marked impression of a claw; but the number of toes is five, placed in a radiating manner, and each print is accompanied by a smaller and fainter impression. The larger of these prints therefore appear to have belonged to the hind feet, and the smaller to the fore feet of an animal, which probably resembled the smaller Lacertians or Alligators.

The next set of impressions (D) are not so numerous as the others, or at least the progressive connection is less easily made out. A few of them however are sufficiently clear to enable us to refer them to a species of reptile different from those already noticed. Each impression exhibits four toes more or less approximated to each other, and showing indistinct marks of claws. Between the toes there may be detected traces of a web in some of the prints. This web reaches nearly to the tips, and where the toes are much closed the web seems to have been folded in between them. These prints may be attributed to some Batrachian animal, or possibly to the *Rhynchosaurus* of Prof. Owen, and they resemble the set figured by Sir R. Murchison and Mr. Strickland in the Geological Transactions*. These latter were however from the new red sandstone of Shrewley Common, Warwickshire, and exhibited a tail impression referred to the animal of the footprints.

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2. *On the circumstances and phænomena presented by the* GRANITE *of* LUNDY ISLAND, *and of* HESTERCOMBE *in the* QUANTOCK HILLS, *compared with those which characterise the Granites of Devon and Cornwall.* By the Rev. D. WILLIAMS, F.G.S.

THE author commenced by referring to two former papers read before the Society†, in which he pointed out the condition of mountain limestone and new red sandstone at their contact with trap-rocks, and expressed his opinion that the trap was itself in great measure or entirely an altered condition of the rock which it seems to penetrate. He now states that he has found very numerous instances of similar reciprocal effects or mutual metamorphism in Devonshire and Cornwall, whenever the sedimentary strata are intersected by dykes of igneous rock, or contain it in an imbedded form, but that very different effects are observable when these strata have been invaded by so-called granite veins or vein-like processes. He proposes therefore to select two instances in confirmation of the evidence formerly adduced, and he wishes these two to be taken merely as examples. He considers the hypothesis of injection insufficient to account for the phænomena presented by the amygdaloidal traps and their association with the new red sandstone in the quarries about Exeter, Crediton and Tiverton.

The granite or syenite of Hestercombe in the Quantocks was first described, many years ago, by Mr. L. Horner‡. It is a true dyke extending at first for about a quarter of a mile in a direction north-east by east and south-west by west, cutting the slate-rocks obliquely. It may then be traced by the rubbly tillage land above in a direction due west, as far as a little glen and rivulet about a furlong and a half distant, where it occurs at the northern extremity of an old and extensively worked slate-quarry, its hard refractory nature having stopped the excavation in that direction. It there dips S.S.W. at an angle of about 40°. At the eastward quarry, where it is vertical, the slate, which abuts immediately against it, is thickly traversed by small veins of quartz, mica and oxide of iron, which give it a brecciated aspect, and the adjacent slate is highly indurated, yielding a stone useful for making hones. In this case the slate is altered to a distance of about a foot from the dyke, and the

* 2nd Ser. vol. v. pl. 28.
† *Vide* Quart. Geol. Journ. vol. i. p. 47 and p. 148.
‡ Geol. Trans., 1st Series, vol. iii. p. 338.

syenite in contact with it is softer, more schistose and finer-grained, containing also more hornblende than towards the centre. The soft and rotten condition of the granitic rock has no doubt obtained for it the name of *pottle-stone* by which it is locally known, since it was formerly wrought for pipkins and other culinary vessels.

As a granite the harder stone is durable, and capable of being rendered ornamental. It may be seen in the pillars of the west gateway and in the basement story of the mansion at Hestercombe.

The slate is very variably affected by this dyke, and the syenite itself is also sometimes more and sometimes less modified, but it is rare to find a specimen in which the two rocks are united together.

The granite of Lundy Island abuts directly against the slate as a vertical lofty wall; there are no granitic veins penetrating the slates, and there is little alteration produced in them, except a slight induration at the place of contact; while on the other hand the granite is greatly altered at the contact, and that to a distance of ten or twelve feet, gradually changing from a well-defined gray syenite through several varieties of hornblende rock to the condition of a black hornblendic trap of a somewhat schistose structure. It has not however been gradually metamorphosed, or at least there are appearances more perfectly syenitic on each side of the hornblende rock.

The granite of Lundy Island occupies a dyke or chasm having a north-east and south-west direction. It extends about three miles in length, and has a breadth of half a mile. The vertical wall which it presents ranges from the Sugar-Loaf on the east to the Rattles on the south of the island.

The author mentions another example of a true granitic dyke near Drewsteignton, on the north-east of Dartmoor. This dyke is about ten or twelve feet wide, and cuts the carbonaceous rocks transversely for about a mile in a north and south direction.

The author then referring to the domes and other masses of granite in Devonshire and Cornwall, and the numerous small veins which proceed from them, contrasts the condition both of the injected and the bounding rock in the case of these veins with that presented by the dykes just alluded to. In the former case, where the veins proceed directly from the central mass, the bounding rock is greatly metamorphosed, while the granite is little changed; in the latter, on the contrary (the dykes), it has been stated that the igneous rock is much altered and the slates simply indurated within a short distance of contact. He considers therefore that the circumstances and conditions could not have been the same in these two cases.

If (as appears to have been the case) we imagine that the granites of Lundy Island and of Hestercombe were fluid when the dykes were formed, the author considers it difficult to explain why the fluid matter did not penetrate and alter the adjacent rocks as the veins of granite have done elsewhere, unless the circumstances and conditions of the case were different.

It appears to be the opinion of the author, that the heat of the melted rock in the dykes was insufficient to produce these effects of metamorphism, and that in the other instances a great body of igneous rock was close at hand, affording a more intense heat capable of producing the modifications observed.

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3. *On the Geology of the neighbourhood of* TREMADOC, *Caernarvonshire.* By J. E. DAVIS, Esq., F.G.S.

THE little town of Tremadoc (in the northern part of Cardigan Bay) is beautifully situated on the north side of a valley formerly covered by the sea. Mr. Maddock having in the year 1813 made an embankment across the wider valley of Traeth Mawr, of which, on the western side, the Tremadoc valley was an inlet, the sea was barred out, the valley brought under cultivation, and the town erected. On approaching this district of Caernarvonshire from the east, it does not require the eye of a geologist to be assured that the sea once, and at a comparatively recent period, extended many miles inland. The succession of cliffs with steep escarpments facing the present line of coast, and extending inland up the eastern side of Traeth Mawr, one behind the other, for several miles, are striking features in the scenery of this romantic neighbourhood.

The stratified rocks of the district have a general strike from north-west to south-east, with a north-east dip. They consist of slates, shales, flags and sandstones, but, from the almost total absence of organic remains, the determination of the age of the beds must be a work of considerable difficulty and time, and is one in which great caution is requisite, for all these rocks have apparently undergone great change of structure in many places, and that which is the same formation or bed, presented under a new aspect, may be easily mistaken for a totally distinct deposit.

Although some of the rocks are described as slates, the slaty cleavage is too imperfect to admit of the rock being quarried for economic purposes, and true slates are not obtained nearer than Festiniog, several miles east of Tremadoc, a district to which these observations do not extend. The strata however, whether flagstone, sandstone or shale, possess in many places a distinct structure, consisting of an irregular prismatic cleavage observable in many places, the rock shivering into splinters of a foot or more in length, and from one to three inches in width. These splinters conform to the direction of the dip, and their points, as far as they have been observed, dip at the same angle. A good example of this structure is exposed by a cutting on the left side of the road leading from Portmadoc to Tremadoc, and within a few yards of the last house in the former place.

The only fossils I met with were a Lingula and traces of Fucoids, occurring in great abundance in flagstones near Penmorfa church, about two miles west from Tremadoc, and also on the south side of Moel-y-Gest. The Fucoids resemble the remains found in the Upper Ludlow rock of the Silurian system, but similar species have been observed near Middleton chapel on the Comden mountain in Shropshire, occurring with *Asaphus Comdensis*, which is believed to be referable to the Llandeilo flags. These fossiliferous beds lie below the other stratified deposits of the neighbourhood.

The igneous rocks of this district may be divided into two classes. The first, consisting of a porphyritic rock, is the most extensively developed, and is intimately connected with the physical aspect of the country. This porphyritic rock occurs in large masses, forming elevated and parallel ridges extending from north-west to south-east. The most southern of these ridges in this neighbourhood forms the mountain called Moel-y-Gest, the southern boundary of the Tremadoc valley, which it separates from the sea. A second more prolonged ridge extends from near Penmorfa, and, forming the north side of the valley and the ridge called Yr Alt Wen, terminates abruptly at Tremadoc. A third ridge runs north of the last, and extending still further east, terminates in the valley of Traeth Mawr. Other ridges occur to the north, and their eastern extremities overhang the road leading from Tremadoc to Beddgelert.

A columnar structure is discernible in many places, varying in form and number of angles, but always on a large scale. Wedge-shaped forms may be observed in the cliff behind the inn at Tremadoc. Two of these wedges form a cube, and where a number of these have given way and fallen from the face of the cliff, a smooth surface is presented, having the appearance of a plane of a highly inclined and nearly perpendicular stratum. Westward of this spot the columnar structure is more readily traced.

The eruption of these rocks was subsequent to the consolidation of the adjacent stratified deposits. This is clearly proved by the effect of their intrusion upon the adjoining strata, and by the position of the beds near and at the points of contact. A few yards east of the inn at Tremadoc, and some hundred feet above the road, the beds of coarse slate or flagstone are nearly vertical. In Moel-y-Gest beds of slate may be seen jammed in between two masses of basalt, and dipping at a very great angle to the east. In the ridge of Yr Alt Wen the intrusive rock appears to have been forced up between beds of sandstone; and it is singular, that while the lower beds do not appear to have been materially affected, the superincumbent mass is much altered, and assumes the splintery structure before noticed. In flagstones also, reposing on the north side of one of these ridges, near Port Treuddyn, and adjoining the road leading from Tremadoc to Beddgelert, about a mile and a half from the former place, the effects of the intrusion are discernible to the distance of many feet from the point of contact by discoloration and partial fusion.

It will be seen that the general strike of the stratified rocks corresponds with the line of irruption, and it seems to be a reasonable inference that the latter was the cause of the former. At the same time it is to be observed that this strike and north-east dip prevail to the shore of Cardigan bay, and further south than any line of igneous rock observed by me.

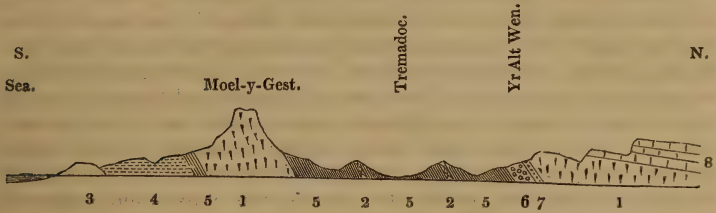
Besides these main lines, smaller outbreaks occur in the vale of Tremadoc, and may be traced in some of the little hillocks or mounds which form such striking objects in the valley, and which, previously to the erection of the embankment, were islands in the bay. Out of seven of these islets or hillocks, *three* were found to be composed of dykes of the same character, and apparently of the same age as the more elevated and extended lines forming the boundaries of the valley. In two of these three islands, Yns hir (Long Island), and Yns cerig duon (the Island of the black stone), it occurs in dykes crossing the slates. In the third, Yns cerig aethnen (Island of the shaking stone), it is stratified conformably with the overlying and underlying slates, but has evidently been forced up between the beds of rock, after the solidification of the latter. The slates on both sides are altered to a considerable distance, and the porphyritic rock contains numerous fragments of that formation. The upper beds are decomposing. The entire thickness of the intrusive rock in this place is about twenty feet.

In the other islands visited the second class of igneous rocks, comprising beds and dykes of clink-stone, occur. The traces of the igneous origin of these rocks were so striking, that it was with difficulty I could persuade myself that I was not standing on the ruins of an ancient furnace; and even when I ascertained beyond a doubt the volcanic origin of the igneous matter around me, it was a considerable time before I could bring myself to assign to these rocks the very remote origin which repeated observations at last compelled me to do. Like the porphyritic islands, the clink-stone occurs in dykes and also in conformable beds, but the analogy between the two descriptions of igneous rock ceases here. While the effects of the porphyry upon the adjacent beds are only seen upon close inspection and comparison of different portions of the latter, the effect of the clink-stone is of the most marked and striking character. Dark blue slates are turned red or black, are vitrified and calcined for the distance of several feet, and exhibit between their laminæ all the hues of the rainbow; and in the little islet near the farm-house called Pen sy flog, where the clink-stone occurs in a stratified form, there is this important distinction, viz. that while the slate upon which this rock-stone rests is affected, as in the instance of the dykes, and the stratum of slate immediately under and in contact with it is changed into a light ashy substance with white flakes (resembling the ash of inferior kinds of coal), the superincumbent strata are scarcely, if at all affected. No fragments of slate-rock were observed in the volcanic matter.

The igneous rocks of both descriptions, and in the mountain ridges as well as in the islands, are traversed by numerous veins of quartz in large crystals. In a dyke of the clink-stone, about a quarter of a mile from Tremadoc, on the left side of the Old Caernarvon road, in addition to these phænomena, I observed the edge of a bed of scoriæ jutting out on the escarpment and former sea-cliff. The volcanic cinders, sand, &c. are clearly discernible, as if the result of an irruption of yesterday. I could not observe any important deviation from the usual north-east dip of the slates, produced by the intrusion of the clink-stone. A folding over of a few feet of the slates, the result perhaps of lateral pressure, exhibited by the cuttings of a mining level at the spot last mentioned, was the effect, and the only effect of this nature which came under my observation. These irruptions of clink-stone are associated with only one and the same sedimentary rock, consisting of imperfect shivery slates, totally devoid of organic remains.

It has already been mentioned that the lower lands of the district present the appearance of having been covered by the sea at no very remote period; and repeated observations, and the evidence of the inhabitants, all tend to the inference that the land has gradually emerged from the sea, and that a movement of this kind is still in operation. The evidence also, that the higher ridges derive their present configuration from the action of water, is very striking. The curved line between one ridge and another (as seen in the

SECTION in the neighbourhood of TREMADOC.



8. Flagstone. 7. Sandstone. 6. Flags. 5. Slates. 4. Flagstones with *Lingula*, &c. 3. Quartz-rock. 2. Clinkstone. 1. Porphyry.

section) is evidently owing to the denudation of the stratified, and therefore softer rocks, which have escaped denudation only in those parts where they have been protected by the superincumbent porphyry (1), or where they have been hardened by immediate contact with it, and have thus resisted the action of the waves.

Along the sides of the porphyritic ridges, a vast talus has accumulated, the effect of the long-continued disintegrating action of rain and frost. A striking example of this talus occurs on the left of the road leading from Tremadoc to Beddgelert, columns of the porphyry of immense size being there piled one above another from a great depth, reaching two-thirds of the height of the perpendicular cliff. Large masses are falling every year, and will inevitably continue to do so until the process of destruction is put an end to by the talus attaining the level of the cliff. This is already the case in the ridges furthest removed from the present sea-level.

In witnessing the slow but certain destruction of the porphyritic ridges by atmospheric action, it is impossible not to be struck with the change which has taken place in this respect between the porphyry and the accompanying slates. When both were exposed to the action of the superincumbent waters, the denudation of the slates and sandstones proceeded rapidly, and was only impeded by the protecting power of the harder igneous rock. In the elevated ridges of porphyry, the process of destruction and the consequent accumulation of the talus is now occasionally prevented by masses of slate in front of the cliff, the remaining evidence of their former denudation.

If it be assumed, as may fairly be done, that this talus dates its origin or commencement of accumulation from the period when the sea ceased to flow at its base, we are furnished not only with data on which to found an approximation with regard to the time which has elapsed since, but also with a proof of the gradual nature of this change; for if the sea were removed at one and the same time, from the lowest as well as the highest ridges, the talus would be equal, or at least in proportion to the respective heights of the cliffs; whereas the fact that the talus is greatest and has generally reached its ultimate limit in the cliffs situated at a greater distance from the sea, is evidence that the process of accumulation has been going on for a longer period, and is consistent with the theory of a gradual elevation.

The evidence of the still more recent and continued elevation of the coast is derived from the embankments which have from time to time been made since the sixteenth century. These embankments, commencing high up the Traeth Mawr, have been succeeded by others lower down, and as the new were secured the older became useless. It is evident that these embankments are not the sole or principal cause of the sea no longer flowing within them, but that the natural recession of the sea (or elevation of the land) induced the inhabitants to anticipate, by the erection of earthen mounds, that which would have been produced in a few years by other causes. The sea-mark may be traced on the surface of the escarpments in several of the islands in the Tremadoc valley, many feet above the present level of high water.

Tradition also lends its aid. From the rocky ground of Yns hir, Madoc, one of the princes of North Wales, leaving his native country, *sailed* to unknown lands*. And to descend to more recent times: I was informed that the parish register of Penmorfa contains entries showing that a place in the parish called Y wern was once a seaport, which immediately before the erection of the great embankment was several feet above high water.

The river, generally known to Welsh tourists as the Pont Aberglasllyn river, instead of taking its present direct course, flowed round the Tremadoc valley, and the soil of the upper part of the valley is composed of peat and decayed vegetable matter, probably deposited from the fresh water, the spot being protected from any strong tidal action. The river appears to have assumed its present course before the erection of any embankment.

The successive geological changes which these observations suggest as having taken place in this district appear to be—

First, The accumulation under water of sedimentary deposits, containing a few organic remains referable to the Silurian period,

* It is on this tradition that Southey founded his poem of 'Madoc.'

and this accumulation accompanied by occasional volcanic outbreaks near the surface, producing merely local dislocation, probably followed by a general depression.

Secondly, The contemporaneous disturbance and upheaval of the whole district by the intrusion of a volcanic rock in nearly parallel lines from south-east to north-west, causing an inclination in the stratified rocks to the north and north-west, and followed by great denudation.

And thirdly, The gradual elevation of the whole country, continued to the present time, by which the present physical appearances were produced by the denudation of the softer rocks, leaving the porphyry in elevated mountain ridges (which have been since materially acted upon by the atmosphere), and leaving insulated masses of the volcanic rock of the earliest period.

November 19, 1845.

The following communications were read:—

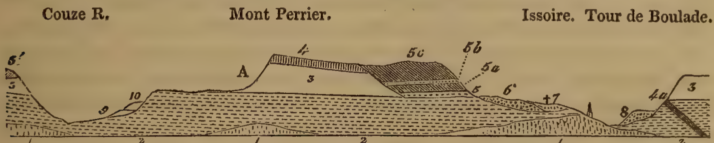
1. *On the Age of the newest Lava Current of* Auvergne, *with remarks on some Tertiary Fossils of that Country.* By Charles Lyell, Esq., M.A., F.R.S., F.G.S. &c.

Until my recent visit to Auvergne in 1843, I was never able to hear of the discovery of any fossils so connected with the most modern class of volcanic cones and currents of lava, as to enable us to assign to them any other than a very indefinite geological date. But when in the course of my last tour I inquired of the Abbé Croizet, well known as an eminent comparative osteologist, if he had yet found any fossil bones or shells in gravel lying immediately under the newest lava-streams, he replied that he had recently met with a great number of mammiferous remains at Nechers, in a bed of reddish sandy clay, which rested against the side of the long and narrow coulée which has issued from the Puy de Tartaret. This hill, as the readers of Scrope's 'Geology of Auvergne' will remember, is one which, by its position in the bottom of a valley at the lower end of the Lac de Chambon, and by the integrity of its heap of loose scoriæ, has all the characters belonging to the class of most modern cones, those which have been least altered by time. The lava issuing from it forms a narrow stripe, occupying for more than thirteen miles the bottom of the valley in which the river Couze de Chambon flows, and at length terminating at the small town of Nechers, about six miles north-west of Issoire. At a short distance above the end of the current in the suburbs of the town, the lava at its side presents a steep and often perpendicular face, twenty-five feet in height towards the river, a meadow only intervening between it and the banks of the Couze. Most of the bones of fossil quadrupeds had been found in a superficial deposit of red sandy clay in this meadow;

but on closely examining the spot in company with M. Bravard the palæontologist, and with M. Croizet, I became convinced, and both these gentlemen are now of the same opinion, that the deposit in question passed continuously under the lava, containing beneath it the same fossils as in the meadow. This fact was made clear by a cave serving as a wine-cellar excavated artificially under the lava; and it has since been more completely established by the investigations of M. Bravard, who will, I believe, soon publish an account of several sections and of the fossil remains. I have little doubt that the current of lava itself once extended farther northwards towards the river, and covered part of the bone-bed which is now exposed. The only fossils which I collected on the spot consisted of the jaw and teeth of a species of *Arvicola*, and the molar of a horse, which Mr. Owen has since examined, and remarks that it agrees precisely with the third lower molar of his *Equus fossilis* from the caves of Oreston (see 'British Fossil Mammalia,' p. 387, fig. 145); showing the same difference from the corresponding tooth in the recent horse in its narrower transverse diameter, which he has figured in his 'British Fossil Mammalia.' The other species found in the same argillaceous sandy bed are referable to the genera *Sus*, *Bos*, *Cervus*, *Felis*, *Canis*, *Martes*, *Talpa*, *Sorex*, *Lepus*, *Sciurus*, *Mus* and *Lagomys*. The bones also of a frog, snake and lizard, and of several birds are associated: in all no less than forty-three species have been brought to light, all closely allied to recent animals, yet nearly all of them, according to M. Bravard, showing some points of difference, like those which Mr. Owen discovered in the case of the horse above alluded to. Several recent land-shells, such as *Cyclostoma elegans*, *Helix hortensis*, *H. nemoralis*, *H. lapicida*, *Clausilia rugosa*, and others, accompanied the bones. M. Croizet has also mentioned to me the horns of a rein-deer found in the meadow. It is highly probable that these animals may have been drowned by floods which accompanied the earthquakes and eruptions by which the Puy de Tartaret was formed: at all events, we may affirm that they belong to the alluvial formations of the river-bed and river-plain which existed at the time of the flowing of the lava of Tartaret, and they consequently give an exceedingly modern geological date to that lava, though we must still infer, that the current was produced at an æra when the mammiferous fauna was very distinct as a whole from that now inhabiting Auvergne.

That the current which has issued from the Puy de Tartaret may nevertheless be very ancient, in reference to the events of human history, we may conclude from the fact, that a Roman bridge of such form and construction as continued in use down to the fifth century, but which may be older, is now seen at a place about a mile and a half from St. Nectaire. This ancient bridge spans the river Couze with two arches, each about fourteen feet wide. These arches spring from the lava on both banks, showing that a ravine precisely like that now existing had already been excavated by the river thirteen or fourteen centuries ago. The bridge is still in use, but the arch on the right side of the river has been half blocked up by the fall of masses of lava from the cliff above. On the whole, therefore, if we take the Puy de Tartaret and its lava as a type of the products of the most modern volcanoes of Auvergne, we may infer, from the facts above described, that the latest eruptions occurred at the close of the Newer Pliocene, if not in the Post-pliocene period, or when the mollusca were identical with those now living, although a great many of the mammalia belonged to species now extinct.

Section from the Valley of the Couze at Nechers, through Mont Perrier and Issoire to the Valley of the Allier, and the Tour de Boulade, Auvergne.



10. Lava current of Tartaret near its termination at Nechers.
9. Bone-bed, red sandy clay under the lava of Tartaret.
8. Bone-bed of the Tour de Boulade.
7. Alluvium newer than No. 6.
6. Alluvium with bones of hippopotamus.
5 *c*. Trachytic breccia resembling 5 *a*.
5 *b*. Upper bone-bed of Perrier, gravel, &c.
5 *a*. Pumiceous breccia and conglomerate, angular masses of trachyte, quartz pebbles, &c.
5. Lower bone-bed of Perrier, ochreous sand and gravel.
4 *a*. Basaltic dyke.
4. Basaltic platform.
3. Upper freshwater beds, limestone, marl, gypsum, &c.
2. Lower freshwater formation, red clay, greensand, clay, &c.
1. Granite.

A. At a point corresponding to this, and situated on the north side of the hill of Gergovia, the *Melania inquinata* has been found in freshwater marl under basalt.

In the accompanying section I have shown at the north-west extremity the position occupied in the valley of the Couze at Nechers by the lava of Tartaret, No. 10, and subjacent bone-bed No. 9. I have at the same time shown, in the prolongation of the same section to the hills on the right bank of the Allier, near Issoire, the position of various other superficial deposits in which MM. Croizet, Bravard, Pomel and others have detected mammalian remains belonging each of them to very distinct assemblages of species, and which have doubtless originated at successive tertiary epochs. In the oldest freshwater tertiary beds, Nos. 2 and 3, the *Palæotherium*, *Anoplotherium*, *Anthracotherium*, *Didelphis*, *Crocodile*, and other genera common to the Paris basin, have been found associated with species of *Rhinoceros*, *Cervus*, and some other genera, which, in Cuvier's experience, had never been met with together in the same formation. Above these rests a sheet of basalt, No. 4, forming the north-west portion of the summit of Mont Perrier. In many places similar elevated basaltic platforms rest on gravel-beds, in which fossil mammalia have been detected. Next in age are the trachytic and pumiceous breccias and accompanying gravel-beds, 5, 5 *a*, 5 *b*, 5 *c*, which were described by Sir R. Murchison and myself in a paper published in 1829 in the Edinburgh New Philosophical Journal for July. In the alluvial deposits 5 and 7, bones have been obtained belonging to the genera *Mastodon* (2 species), *Rhinoceros*, *Tapir*, *Sus*, *Bos* (2 species), *Cervus* (about 20 species), *Antilope*, *Capra* (2 species), *Felis* (7 species), *Hyæna* (2 species), *Martes*, *Lutra*, *Canis*, *Ursus*, *Erinaceus*, *Marmot*, *Castor*, *Arvicola* (2 species), and *Lepus*, all referable to extinct species. Next in age come two other alluvial deposits, Nos. 6 and 7, in which fossil mammalia of other species, according to M. Bravard, occur, the bones of *Hippopotamus* in particular having been met with in No. 6. Passing then to the south-east of Issoire, and crossing the Allier, we arrive at No. 8, the celebrated bone-bed of the Tour de Boulade, in which a great many other mammalia have been collected by the labours of MM. Bravard and Pomel; among others the *Elephant*, *Rhinoceros* (*R. tichorhinus*), *Equus*, *Bos*, *Cervus* (including Reindeer), *Antilope*, *Felis*, and *Canis*. This assemblage differs considerably in its species from any other in the neighbourhood, and may be considered as more ancient in character than No. 9, alluded to in the beginning of this paper, or the bed which underlies the lava at Nechers. In regard to the Tour de Boulade bed, No. 8, its base is about sixty feet above the level of the Allier. It consists in great measure of angular pieces of freshwater limestone and basalt, which seem to have fallen from the steep slope of the hill above, or which at least are unrounded, and have not been brought from a distance. Some of the angular blocks are three feet in diameter. There is an intercalated sandy bed with bones such as may have been deposited in a river or sheet of water, into which these fragments of rock, detached by frost from the precipice, have rolled down. In this sandy stratum two marine shells have been found by MM. Bravard and Pomel, belonging decidedly to the genera *Natica* and *Pleurotoma*. Although too imperfect to allow of the species being positively determined, they both approach closely to shells which I have from the faluns of Touraine. As no marine tertiary shells had been previously observed nearer to this part of Auvergne than the valley of the Loire, and as the deposit under consideration has a purely terrestrial or supra-marine aspect, I should not have given credit to this discovery if not attested by geologists, who are so cautious, and who were so alive to the novelty and importance of the phænomenon at the time when they found them, as were the naturalists above mentioned. They have been as much perplexed as I am to conceive how any current of water could have brought such shells from the north; and we can hardly suppose the Miocene sea to have ascended the valley of the Allier without leaving there some more decided monuments of its sojourn.

There is only one other subject on which I shall offer a few observations. It has long been announced, that in the celebrated mountain of Gergovia M. Bouillet had found the *Melania inquinata* in some argillaceous marls in the north flank of the hill. I examined the spot with attention, and obtained by digging many specimens of the *Melania* in question, and of a *Unio* and *Melanopsis* which accompanied it in abundance. Some doubts had been raised by M. Bouillet whether the strata containing these shells belonged merely to a local deposit, or really formed an integral part of the great freshwater formation of Auvergne, of which the mass of the hill of

Gergovia is composed. I consider the section however as perfectly clear, and the *Melania* and other fossils are evidently imbedded in a stratum, which crops out from beneath the capping of basalt which constitutes the flat summit of the mountain. It will be unnecessary to give a separate section, because the position of the beds is fully indicated by the point A, which I have placed in the upper freshwater strata below the basalt on the steep north-west slope of Mont Perrier. Many palæontologists who had been inclined to regard the strata of the Limagne as considerably newer than the tertiary beds of any part of the Paris basin, had been surprised that a fossil eminently characteristic of the lower part of that basin, and found also under similar circumstances in the plastic clay of the London basin, should occur in the highest beds at Gergovia. I find however that all these Auvergne shells belong, if not to a distinct species, at least to a perfectly different variety from that found in the neighbourhood of Paris and London; and what renders the fact still more interesting, it is a variety which can hardly be distinguished from the recent Melania of the Philippine Islands, which M. Deshayes first identified with the Parisian fossil. Mr. G. B. Sowerby, in the Malacological Magazine, part 1, 1838, pointed out the differences existing between all the varieties of the Eocene *Melania inquinata* then known, and the varieties of the recent shell, which he proposed to name *Melania Philippinarum*; but he now admits that the most marked of these points of difference cannot be detected in the specimens I brought from Gergovia, which, although they may not be perfectly identical with any one variety of the living species, would yet be considered by most conchologists as merely another variety of the same. The most obvious distinction between the ordinary Paris or London basin fossil, from the living Melania of the Philippines, consists in the absence in the former of those spiral ridges or raised striæ which in the living shell intervene between the principal row of tubercles in each whorl and the suture. In all the fossil individuals from England and the Paris basin these are wanting, although I possess one specimen given me by M. Graves from the department of the Oise in which the striæ are visible, though obsolete, a fact to which Prof. E. Forbes called my attention, and which may lead us to suspect that a series of intermediate gradations may one day be detected between the Parisian (Epernay), the Gergovian and the recent shell. In the meantime, however, we may regard the Auvergne and Philippine Island species, both in the form of the volutions, the prominent striæ above mentioned and other characters, as belonging to one type, while the fossils of the Paris and London basins are referable to another. If all could be regarded as one species, its changes may be compared to those which the *Cardium porulosum* undergoes, as M. Deshayes has shown, as it appears successively in the sands of the Soissonois, in the calcaire grossier, and in the upper marine formation near Paris. No argument can therefore be founded in favour of the identity in age of the Parisian and Gergovian beds from the occurrence in both of this Melania, as the Auvergne variety is so distinct. This modification in form would be quite natural on the supposition that the freshwater beds of Auvergne were referable to the Miocene epoch. The Melanopsis associated with the Melania in the hill of Gergovia is more allied to the *M. Dufourii* than to *M. buccinoides*; the Unio seems peculiar at present to the locality. In regard to the age of the Auvergne beds generally, I have not yet seen sufficient reason, whether from the nature of the mammalian, reptilian, conchological or vegetable remains imbedded in them, to abandon the idea of their being Eocene, although it is true that they exhibit some characters in common with the Miocene period.

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2. *Geological Position of the* BITUMEN *used in* ASPHALTE PAVEMENTS. By S. P. PRATT, Esq., F.R.S., F.G.S. &c.

THE bitumen which has been so extensively used for pavements, &c. is found in considerable abundance, and of the best description, at Bastenne, a small village in the south of France, about fifteen miles north of Orthez. The geological circumstances connected with its appearance being somewhat interesting, a short account of them may be desirable.

The country about Bastenne is formed of numerous small conical hills two or three hundred feet high, separated from each other by deep narrow valleys or ravines; they are chiefly composed of a coarse sandy limestone, which M. de Fresnoy places in the cretaceous system; their upper part consists of variously coloured sands and clays from fifty to sixty feet in thickness, the whole being covered by gravel and sand, which extends for many miles in every direction. The sands and clays are usually horizontal, but are occasionally much disturbed and highly inclined; whenever this occurs it is evidently owing to the protrusion of igneous matter, which is then found in connexion with them. The bitumen is worked in three localities near to each other, and the following section was made at the principal mine:—

Gravel.

12 feet of yellow sand, consisting of numerous thin layers, varying in colour—red, yellow and white.

2 feet of red and green clay.

24 feet of coloured sands as before.

1 foot of clay.

6 feet of sands as before.

4 feet of blackish sand containing a small quantity of bitumen.

5 to 15 feet of bitumen which varies much in character, the upper part consisting of looser and coarser sand, with a less proportion of the bitumen, while the lower part is more compact, containing finer sand, and being chiefly composed of bitumen.

10 or 15 feet of sand without bitumen occurs in some places, although where the bituminous sand is found of the greatest thickness, it then rests upon the sandy limestone, which forms the chief part of the surrounding country.

This section was taken on the side of the hill where the bitumen crops out, the upper beds being cut through to expose the bed; its extent is about 2000 feet by 900; it terminates suddenly in one direction, as the horizontal strata are cut off by a fault, by which the beds are elevated to an angle of 70° or 80°.

In the sands and clays no fossil remains have been met with except occasionally small pieces of lignite, and the bitumen is generally free from any extraneous matters, except in two localities, where numerous marine shells are found, which may be referred to the miocene period. In one of these, where the bed of bitumen is from ten to twelve feet thick, the shells are disposed in numerous layers at a few inches' distance from each other,—the shells of the same kind generally forming distinct layers, although occasionally, where the layer is thicker, many species occur together: where the mass has been cut through vertically, the appearance is very striking, bright white lines appearing on the black bed of bitumen. The shells are not broken or disturbed, nor are the valves separated from each other; they are, on the contrary, perfectly preserved, the most minute markings appearing upon them when freshly dug up, but (in consequence of the loss of the animal matter) they fall into powder upon being exposed to the air. Notwithstanding this, perfect casts may be readily procured, as they easily separate from the sandy mass. The bitumen has evidently been forced into them in a soft or liquid state, as the smallest cavities are filled, and this must have taken place after their deposition in the sands in which the animals lived. The date of this formation (as indicated by the numerous species which have been determined) may be referred to the miocene æra; and as the eruption of bitumen is evidently connected with the appearance of the *ophite*, an igneous rock, which has produced such great changes in the Pyrenees, a limit may thus be obtained for these changes. The bitumen worked in the other localities appears under similar circumstances, except that no shells have been found in it; the bed is nearly horizontal, dipping slightly towards the centre, where it becomes of greater thickness; indeed it is said the depth has not been reached in one part where it is generally supposed to have risen from beneath. The bitumen is easily cut when first exposed, but in a few days it hardens so much as to become incapable of purification; the purification is effected by boiling the sandy mixture in a large quantity of water two or three times, when by continued and careful stirring the sand gradually settles to the bottom, while the pure bitumen rises to the surface and is taken off.

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3. *On the Occurrence of* Coal *in* Formosa. By — Cooper, Esq.

Specimens of this coal were exhibited to the meeting, but it did not appear from the notice under what geological conditions the coal existed.

December 3, 1845.

James Ashwell, Esq., B.A., and A. W. Jackson, Esq., were elected Fellows of the Society.

The following communications were read:—

1. *On some remarkable* Fossil Ferns *from* Frostburg, Maryland, *collected by* Mr. Lyell. By C. J. F. Bunbury, Esq., F.G.S.

Plates VI. VII.

The first of the fossil Ferns (see Plate VI.) which I wish to bring under the notice of the Society has so great a resemblance to the *Diplazites emarginatus* of Göppert*, that I doubt whether it can with propriety be considered as a distinct species. The specimens are however much more complete than the one he has figured, and in particular exhibit the fructification in a far more distinct and satisfactory manner; and this fructification clearly proves, as I think, that the plant has no close affinity with the recent genus *Diplazium*, to which Göppert referred it chiefly on account of its venation. The specimen figured by that distinguished author, and which was the only one he had seen, was procured from the neighbourhood of Ilmenau, and exhibited only two or three detached pinnæ, without any portion of the rachis; one of those pinnæ was partly covered with granulations, exhibiting no distinct structure or arrangement, which he believed to be the fructification in an over-ripe state, having lost (as often happens in ferns) all trace of its original arrangement.

In the specimens from Frostburg, the rachis or main stalk is flat, from one-eighth to one-fifth of an inch in breadth, faintly striated, and marked with small depressed dots, which doubtless indicate the insertion of hairs. The frond appears to have been simply pinnated. The pinnæ are closely set, at right angles or very nearly so to the stalk, to which they are attached by nearly the whole breadth of their base, not in the least dilated or decurrent in that part, ligulate in their general outline, rounded at the end, rather convex, about two and a half inches long, about half an inch broad, and of equal breadth through nearly their whole length; their margins regularly and neatly crenated, with shallow sinuses. The primary veins, which proceed at first rather obliquely from the midrib of each leaflet, but soon take a direction nearly perpendicular to it, are pinnated, with numerous, alternate, very oblique branches or veinlets, most of which reach the margin at an angle not far from a right angle. So far the venation agrees with that of Göppert's *Diplazites*, and of Brongniart's *Pecopteris longifolia*; but in this Frostburg plant, if I am not mistaken, the lowermost pair of veinlets belonging to each primary vein, instead of proceeding to the margin, meet the lowermost branches of the next veins, at a very acute angle, as in the recent genera *Anisogonium* and *Nephrodium* of Presl. Unfortunately, the veins are but faintly and obscurely marked in the

* Systema Filic. Fossil. p. 274. tab. 16. fig. 1 & 2.

specimens before me. In Göppert's figure, indeed, of *Diplazites emarginatus,* some of the veinlets are represented as meeting each other in the manner I have described, but in the description he states that they all reach the margin of the frond.

The fructification, which is very conspicuous in some of our Frostburg specimens, has the appearance of small, crowded, roundish spots (*sori*), placed with considerable regularity in double rows between the primary veins. Some of the pinnæ are entirely covered with it except at their extreme margins; on one it occupies the upper part, from about the middle to within a short distance of the extremity.

As Göppert himself ascribes the confused manner in which the fructification of his *Diplazites emarginatus* covers the frond, to its advanced stage of maturity, it is very possible that, in an earlier state, it might have been arranged in the same manner as in our plant. In that case there would be no difference between them, except, perhaps, in the angular confluence of the lower veinlets. I say perhaps, because his own plate is at variance with his description in that particular. The pinnæ of our plant are not indeed emarginate at their extremities, but neither are they represented so in his figure.

The *Pecopteris longifolia* of Brongniart (*Diplazites longifolius* of Göppert) differs from ours in its much narrower pinnæ, as well as in all its veinlets being free, and perpendicular to the margin.

If now we compare our Frostburg fossil with recent ferns, we see that the round sori remove it altogether from the group to which *Diplazium* belongs, and would lead us to look for its affinities among the *Polypodeæ* or *Aspideæ.* The genera *Goniopteris* and *Nephrodium* (as limited by Presl) have a venation nearly resembling that of our plant, except that the veinlets are less oblique; in the former genus there is a farther similarity in the arrangement of the sori, in double rows between the primary veins. I do not, however, know any species of either genus that comes sufficiently near, as a species, to our plant, to be worth comparing with it.

As the generic name *Diplazites* is thus shown to be inapplicable to this fern, we must either give it a new generic name, expressive of its apparent affinity with *Goniopteris,* or place it in the large and miscellaneous genus *Pecopteris,* next to Brongniart's *P. longifolia.* The latter will be, for the present, the safer plan, for much confusion and error may be produced by hasty attempts to refer the fossil ferns positively to recent genera; and Pecopteris, though a heterogeneous assemblage, at least possesses definite and intelligible characters, which is more than can be said for most of the genera that have been formed out of it. As it appears most probable that the species is the same as Göppert's *Diplazites emarginatus,* the specific name (though not particularly appropriate) must be retained, at least provisionally; and it may stand as*

* It might form a distinct section of the genus, to be called *Goniopteridites.*

1. Pecopteris emarginata.

Plate VI.

P. fronde pinnatâ (?): pinnis ligulatis obtusis late et obtusissime crenatis; basi subcontractis; costâ validâ apice attenuatâ; venis costæ subperpendicularibus pinnatis; venulis valde obliquis, infimis in angulum acutum confluentibus; soris rotundis confertis inter venas biserialibus.

2. Pecopteris elliptica (n. sp.).

Plate VII.

P. fronde bipinnatâ: pinnulis ellipticis oblongisque convexis integerrimis apice rotundatis basi contractis discretis remotiusculis; venis obliquis prope basin furcatis; soris subrotundis confertissimis.

This plant, from the same locality as the foregoing, appears to be new; at least I can find no description or figure well-agreeing with it in the works of Brongniart, Lindley and Hutton, or Göppert. The figure of *Pecopteris adiantoides* (Fossil Flora, vol. i. t. 37) has most resemblance to it in the form of the pinnules; but neither the plate nor the description of that species gives sufficient details to enable us to say whether it be the same. The fructification of *P. adiantoides* appears to be unknown.

The frond of our plant is apparently bipinnate. The insertion of the pinnæ on the main stalk is not very satisfactorily shown in our specimens, but there are no appearances indicating that they were decurrent along it, as in *P. gigantea.* The barren pinnules are considerably convex, wider apart than in most species of Pecopteris, quite distinct from one another, and contracted at the base, so that their form is pretty accurately elliptical, though rather oblique. The veins are similar to those of *P. gigantea*, except that the forking takes place very near to the midrib. The fructiferous pinnules are rather longer and narrower than the others, and of more equal breadth throughout, oblong rather than elliptical, and more suddenly contracted at the base. The fructification covers their whole surface, obliterating the side veins, and almost the midrib; it has the appearance of roundish spots, so much crowded that their arrangement is scarcely distinguishable; but I think I can perceive traces of their having formed two rows on each side of the midrib. On one of the pinnæ in a specimen in my possession, part of the pinnules are barren and part fertile, so that there can be no doubt of their belonging to the same plant.

I am not acquainted with any recent fern which closely resembles this species; but its nearest affinities are probably to be sought among the *Polypodeæ, Aspideæ*, or *Cyatheæ*. In very many ferns of these tribes, the fructification is at first in distinct spots, which become confluent when they have attained to maturity, and cover the under side of the frond almost entirely; and such appears to have been the case in the plant before us.

The third of these fossil ferns which I would mention is not indeed in a very satisfactory condition, but I have thought it worth noticing on account of its very remarkable fructification. It nearly agrees (except in size) with the *Danæites asplenioides* of Göppert*;

* Systema Fil. Fossil. p. 381. tab. 19. fig. 4, 5.

and as the specimen figured and described by that author is still more incomplete than Mr. Lyell's, so that one can hardly either distinguish or identify them with certainty, I think it safer to consider them provisionally as the same species. Our Frostburg plant will therefore stand as

3. Danæites asplenioides *var.* major.

The frond appears to be bipinnate, and if a flattened stem (apparently the stipes of a fern) which occurs in the same slab belonged to this plant, it was of large size, for the stem in question, in its compressed state, measures an inch and a half across. The pinnules are closely set, oblique, rounded at the end, slightly combined at the base, but neither dilated nor decurrent, of an oblong or broadly linear form, flat, or scarcely convex, about $\frac{4}{10}$ths of an inch long, and about half as much in breadth. Veins very indistinctly marked, but seemingly nearly perpendicular to the margin. The fructiferous pinnules (which are on a separate pinna, but which I believe to belong to the same species) are rather larger than the others, but of the same shape; the fructification has the appearance of linear masses, placed parallel and nearly contiguous to one another, perpendicular to the midrib, and extending from it quite to the margin. Its general resemblance to the fructification of the curious genus *Danæa* is very striking, but I am not quite satisfied that it is really of the same nature; for on a close examination one may detect traces of round spots; and perhaps the apparently linear masses may have been made up by the aggregation of numerous round ones.

Göppert has not figured the barren pinnules of his *Danæites asplenioides*; the fertile ones represented in his plate differ from those of our plant merely in being considerably smaller, and perhaps rather narrower in proportion.

It is to be observed, that although the appearances of fructification in all these three plants are clear and unequivocal, yet in the first two species at least, it is invariably the upper surface of the frond that is exhibited to our view; now, in all recent ferns, the fructification is situated on the under surface; we must therefore suppose that what we see in these specimens are not the masses of capsules themselves, but the impressions of them, as it were, stamped through the substance of the leaves by the pressure to which they were subjected in the process of fossilization. This appears to be most usually the case with those fossil ferns which occur in a fertile state, and may be one reason why it is more difficult to determine with precision the characters of the fructification in these than in the recent plants. Dr. Lindley long ago observed*, that fossil ferns are much more often found with their upper than with their lower surface exposed to view, the lower seeming to adhere more closely to the matrix; and Professor Göppert†, in his curious experiments

* Fossil Flora, text to t. 83.

† Syst. Filicum Fossilium, p. 293.

on the artificial production of vegetable impressions, found that plants of this tribe did, in fact, constantly remain attached to the substance in which they were imbedded, by their lower and not by their upper surface, especially if they were in fructification.

The carboniferous strata at Frostburg in Maryland, from which these fossils were procured, are described by Mr. Lyell* as being arranged geologically in a trough, and the shape of the successive beds has, he observes, been aptly compared to a great number of canoes placed one within another. The principal coal-seam is ten feet thick; the coal bituminous, though containing less of volatile matter than what is found farther west on the Ohio. There are numerous smaller seams of coal, under several of which Mr. Lyell found clays containing *Stigmaria*, "usually, as elsewhere, unaccompanied by other fossil plants;" but in one bed of clay, underlying a coal-seam, about fifty feet above the millstone grit on which the whole rests, he found leaves of two species of Pecopteris and an Asterophyllite, intermixed with abundance of Stigmariæ. Higher in the series, but still 300 feet below the principal coal-seam, occurred a bed of shale full of marine shells, some of which were identical with, and others had a near affinity to, species found in the British coal-measures†.

The fossil plants procured by Mr. Lyell at Frostburg, in addition to the three ferns already described, were the following:—

4. *Neuropteris cordata.*

(Very abundant, and certainly identical with the English plant. Very variable in size and in the proportional breadth of its pinnæ. These are sometimes oblique at the base, nearly as much so as in *N. acutifolia* of Brongniart, which is probably a variety of this species.)

5. *N. gigantea?*

(Doubtful; pinnules as closely placed as in *N. flexuosa*. It is intermediate in character between *N. flexuosa* and *N. gigantea.*)

6. *Cyclopteris?*
7. *Pecopteris arborescens.*
8. *P. abbreviata?*
9. *P.* —— (?).

(Perhaps a fragment of *P. gigantea* or *P. punctulata*, but too imperfect to be positively determined.)

10. *Lepidodendron tetragonum.*
11. *L. aculeatum.*
12. *Lepidodendron* ? ?

(Resembling in its markings the *Sigillaria Menardi* of Brongniart, and also the *Ulodendron minus* of Lindley and Hutton.)

13. *Sigillaria reniformis?*
14. *Stigmaria ficoides.*
15. *Asterophyllites foliosa.*
16. *A. tuberculata?*
17. *A. equisetiformis?*

* Travels in North America, vol. ii. p. 16–19. † Lyell, *ibid.*

18. *Asterophyllites.*
(Undescribed, but said to be found in the "middle coal" near Manchester.)
19. *Artisia* —— ?
20. *Calamites nodosus.*
21. *C. dubius* ?

I am not aware that any of the three ferns which I have here particularly described, are marked by peculiarities calculated to throw any new light on the questions relating to the climate of the coal period. But the very striking similarity between the coal-plants of North America and those of Europe makes it probable that a similar kind of climate also existed in both countries at that æra; and whatever conclusions we may arrive at in relation to the carboniferous period in the one continent seem equally applicable to the other. Nothing that has yet been ascertained relative to the coal formations of either continent seems at all inconsistent with the suggestion of Mr. Lyell* touching the climate of the period in question. This view, which seems to me by far the most probable, is, that the climate was then characterized by excessive moisture, by a mild and steady temperature, and the entire absence of frost, but perhaps not by intense heat. I must admit, indeed, that our materials for the foundation of this theory are perhaps somewhat scanty, being chiefly the general character of luxuriance of the carboniferous vegetation, the great abundance of ferns, and the presence of large-leaved monocotyledonous plants of a tropical or subtropical aspect; for with regard to the Sigillariæ, Stigmariæ, Asterophyllites, Calamites, &c., their real affinities are, I think, too doubtful to allow us to found any arguments on them.

That extreme heat is not necessary to the existence of a very luxuriant and quasi-tropical vegetation, is sufficiently clear from Mr. Darwin's interesting observations on Chiloe and other islands of the southern temperate zone†. Chiloe, situated in the forty-second degree of south latitude, enjoying little summer heat, and subject to perpetual rains and mists, is covered, as he states, with forests of extraordinary density, and the luxuriance of the vegetation is such, that it reminded him of Brazil; large and elegant ferns, parasitical monocotyledonous plants, and arborescent grasses reaching to the height of thirty or forty feet, are abundant. Indeed, in the southern hemisphere generally, owing to the equable climate produced by the great proportional extent of sea, tropical forms both of vegetable and animal life range much farther from the equator than in our hemisphere. It appears very probable that the climate of the northern temperate zone, during the epoch in which the coal-measures were formed, may have been similar to that now existing in Chiloe and the adjacent parts of South America.

Still, considering that the principal coal-fields of England are situated from 13° to 15° farther north than that of Frostburg, of which I have here spoken, the close resemblance of their vegetation

* Travels in North America, vol. i. p. 148–9.
† Darwin's Journal, 2nd edit. p. 242, *et seq.*

is very striking. The absolute identity of some species is not perhaps so remarkable as the very great general similarity of the whole; for those among the Frostburg plants, which cannot be satisfactorily identified with British species, are in every instance very closely allied to them. We should not find so great a degree of resemblance on comparing the recent floras of two regions separated by so many degrees of latitude, whether in Europe or North America. If we may reason at all as to climate from the fossil vegetation of a country, we must suppose that the climate varied less rapidly with the latitude than it does at present.

I must not omit to take notice of the opinion maintained by Professor Lindley*, "That the numerical proportion of different families of plants found in a fossil state throws no light whatever upon the ancient climate of the earth, but depends entirely on the power which particular families may possess, by virtue of the organization of their cuticle, of resisting the action of the water wherein they floated previously to their being finally fixed in the rocks in which they are now found." To this conclusion it appears to me that there are strong objections. It seems to have been deduced by Professor Lindley from the results of an experiment (recorded in the third volume of the 'Fossil Flora') on the comparative durability of various plants when immersed in water. In the first place, as M. Adolphe Brongniart has already remarked, Dr. Lindley's theory does not at all explain why the proportional number of ferns should be greater in the coal formation than in any subsequent deposit, nor why the leaves of dicotyledonous plants, which are almost, if not entirely wanting in that formation, should be so abundant and so well-preserved in the freshwater deposits of the tertiary period. If maceration in water destroyed them in the one case, it would surely have done so in the other. Moreover, Dr. Lindley's experiment, however ingeniously devised and carefully conducted, does not supply all the data necessary for deciding the question; nor are its results altogether in accordance with the phænomena we observe in the carboniferous strata. The species of ferns submitted to experiment by him were only *six* in number†,—too few, I think, to justify us in concluding that the plants of that tribe generally possess in an eminent degree the power of resisting maceration in water. In this number were not included any of the more tender and delicate kinds of ferns, such as those *Hymenophylleæ*, which are almost comparable to mosses in the filmy, delicate and fragile texture of their leaves, and of which many representatives are found in a fossil state. It is difficult to believe, without more positive proof, that fronds so thin and membranous as those of several species of *Sphenopteris* which occur in the coal formation, could have endured long maceration in water, when we learn from Dr. Lindley's experiment that even that singularly hard and rigid plant the *Equisetum hyemale*, of which the stems are coated with silex, perishes within two years under this process.

Again, Dr. Lindley concluded from his experiment that the fruc-

* Fossil Flora, vol. iii. p. 12. † Ibid. p. 5.

tification of ferns was destroyed by long immersion in water; and he seems to consider this as an important corroboration of the justness of his views. He speaks* of "the very remarkable fact, that ferns are scarcely ever met with in fructification in a fossil state;" and if this were a fact, it would certainly be in accordance with the result of his experiment. But it is now known that the occurrence of the fructification of ferns in a fossil state is by no means so rare as that distinguished botanist supposed. It is shown in the present paper, that out of nine fossil ferns observed by Mr. Lyell at Frostburg, three were in a good state of fructification. And Göppert, in his 'Systema Filicum Fossilium,' figures and describes not less than twenty-five species in that condition, mostly from the coal-mines of Silesia.

Professor Lindley also found that branches of dicotyledonous trees, when soaked in water, lost their bark, and all external marks by which they might be recognised. But it is well known that the Sigillariæ (which Dr. Lindley himself considers as true Dicotyledons) are constantly found in the carboniferous strata with their bark and all its markings well-preserved.

These considerations seem to me to render it improbable, that the plants preserved in the rocks of the coal formation should have been subjected to maceration in water for a length of time before they became fossilized.

Another point which deserves some attention, in reference to the present question, is the compressed state in which the trunks of *Sigillaria*, *Lepidodendron*, and *Calamites*, are usually found in the strata accompanying the coal. This indicates that they must have undergone a very considerable degree of pressure previous to petrifaction, and while they were still in a comparatively soft and yielding state. The pressure which flattened these large stems, and which prevented the escape of the volatile ingredients of those accumulations of vegetable matter that formed the coal, would probably also prevent the decomposition of the other plants that accompanied them.

I think, therefore, there is reason to believe that the ferns and other plants which occur in the shales and sandstones accompanying the coal, were not subjected to the same conditions as the plants upon which Dr. Lindley made his observations. If they had, like those, been macerated in water for a great length of time, we could readily admit that a large proportion of the species might have perished. But if, as seems more probable, they were speedily buried beneath great accumulations of mud and detritus, then the conditions were essentially different from those of Dr. Lindley's experiment; and we have no right to infer from that experiment that whole tribes of dicotyledonous plants had perished, while the ferns which grew in company with them were preserved.

I have entered at some length into this question, because of the high authority which Prof. Lindley's name deservedly carries with it, and because I have observed that some of the most eminent geo-

* Fossil Flora, vol. iii. p. 3.

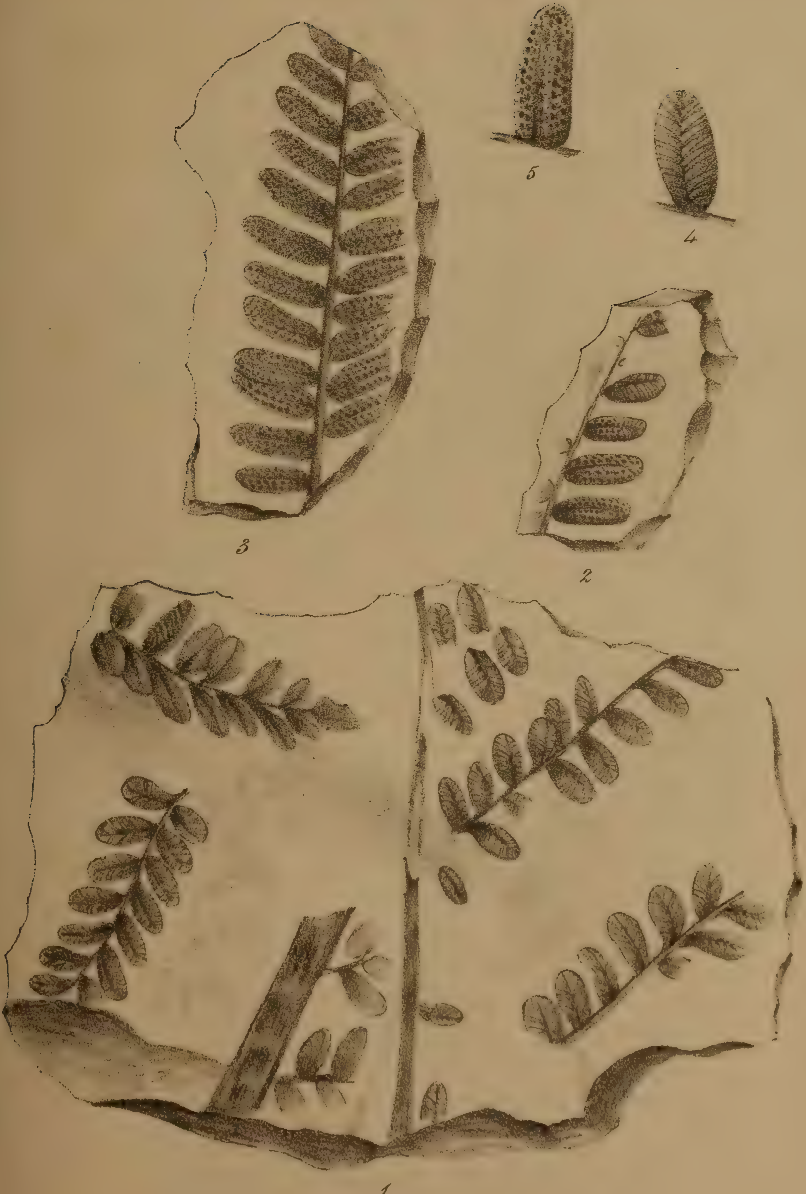
logists are disposed implicitly to adopt his conclusions, and to disregard altogether the evidence of fossil plants as to the former state of the earth's surface.

At the same time I readily admit, that the plants, of which we now find the remains imbedded in the carboniferous strata, may probably be but a very small proportion of those which at that time flourished on the earth. If, as seems to be now most generally believed, the coal-beds are derived from the vegetation of ancient swamps or lakes, existing in the very localities now occupied by such beds of coal, we could not expect to find in them the remains of other plants than such as grew in those bogs, or lakes, or swampy forests, or immediately around them, together perhaps with some which might be washed into them by occasional inundations. May there not have existed at the same time, in other parts of the world, (nay, perhaps, at no very great distance from the carboniferous regions,) great tracts of country, indeed whole continents, in which the local circumstances were unfavourable to the preservation of vegetable remains, and of which, consequently, the flora is totally lost to us? If, on the other hand, as some suppose, (and as may probably have been the case in some instances,) the coal was formed out of vegetable matter drifted down by rivers, and accumulated in estuaries or shallow bays, then it is clear that such deposits are not likely to include anything like a complete series of the vegetation of the then existing lands.

I think, therefore, that we ought to proceed with great caution in theorizing with respect to the vegetation and climate of the carboniferous æra. I do not admit that Professor Lindley's observations have destroyed the value of the evidence afforded by the great proportional number of ferns in the Flora of the coal-measures; I believe that that preponderance, together with the other characteristics of the fossil vegetation of that period, affords to a certain degree good evidence respecting the climate of those particular regions in which the coal-measures occur; but we should not be justified in extending our inferences farther. Those parts of Europe and North America in which the coal-fields were accumulated, may have existed at that time in the state of islands, like those of the present Pacific Ocean; but it would be rash to infer, as M. Adolphe Brongniart seems disposed to do, that no extensive continents at that time existed in any part of the globe. If, in all departments of geology, it is necessary to advance with caution, and to avoid dogmatism and rash generalizations, it is more especially necessary in the department of Fossil Botany, where so much of the evidence we possess is fragmentary and imperfect.

Additional Remarks on PECOPTERIS EMARGINATA.

Since this paper was written, I have seen in the British Museum specimens of *Diplazites emarginatus*, Göpp., from Wettin near Halle. They are not in fructification, but exhibit the venation, and



C. J. F. Bunbury, delt. Miller, lith. Reeve, imp.

Frostburg Ferns. *Pecopteris elliptica.*

(Mr Bunbury.)

2

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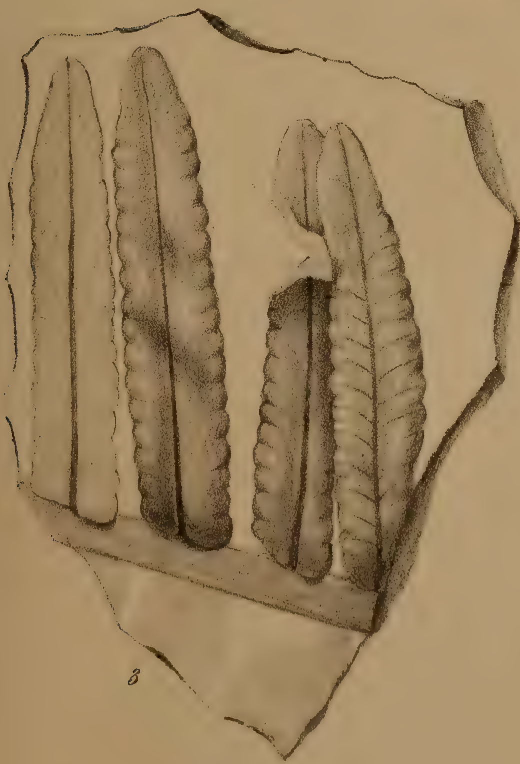

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C. J. F. Bunbury, del^{t} Miller, lith.

Reeve, imp.

Frostburg Ferns. *Pecopteris emarginata.*

(M^{r} Bunbury.)

especially the anastomosing of the lower veinlets, more distinctly than our American specimens. With these they agree so well, that I cannot but consider them as the same species; and therefore, although the specific name of *emarginatus* is certainly not applicable, I think myself obliged to retain it, to avoid the confusion arising from a multiplication of synonyms.

The *Pecopteris Göpperti* of Mr. Morris, from the Permian system of Russia, comes very near, in several respects, to *P. emarginata*; but the insertion of the pinnæ on the stalk appears to be different, and the veinlets are generally forked, whereas in our plant they are always simple.

DESCRIPTION OF THE PLATES.

Plate VI.

Figs. 1, 2, 3, *Pecopteris emarginata*, natural size.
4, 5, „ „ magnified.

Plate VII.

Figs. 1, 2, 3, *Pecopteris elliptica*, natural size.
4, „ „ barren pinnules magnified.
5, „ „ fertile pinnules magnified.

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2. *Notes on the* Wealden Strata *of the* Isle of Wight, *with an account of the Bones of* Iguanodons *and other Reptiles discovered at* Brook Point *and* Sandown Bay. By G. A. Mantell, Esq., LL.D., F.R.S. &c.

The author commenced with some remarks on the general geological structure and picturesque features of the Isle of Wight, and then proceeded to direct special attention to some extensive ledges of low rocks visible from a considerable distance, and occurring seaward of Brook Point, a low promontory near and to the east of Compton Bay. The face of the cliff is here formed by the bassetting edges of the Wealden clays and sands, which alternate with occasional layers of argillaceous shelly limestone, rolled blocks of which are strewed along the beach. This limestone is formed of the shells of *Paludina*, *Cyclas* and other Wealden species, and is in every respect identical with the Petworth marble and Ashburnham beds of Sussex.

The cliff at Brook Point is between thirty and forty feet high, and is capped by an alluvial bed of loam, sand and gravel. It is composed of beds of laminated clay and shale, with sands and sandstones of a bluish and reddish-gray colour, and these are interspersed with layers and isolated masses of lignite and lumps of iron pyrites.

East of the Point a chine or chasm occurs, from the summit of which a stream gushes out and dashes down the face of the cliff to the sea-shore. This stream rises from beneath the sand beds inland, and flows through the alluvial gravel to the summit of the cliff.

The author then proceeded to quote a graphic description of this spot, written nearly thirty-five years ago by Mr. Webster*, and he referred also to the account given twenty years afterwards by Dr. Fitton†, who considers the compact variegated clay and sand appearing below the sand-rock of the Point as the lowest visible strata of the island. Both Mr. Webster and Dr. Fitton mention the great abundance of fossil wood at this spot, where there have been found many large trunks of petrified coniferous trees, of a dark brown colour. This petrified forest occurs in the variegated sand-rock above alluded to, and the stratigraphical features of the cliff containing it have therefore been long known. It appears that the projecting masses at the base of the cliff are the protruding edges of the sand-rock in which the fossil trees were imbedded, for this rock, from its greater hardness, resists the action of the waves long after the upper and less coherent strata have been washed away. The reefs seen at low water have in this way been formed.

Fossil Forest.—" The trees are lying confusedly one upon another. I saw no erect trunks, or any other indication that the forest had been submerged while growing in its native soil like that of the Isle of Portland; but, on the contrary, the appearance both of the trunks in the sand-rock, and of those exposed to view by the removal of the materials in which they were originally imbedded, is that presented by the rafts that float down great rivers, as for example the Ohio and Mississippi. Such rafts entangle in their course the remains of animals and plants that may happen to lie in the bed of the river, and at length subside and are buried in silt and sand. The fossil trees in this cliff are associated with large river shells and with the bones of colossal land reptiles. The fossil forest at Brook Point we may therefore consider as a raft of pines which floated down the river of the country near which the Wealden beds were deposited, and had become submerged in the delta or estuary at its mouth, burying with it the bones of reptiles and the large freshwater mussels it had entangled in its course.

" The trees when lying in the sandstone are invariably covered with their bark, which is now in the state of lignite, varying from one to three or four inches in thickness, according to the magnitude of the trunk. This carbonized cortical investment is quickly removed on exposure to the action of the waves, but the ligneous structure, the woody fibre, remains.

" The trees are calcareous and not siliceous like those of Portland. They are more or less traversed by pyrites, and the delicate veins and filaments of this mineral which permeate the woody fibre impart a beautiful appearance to the polished specimens, particularly to those which exhibit a transverse section of the stems. The trunks are generally of considerable magnitude, being from one to three

* Englefield's Picturesque Beauties of the Isle of Wight, p. 153.
† Geol. Trans., 2nd Ser., vol. iii. p. 202.

feet in diameter. I traced two upwards of twenty feet in length, and these were of such a size as to indicate a height of forty or fifty feet when entire. They appear to have attained maturity.

"In the conversion of the bark into lignite, and in the smooth condition of the trunks, this fossil forest presents a remarkable dissimilarity from that of the Isle of Portland, in which, so far as I have observed, the carbonized bark rarely, if ever, occurs, and the surface of the stems is similar to that exhibited by the trunks of old decorticated trees that have been much weathered by alternate exposure to air and moisture. At Brook Point, on the other hand, the trees appear to have been engulfed when fresh and vigorous, and when their bark and vessels were full of sap. The annular lines of growth are often very distinct, and I have traced from thirty to forty on some of the stems, but these circles are unequal, and indicate therefore a variation from year to year in the climate of the country in which they grew. The wood exhibits, under the microscope, coniferous structure of the type seen in the *Araucaria* (Norfolk Island Pine), the rows of glands or ducts being placed alternately, and the appearance being similar to that of the fossil wood of Willingdon in Sussex*. I observed no trace of the foliage of these trees, nor of their fruit, with the exception of a small cone, scarcely so large as that of the larch†.

"In the strata that overlie the fossil forest, thin interrupted seams and irregular masses of lignite are very abundant, and their substance is more or less impregnated with and permeated by iron pyrites. Fossils similar to these occur also in the clays of Tilgate Forest and at Hastings.

"The various conditions in which the remains of vegetables are preserved in the Wealden strata suggest many interesting inquiries. Why, for instance, is the bark so much more frequently carbonized than the woody fibre? Why do the trunks of Coniferæ occur in the state of coal in the old carboniferous strata and not in the deposits before us? What conditions occasioned the difference observable in the state of the fossil trees at Brook Point and at Portland? Why has the *Endogenites erosa* of the Wealden (a monocotyledonous tree) always a thick coat of lignite, while the *Clathraria* (a plant allied to the Yucca) is never carbonized? And lastly, is the interpretation of these phænomena to be sought for in the original organization of the plant, or in the state of the trees at the period of their submergence, or in the conditions of deposit, whether mineral or with reference to the degree by which they were affected by air and moisture?‡"

* Quart. Geol. Journ. vol. ii. p. 51; Medals of Creation, p.166, pl. 5. f. 3.

† Two cones (now in the possession of Mr. Dixon) have been obtained from the Isle of Wight, probably from the Wealden strata; but their locality being uncertain, no satisfactory evidence is afforded of their relation to the fossil trees under consideration.

‡ The author suggests that a white calcareous incrustation observed on many fossil bones obtained from this spot may probably be derived from the fresh-water springs that percolate through the strata of the cliff, which are composed of clay,

The strata at Brook Point continue for several hundred yards along the cliffs, and it was in these beds that the author discovered the large mussel-shells that inhabited the river of the country already alluded to. The *Unio valdensis* (as this species has been named) was first observed in the sandy clay beds immediately above the fossil forest, and several examples have since been found in other places along this line of cliffs. It is a species remarkable both for its large size and for the perfect state of preservation in which it is found. The horny ligament generally remains in a carbonized state, and the body of the animal occurs as molluskite, but the substance of the shell is often changed into compact calcareous spar, and nodules of crystallized sulphate of barytes of a pink colour are not uncommon within the shells*. From the same strata bones of the Iguanodon and other Wealden reptiles are obtained, the specimens usually collected having been washed out of the cliffs by the inroads of the sea, and being strewn along the shore. In this way they have commonly suffered so much by attrition that the processes are destroyed, and those parts defaced which are of most value to the anatomist as distinctive characters.

The number of bones collected along this coast during the last ten years amounts to many hundreds, and although from their rolled condition most of them are of no value as specimens, yet they serve at least to show the abundance of these relics. Many of them surpass in magnitude the largest of the Wealden bones in the British Museum.

The strata at Sandown Bay, shown in Dr. Fitton's section, emerge from under the greensands, and consist of clay, clay-shale, sand, and slabs of bluish-gray argillaceous limestone abounding in the usual shells of these freshwater deposits; and here, as at Brook, the bones of colossal reptiles are continually washed out of the cliffs. This shelly limestone, occurring in layers from one to three inches thick, and of uniform surface, is often employed for paving; slabs with the shells of the *Cyclas*, *Paludina* and *Unio* may often be detected in the pavements at Ryde and other places in the island, as at Battle, Hurstmonceaux and elsewhere in Sussex. The surface of the slabs is often deeply sculptured with ripple-marks; and very recently some markings have been observed that are supposed to be the imprints of the feet either of birds or reptiles.

Fossil remains of many of the large reptilian animals which have conferred so much celebrity on the strata of Tilgate Forest have been obtained from these contemporaneous deposits in the Isle of Wight, and amongst them the bones of the *Megalosaurus*, *Strepto-*

lignite, sulphuret of iron, and shelly limestone. The lignite he thinks might have supplied the carbonic acid, and he quotes the authority of Dr. Liebig in favour of this view.

* Doubt having been expressed as to the correctness of assigning a new specific name to this shell, the author states that Mr. James Sowerby, who figured and described the *Unio Martini* of Dr. Fitton (presumed by some to be the same species), concurs in his opinion, and has figured the shell under the above name for the 'Mineral Conchology.'

spondylus and *Iguanodon* are the most numerous. The author directs especial attention to a large thigh-bone together with portions of ribs and vertebræ (exhibited to the Meeting when this paper was read) which he obtained lately from the clay at the foot of the cliff near Brook. The thigh-bone is three feet four inches long; it well exhibits the peculiar characters of the femur of the Iguanodon, namely, the head with its flattened lateral trochanter, the middle of the shaft with the mesial lateral process, and the inferior extremity with its double condyles separated by a deep sulcus or furrow both anteriorly and posteriorly. With this femur was found a tooth, fragments of ribs and other bones, and several vertebræ, caudal and dorsal. The tooth is large and worn down to a stump, and the fang has been absorbed owing to the pressure of a successional tooth. Like the femur it evidently belonged to an aged animal, and very probably to the same individual. The caudal vertebræ may also be assigned to the same reptile without hesitation, but the dorsal appears to be referable to the Cetiosaurus.

Another bone of Iguanodon to which the author directs particular attention is from Sandown Bay, the locality whence was obtained a large toe-bone, figured by Dr. Buckland in the Geological Transactions*. This specimen is the lower extremity of a tibia, or large bone of the leg, and its proportions are more colossal than those of any bone of this reptile hitherto described. The Sandown specimen exceeds by four times in linear dimensions the tibia of a young Iguanodon from Tilgate Forest one foot in length. It was therefore probably four feet long when entire; and from the relative proportion of the thigh-bone and leg-bone of the Iguanodon, as shown by specimens of the same individual in the British Museum, the femur of the limb to which this tibia belonged must have measured five feet, so that the entire length of the leg and thigh would be nine feet.

Besides these bones, the author has collected a fine metatarsal from the Wealden near Atherfield, as well as several very large and well-preserved vertebræ of the Streptospondylus, and fragments of the ribs of a large Iguanodon.

Section of the Wealden strata exposed by the cutting in the Tunbridge Wells Railway near Tunbridge.

"As connected with the subject of this paper, though situated in a district remote from the Isle of Wight, I add a few remarks on a section of the Wealden beds recently exposed, which is so interesting and so easily accessible, and may possibly be so soon obliterated, that a brief notice of it will be useful.

"This section has been formed by the cutting for the railway lately opened from Tunbridge to Tunbridge Wells, the line traversing Wealden strata along the whole distance. Immediately on leaving the Tunbridge station there is a deep cutting which exposes two bands, from three to four feet thick, of fawn-coloured sandstone re-

* Geol. Trans., 2nd Ser. vol. iii. pl. 41.

sembling that around Tunbridge Wells. Between these bands are beds of clay and laminated clay-shale, and seams of shelly argillaceous limestone of a bluish-gray colour. The usual shells of the Wealden and the remains of several species of *Cypris* abound in these strata, and the laminated character and general appearance of the clay beds and their fossils will remind the observer of the strata at Brook and Sandown Bay.

"These strata continue through the tunnel which then succeeds and for a considerable distance on the other side, and both in the sandstones and clays, stems of *Equisetum Lyelli* (a plant first discovered by me at Pounceford in Sussex) are abundant. They are invariably carbonized, and thin seams and blocks of lignite, evidently derived from accumulated masses of the same species, are thickly interspersed.

"Beyond the tunnel and after passing under a small bridge, blocks of marly sandstone may be observed containing remains of *Equisetum*, of *Cypris*, and of minute bivalves (*Cyclas parva* of Dr. Fitton). The surface of the shales and clays is often deeply rippled and covered with slight markings resembling worm-tracks, but these when freshly exposed have a carbonaceous coating indicative of their vegetable origin. The position of the strata in these Tunbridge sections is interesting, as it exhibits in a striking manner the undulated condition of the beds so commonly to be observed throughout the Wealds of Kent and Sussex,—a result of those earthquake waves, if we may so say, to which this region must have been long ago subjected.

"In the line that extends from Tunbridge to Maidstone, good sections of Wealden strata are exhibited in several places. At Wateringbury, as Mr. Bensted first pointed out, the clays and marls abound in *Paludinæ*, *Cyclades*, scales of fishes (*Hybodus*), &c.; and in some of the slabs of marlstone from this place, sent to me by Mr. Bensted, I found elytra of two or more species of Coleoptera, which are the only vestiges of insects I have obtained from the Wealden deposits of the south-east of England."

December 17, 1845.

John Morris, Esq., and Dr. Edward Kellaart were elected Fellows of this Society.

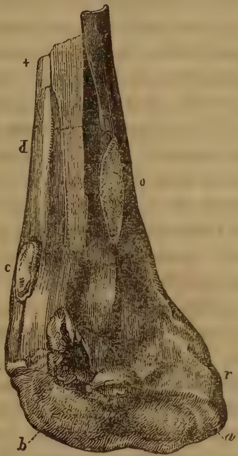
The following communications were read:—

1. *On the supposed Fossil Bones of* Birds *from the* Wealden. By Prof. Owen, F.R.S., F.G.S. &c.

Having lately, in a re-examination of the Wealden fossil described in the Transactions of this Society*, chiefly on my authority, as the tarso-metatarsal bone of a Bird, exposed by the detachment of the

* 2nd Series, vol. v. p. 175. pl. 13. figs. 1*a*, 1*b*.

Fig. 1.



Anterior or palmar aspect of the distal end of the humerus of a Pterodactyle. Wealden. (Natural size.)

matrix that adhered to its extremity some characters not visible when the fossil was first submitted to me, and having been led by those new characters to institute a more extended and rigorous comparison of the fossil than it was in my power to do ten years ago, I believe myself in a condition to demonstrate my former error in ascribing it to the class of Birds, and I therefore lose no time in rectifying it. The character mainly relied on as proving the fossil in question to be the lower end of a tarso-metatarsal bone of a wading bird, was the rough oval spot marked *o* in fig. 1 *b*, pl. 13, of the above-cited volume, and this, if interpreted as the articular surface for the hind-toe, would indicate a form of metatarsal bone like that of the restored figure given by Dr. Mantell, by the dotted outline in the above-cited plate. But the characters since brought to light prove the bone (fig. 1) to have terminated much nearer the oval spot (*o*), since they consist of *two portions of the distal smooth articular* surface, one (*a*, fig. 1 & 3) situated near the margin of one side of the joint, at right angles to the axis of the bone; the other surface (*b*) being a smooth protuberance near the middle of the concave side, but at the end where the small mass of light-coloured matrix appears in Dr. Mantell's figure 1 *b*. Now, as these surfaces have formed part of the articular extremity of the fragment, and establish its true position, traces of the vertical or longitudinal fissures separating the condyles ought to be present, if the fossil were actually part of a tarso-metatarsal bone, and more especially on the convex side, fig. 2; for in none of the tarso-metatarsal bones of the numerous birds which have been compared with the fossil, are the grooves or foramina, indicative of the divisions of the end of the bone for the trochlear joints of the toes, entirely absent, as they are in the smooth, slightly undulating convex surface of the expanded end of the fossil.

Fig. 2.

Posterior or anconal aspect of the distal end of the humerus of a Pterodactyle. Wealden. (Natural size.)

On the metatarsal hypothesis, the prominent convex articular surface *b*, fig. 1, could be no other than part of the projecting trochlea for the middle toe; but it is uniformly convex, not grooved as in that trochlea in the Heron and other birds; and, moreover, there is no cleft in the fossil bone separating it from the adjoining condyle, which cleft must have been present if the fossil had been a tarso-metatarsal. There is a second smaller rough elliptical surface at *c* (fig. 1), on the concave side of the bone near the margin opposite to that where the larger surface *o* is situated: the median margin of the smaller surface *c* is slightly raised. This surface is wanting in the tarso-metatarsals of the Heron and other birds. But the most decisive evidence against the metatarsal character of the fossil in question, now that the true position of the distal articulation is determined, is given by the configuration of the opposite or convex side of the expanded end of the bone, which proves that end to have been simple, not trifid (fig. 2).

After the recognition of the above characters of the Wealden fossil, I proceeded to compare it with other bones of the skeleton of birds, and found in the lower or distal extremity of the humerus, the part that most nearly resembled the fossil in its present condition. This part presented, for example, the same unequal expansion, the same smooth and gently undulating convexity on the back part, and a similar concavity on the fore part; a portion of the distal articular surface corresponding with that marked *a*, and a prominence of the outer condyle, which corresponds with that marked *b* in fig. 1. In the humerus of most birds of flight, there is a rough surface on the concave (anterior) side of the distal end, about as far from the condyle or articular surface as the spot *o* in the Wealden fossil, and there is also, in some, as the Cranes and Herons, a small elliptical surface, lower down, near the opposite margin, with the edge next the middle of the bone slightly raised, like that marked *c* in fig. 1, but nearer the distal end.

I am led by these resemblances to regard the fossil as the distal end of a humerus, and by the analogy of that bone in Birds, to be part of the left humerus. The thin compact walls (figs. 4 and 7) and large cavity of the bone determine it to have belonged to a creature endowed with the power of flight. Yet, although the first bone of the wing in Birds offers the nearest general resemblance to the fossil, there are several important differences in the fossil.

The surface answering to *o* (fig. 1) is usually larger and of a

Fig. 3.

Fig. 4.

Fig. 3, under view, fig. 4, upper view, of the distal end of the humerus of a Pterodactyle. Wealden. (Natural size.)

rhomboidal form, as in the Eagle, or is triangular, as in the large Cranes, extending into the anterior concavity, and in all cases nearer to the smaller surface *c*, than in the fossil. The surface answering to *c*, also, is always lower down in the humerus of birds; in fact, on the fore-part of the ulnar condyle. The fossil humerus has the radial or outer condyle more produced, more extensive and thinner; the whole distal end expands more gradually, and to a greater extent in the fossil in proportion to the diameter of the shaft, *i.e.* than in any bird's humerus. If the surface *b* (fig. 1 & 3) be the anterior extremity of an oblique elliptic articular tuberosity, answering to the radial tuberosity in the bird's humerus, it is nearer the middle of the distal end of the bone, as it is in Bats and Pterodactyles; and the outer distal surface *a* is broader than the analogous surface, which rests on the radio-ulnar ligament in Birds.

The linear ridges *d*, like those that afford attachment to the aponeurotic thecæ, which bind down the tendons as they glide along the metatarsus to the toes, in Birds, are not present on the fore-part of the humerus of Birds; but similar ridges are present on the back part of the upper half of that bone, and they exist in most of the long bones of Pterodactyles.

In short, the amount of resemblance and of difference respectively, which is demonstrable between the fossil and what I take to be the corresponding bone in Birds, is such as is found in certain bones of those bird-like reptiles the Pterodactyles.

The distal end of the humerus in the *Pterodactylus macronyx* from Lyme Regis, now in the British Museum, described and figured by Dr. Buckland in the 'Geological Transactions,' vol. iii. 2nd series, pl. 27, shows the same general form and gradual expansion; but the condition of the fossil does not permit the comparison to be pursued into the needful details for unequivocal determination. I proceed, therefore, to give the result of my re-examination of the second of the most characteristic fossils from the Wealden, attributed to a bird, that, viz., which I formerly stated in the note cited by Dr. Mantell to be "very like the head of the humerus of a bird, but to differ from any in the Museum of the College in the sudden expansion of the head *."

This expansion is due to the outward extension of the broad and thin process *g*, fig. 5, answering to the outer or deltoidal process in the

Fig. 5.

Posterior surface of the proximal end of the humerus of a Pterodactyle. Wealden. (Natural size.)

* *Loc. cit.* p. 176.

humerus of the bird, and to a corresponding production, though to a less extent, of the opposite or thicker angle *f*, answering to the inner tuberosity in Birds. The exposed surface of the fossil is therefore the posterior or *anconal* surface, towards which the transversely extended articular head of the bone *e* is inclined. The difference between the fossil proximal portion of the humerus and that part of the skeleton in birds of flight, is manifested by the more reniform figure of the head *e* in the fossil (figs. 5 and 6), its closer proximity to the inner tuberosity *f*, the minor production of that tuberosity, the absence of the cavity on its back part, and of the pneumatic foramen, which in birds of flight is there situated; and lastly, the greater length and less extent in the direction of the axis of the bone, of the outer plate or process *g*.

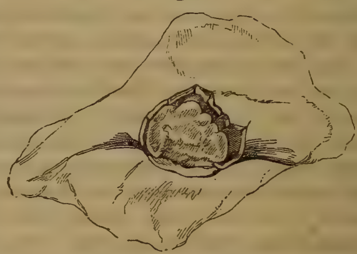
Fig. 6.

Upper view of proximal end of the humerus of a Pterodactyle. Wealden. (Natural size.)

It may therefore be inferred, that the large cavity shown at the broken ends of the fossil (fig. 7) was filled, as in Bats and Pterodactyles, by a light fluid marrow, and not by air.

The humerus of the *Pterodactylus macronyx* above cited shows a similar form of the outer proximal plate marked 1″*, and though this process is unluckily broken off in both humeri of that unique specimen, yet its great length is indicated by an impression in the matrix. The whole extent of this process is fortunately shown in the *Pterodactylus crassirostris* figured by Goldfuss†; and in that of the *P. longirostris*, given by Cuvier in the 5th volume of the 'Ossemens Fossiles,' pt. ii. pl. 23, Cuvier says, in reference to the humerus of the Pterodactyle, "On peut remarquer que sa tubérosité antérieure, (1) est fort saillante comme dans les tortues de mer et dans les oiseaux, ce qui convenoit très-bien au premier os d'une véritable aile." (p. 369.)

Fig. 7.



Lower view of proximal end of the humerus of a Pterodactyle. Wealden. (Natural size.)

The comparison is obviously general, in reference to the modification of the humerus in relation to flight; but the special difference of form and proportion between the process alluded to in the Pterodactyle and the homologous one in the bird, is precisely that which the fossil head of the humerus from the Wealden presents in comparison with the humerus of a bird of flight.

* *Loc. ante cit.* pl. 27.

† Beiträge zur Kenntniss verschiedener Reptilien der Vorwelt; Goldfuss, Nova Acta, &c., xv. pt. i. p. 63. tab. 7, 8, 9.

I conclude, therefore, that the Wealden fossil (fig. 3) is the proximal end of the left humerus of a Pterodactyle: and since the other fossil from the Tilgate strata (figs. 1 to 4) is the distal extremity of a left humerus, presenting the same degree of approximation to that part in the bird, but with differences irreconcileable with their identity, and which are most likely to be such as will be found in the same part in a Pterodactyle; and since the fossil (figs. 1 to 4) corresponds precisely in its proportions and the size of the shaft with the fossil (figs. 5 to 8), it is highly probable that it is part of the same bone; and it is more than probable that it has belonged to a Pterodactyle, and not to a bird: and thus it appears that an affirmative reply must be returned to the sagacious inquiry by Dr. Buckland, whether "the bones discovered in the strata of Tilgate forest may not, on more careful examination, prove to belong to the Pterodactyle*."

The Wealden fossils here commented on formed part of Dr. Mantell's valuable collection and are in the British Museum.

The species indicated by the highly interesting fossils, viz. the proximal and distal end of the humerus above described, must have been about one-third larger than the *Pterodactylus macronyx* from the lias of Lyme Regis, described by Dr. Buckland in the 3rd vol. of the 2nd Series of the Society's Transactions, p. 217; and it was probably as large as the Pterodactyle from the chalk exhibited by Mr. Bowerbank at a meeting of the Society in May last†.

This latter discovery has very naturally suggested a doubt respecting the described Ornitholites from the chalk, analogous to that expressed by Dr. Buckland with regard to the supposed Ornitholites from the Wealden, and the question may now be urged with greater force, since the re-examination of the supposed Wealden Ornitholites has tended to prove them to belong to the Pterodactyle. If only the shafts of hollow, long bones, like that figured in the Geological Transactions, 2nd Series, vol. vi. pl. 39. fig. 1, had been discovered in the chalk, the idea of their having belonged to Pterodactyles might be admissible; notwithstanding the prodigious size which, in that case, must have been attributed to the species of Volant Reptile of the cretaceous epoch; but the evidence of a bird in the chalk formation rests upon a much more characteristic bone, the distal trochlear end, *e.g.* of a tibia, a figure of which is given in the plate above-cited, fig. 2.

This form of the lower end of the tibia is quite peculiar to Birds, and relates to the equally peculiar absence of distinct tarsal bones; these bones being confluent with, and apparently forming, the simple superior extremity of the tarso-metatarsal bone in the bird. In the Pterodactyle there is a true tarsus, consisting of two larger ossicles in the first row, and of two or three in the second row, like those of Lizards, and the distal end of the tibia is modified conformably.

I have recompared the specimens originally submitted to me by the Earl of Enniskillen, and described as the remains of a longipennate bird in the Society's Transactions‡; and I cannot, at present,

* Geol. Trans. 2nd Series, vol. iii. p. 220. † See *ante*, p. 7.
‡ 2nd Series, vol. vi. p. 411, and pl. xxxix.

see grounds for any other determination of those chalk fossils. If, as seems most probable, the Ornithichnites of the New Red Sandstones of Connecticut are the foot-prints of birds, species of the feathered class may well have been associated with Pterodactyles in the more recent secondary strata.

We have no satisfactory evidence, however, of the existence of birds in the Wealden.

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2. *On* Amber *and on the Organic Remains found in it.* By Professor Göppert of Breslau.

[Communicated by Sir R. I. Murchison, G.C.S.]

Amber appears to be a product formed during the period of the Molasse. The forests in which the trees grew whence this substance was derived, were situated in the south-eastern part of what is now the bed of the Baltic, in about 55° north latitude, and 37°–38° east longitude. With the commencement of the diluvial period this forest was gradually (probably at long intervals) destroyed, being swept away by diluvial torrents, and possibly also by storms coming from the north and north-east, and the amber was thus drifted to the south and south-west, on the coasts and in the countries where we now find it. Amber was a resinous exudation from an extinct pine, *Pinites succinifer*, most nearly allied to *Pinus abies* and *P. Picea,* but differing from these in several respects. The resin exuded chiefly from the root stock, but also from the bark and the wood, as is still the case with the resin called *Copal*, and others. The different colours of amber are derived from local circumstances of chemical admixture.

Among the fragments of vegetable matter contained in this substance those of dicotyledonous trees are chiefly abundant, and the tribe of *Coniferæ* no doubt occupied a great part of the amber forest. Of Pine there are at least four species, and with these we find *Cypress*, *Taxodium*, *Thuia* (five species), and also *Juniper* and *Ephedra*. Of leaf-bearing trees we find *Quercus*, *Fagus*, *Carpinus*, *Betula* and *Populus*; and of underwood, *Ericaceæ* with coriaceous leaves, &c., forming in the whole a flora comprising forty-eight species, which has considerable resemblance to that of North America. There was also a cryptogamous flora, including a beautiful fern, *Pecopteris Humboldtiana*, several mosses, and some small *fungi*, *Confervæ* and liverworts which are yet undetermined.

The fauna of this period was extremely numerous, upwards of 800 species of insects having been discovered, besides the remains of *Crustacea*, *Myriapoda*, *Arachnidea*, &c. The insects include *Aptera*, *Diptera*, *Neuroptera*, *Coleoptera*, *Libellulæ*, &c., but water insects are rare. Only a few hairs and feathers of Mammalia and Birds have as yet been obtained, and the fragments of Amphibia and Fishes that have been described are artificial productions.

All the remains, both of vegetables and animals, contained in the amber exhibit only a generic identity with existing plants and animals, and are not specifically the same. The most nearly allied forms occur sometimes in the same district, but more frequently in North America. Several of the species exhibit, however, no analogies with known forms.

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3. *Notice of an Earthquake and a probable Subsidence of the Land in the district of* CUTCH, *near the mouth of the* KOREE, *or Eastern branch of the* INDUS, *in June* 1845. Extracted from a Letter to Capt. NELSON, R.E.

[Communicated by the President.]

" ONE of Capt. McMurdo's guides was travelling on foot to him from Bhooj. The day he reached Luckput there were shocks of an earthquake, which shook down part of the walls of the fort, and some lives were lost. At the same time as the shock the sea rolled up the Koree (the eastern) mouth of the Indus, overflowing the country as far westward as the Goongra river (a distance of twenty English miles), northward as far as a little north of Veyre (forty miles from the mouth of the Koree), and eastward to the Sindree Lake. The guide was detained six days (from June 19th to 25th), during which time sixty-six shocks were counted. He then got across to Kotree, of which only a few small buildings on a bit of rising ground remain. Most of the habitations throughout the district must have been swept away, the best houses in Scinde being built of sun-dried bricks, and whole villages consisting only of huts made of a few crooked poles and reed mats. The guide travelled twenty miles through water on a camel, the water up to the beast's body. Of Lak nothing was above water but a Fakeer's pole (the flagstaff always erected by the tomb of some holy man); and of Veyre and other villages only the remains of a few houses were to be seen.

" There are said to be generally two earthquakes every year at Luckput. The Sindree Lake has of late years become a salt marsh."

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4. *On the Occurrence of Nodules (called Petrified Potatoes) found on the Shores of* LOUGH NEAGH *in Ireland.* By the Very Rev. Dr. BUCKLAND, F.R.S. &c. &c., Dean of Westminster.

THE author stated that these peculiar nodules seem to be limited in their occurrence to the space between high and low water on the margin of Lough Neagh. Their average size is from two to three inches in diameter; they are irregularly spherical or suboval, with the surface occasionally indented. They are composed of a grey marlstone interspersed with black and green sand. They effervesce with acids.

Extraneous fragments occasionally project from them and are half imbedded in their sides. On being broken they are found to be intersected with cracks, like septaria, probably the result of desiccation, and subsequently filled by crystalline carbonate of lime.

The author explains the origin of these stones by referring to the analogous concretions of clay described by him many years ago, and occurring on the sea-shore at Lyme Regis. These latter are coprolitic, containing within them undigested scales and bones of fishes; but the Lough Neagh stones, although only containing fragments of stone, are, like these marine Bezoars of Lyme, formed by the rolling action of the waves of the lake on balls of clay, which gather up any extraneous substance that may come within their adhesive contact.

They have been subsequently hardened by exposure to the drying action of sun and wind in summer, and afterwards have again undergone attrition by the waves when the waters of the lake have once more reached them, perhaps at the return of winter.

January 7, 1846.

Henry Scale, Esq., and George Thornton, Esq., were elected Fellows of the Society.

The following communications were read:—

1. *On the Fossil Remains of* Birds *in the* Wealden *Strata of the* South-east *of* England. By G. A. Mantell, Esq., LL.D., F.R.S.

As the recent communication of Professor Owen, "on the Supposed Fossil Bones of Birds in the Wealden,"* relates to a specimen described by me in the Geological Transactions, vol. v. p. 175, and accurately figured in that volume (pl. 13. figs. 1 and 3), I am inclined to solicit the attention of the Society to the following remarks on this interesting subject.

These two portions of bone were discovered by me twelve years since in a quarry near Cuckfield in Sussex. Each specimen was imbedded in a mass of sandstone of the same colour and composition; and though formed separately, and the intermediate portions both of bone and sandstone wanting, the resemblance between the fossils was such that I did not hesitate to consider them as the upper and lower extremity of the same bone. I cleared away the stone with great care, and attached the two portions to a card, with a dotted outline to indicate the supposed line of union. The specimen was exhibited in this state in my museum at Brighton; the humerus of a bird being placed beside it, to show the general resemblance

* See *ante*, p. 96.

between it and the fossil. When Professor Owen, in 1835, obligingly offered to institute a rigorous examination of all the bones in my collection that were supposed to be referable to Birds or Pterodactyles, his attention was particularly requested to the specimen in question. The result of that examination was given by me in the Memoir on Fossil Birds, above referred to, and to that paper I beg to refer, to avoid unnecessary repetition. It will suffice for my present purpose to state that Professor Owen deemed my conjecture as to the original individuality of the two portions erroneous, and referred the head of the bone to a humerus, as I had done, but the other extremity he pronounced to be the tarso-metatarsal of a Wader. In Professor Owen's recent communication to the Society, the data on which his present interpretation of that fragment is founded are fairly and perspicuously detailed. Both portions he now admits to belong to but one bone; and the supposed tarso-metatarsal, which upon such high authority I had announced as affording proof of the existence of birds during the Wealden period, proves to be the lower extremity of a humerus. This humerus, for anatomical reasons which are fully explained in Professor Owen's communication, he now considers to be indisputably that of a Pterodactyle, and not of a Bird; and he also arrives at the conclusion that all the other supposed birds' bones of the Wealden must be referred to flying reptiles; an opinion which I submit is not based on satisfactory grounds. In the first place, the bone which has given rise to these remarks is imperfect at both extremities. The inferior end, though now rendered somewhat more intelligible from a few particles of stone having recently been removed, has but a very small part of the articulating surface remaining, and there are no characters by which a correct outline of the original could be restored. The upper part is also imperfect, and if it be assumed to belong to a Pterodactyle, it should, I conceive, have some indications of the prominent convex head (*a*) to fit the socket of the glenoid cavity, as in the humerus of the *Pterodactylus crassirostris* of Goldfuss, of which an outline is annexed; but no vestige of such a process can be discovered. The utmost therefore that can be predicated as to the fossil is, that it is the humerus of an animal capable of flight; that it possesses characters which bring it in close relation to the corresponding bone of Birds and Pterodactyles, but that the state of the articulating surfaces of the extremities is too imperfect to warrant a positive determination as to which order of beings the original belonged. To affirm that this humerus is that of a Pterodactyle appears therefore to me, in the present state of our knowledge, just as likely to lead to error as was the former misinterpretation of the lower extremity of this fossil. In the next place, notwithstanding the accession which has been made to palæ-

Humerus of Pterodactyle from Goldfuss.

ontology since the lamented death of Baron Cuvier, the opinions of that illustrious philosopher on this subject ought not to be rejected upon such insufficient data as those hitherto obtained. Some of the specimens inspected by Baron Cuvier are not at this time exhibited in the British Museum, nor have I been able to obtain a sight of them to examine them anew; the humerus was not found till after the death of Baron Cuvier. The whole of the evidence which satisfied the founder of Palæontology of the existence of birds' bones in the Wealden strata is therefore not before us: but be this as it may, I contend that it is premature and unphilosophical to pronounce that all the bones belonging to animals capable of flight found in these deposits are to be referred to Pterodactyles; the evidence may be deemed presumptive but not conclusive: surely the great discrepancy between the former and present interpretation of the fossil that has given rise to these observations affords a salutary caution which should not be wholly disregarded.

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2. *On the Classification of the Fossiliferous Slates of* CUMBERLAND, WESTMORELAND *and* LANCASHIRE (being a Supplement to a paper read to the Society, March 12, 1845). By the Rev. A. SEDGWICK, M.A., F.R.S., Vice-Pres. G.S., Woodwardian Professor of Geology in the University of Cambridge.

PART I.

§ 1. *Introduction.*—An abstract of my former memoir on this subject having been published in the first volume of the Geological Journal*, I am spared the necessity of entering on many details by way of introduction. Since however the subject before me is one of great complexity, I may be permitted to enumerate the results I before arrived at, and to illustrate them by sections.

The general section through the great Cumbrian cluster of mountains gives us three distinct groups of slate rocks.

1. GENERAL SECTION across CUMBERLAND.

11. New red sandstone.
10. Coal-measures.
9. Mountain limestone.
8. Old red sandstone.
7. Coarse slate and flagstone.
6. Calcareous slate of Coniston.
5. Green roofing slate and porphyry.
4. Skiddaw slate.
3. Chiastolite slate.
2. Syenite.
1. Granite.

* Vol. i. p. 442.

III. Upper system of slates, with a few calcareous bands full of fossils, the whole deposit more or less fossiliferous.

II. Green roofing slate and contemporaneous porphyry, &c.

I. Skiddaw slate, the lower part of which is metamorphic.

The superficial extent of these three groups is represented on the maps of Cumberland and Westmoreland which I have had the honour to present to the Society, and the lowermost (I.) has no exact parallel in Wales. The one marked II. is put on the parallel of the Snowdonian slates, but in Cumbria contains no fossils. The next (III.) commences with beds of the age of the Caradoc sandstone, and ends with rocks obviously of the age of the Upper Ludlow rocks and tilestone of the Silurian system: it therefore includes the whole or nearly the whole of that system. The subdivisions of this great physical group (III.) were described in detail in the paper just alluded to, and were in the following order:—

6. A great group nearly parallel with the Upper Ludlow rock, and ending on the banks of the Lune with a red flag or tilestone.

5. Coarse slates, flags, grits, &c.

4. Ireleth slates, &c., subdivided into three subordinate groups: viz.

- *γ*. Upper Ireleth slate.
- *β*. Calcareous slate and limestone.
- *α*. Lower Ireleth slate.

3. Coniston or Furness grits. Thickness greater than No. 2.

2. Coniston or Brathay flagstone. Thickness 1500 feet. On the parallel of Wenlock shale.

1. Coniston limestone, surmounted by calcareous shales and slate. Aggregate thickness about 300 feet. Fossils, Lower Silurian.

During the past summer I have re-examined a part of the evidence on which I endeavoured to establish these subdivisions of the fossiliferous slates of Westmoreland, &c., and I still adopt the first four subdivisions almost without change. But No. 5. (coarse slates, flags, grits, &c.) I now consider as forming a sub-group of No. 4, or Ireleth slates, and No. 6. I subdivide into two groups,—a lower and an upper. The lower of these two groups passes into the system of the Ireleth slates in the descending sections, and in the ascending sections passes into the upper group, which ends with the tilestone. This slight change I was compelled to adopt when I endeavoured to lay down the subdivisions of the whole fossiliferous series on the county map; but it is in itself unimportant, and it involves no change of principle. According to this scheme, No. 5, the upper group (on the parallel of the Upper Ludlow rock) is subdivided into—

- *b*. Arenaceous slates, grits and flags, almost without cleavage, and passing in ascending order into green and red arenaceous flagstone (*tilestone*) (*c*.).
- *a*. Slates, grits and flags, with partial slaty cleavage, and passing into and blending with *δ* of No. 4.

No. 4. Ireleth slates, &c., includes

- *δ*. Coarse slates, flags and grits, &c.
- *γ*. Upper Ireleth slates.

β. Calcareous slate and limestone.
a. Lower Ireleth slates.

These are followed by No. 3, the Coniston grits, No. 2, the Coniston flagstone, and No. 1, the Coniston limestone, &c.

The scheme here given agrees with the annexed ideal vertical section of the whole Cumbrian series, inferior to the old red sandstone.

IV.	7 Great scar limestone.	
	6. Old red sandstone.	
III.	5. Upper slate of Kendal.	c. Red flagstone.
		b. Coarse flagstone.
		a. Finer flagstone.
	4. Ireleth slates.	δ. Coarse slates, flags and grits, &c.
		γ. Upper Ireleth slates.
		β. Calcareous slate and limestone.
		α. Lower Ireleth slates.
	3. Coniston grit.	
	2. Coniston flags.	
	1. Coniston limestone.	
II.	Green slate and porphyry.	
I.	Skiddaw slate, the lower part metamorphic.	
	GRANITE.	

Note.—The letters and figures of reference in this table apply to the different sections accompanying the present paper.

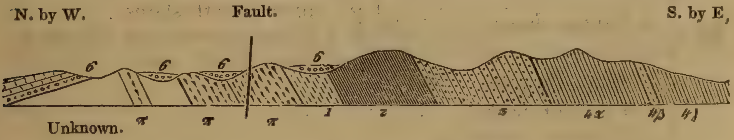
In the following communication it is my object, first, to explain the scheme above given by an appeal to actual sections and lists of fossils; and secondly, by help of this scheme to explain the physical structure and geological relations of a remarkable tract of country, including Howgill Fells, the Fells near the foot of the valley of Dent, and Middleton Fells, which range to the neighbourhood of Kirkby Lonsdale. The latter portion of my task is by far the most important, as it relates to a country with the structure of which I was almost entirely unacquainted before last summer, and which had never before been examined in any detail.

§ 2. *Successive groups.—The fossiliferous series.—Evidence offered by detailed sections,* &c.

1. *Coniston limestone and calcareous slate, &c.*—The general relations, structure and fossils of this group have already been given in some detail; and I should not here attempt to add anything on this head to the published abstract, had I not, during the last summer, visited the north-eastern extremity of the formation near Shap Wells, and the other extremity at the south-western end of Cumberland. At both localities there are phænomena which deserve a passing notice. Near Shap Wells the Coniston limestone is in an indurated, concretionary and altered form, and is repeated twice over in the brook which runs past the wells; while an overlying mass of old red sandstone and a mass of felspar rock occupy the interval (about two or three hundred yards) between the two masses of limestone.

I formerly explained these appearances by supposing that the altered structure of the limestone or calcareous slate was due to the porphyry and felspar rock, which had burst in upon the line of the limestone and separated it into two masses. New cuttings for a railroad through this part of the country have given me what I think a better view of its structure. I now think the porphyry (like the porphyry found in some places immediately under the range of the limestone) is of an older date, and that the double appearance of the limestone is due to a fault. The accompanying section will sufficiently explain my meaning.

2. Section showing the reappearance of the Coniston limestone in consequence of a fault.



The phænomena are of great interest, but my limits prevent me from giving more than this passing notice of them; and it is obvious that they involve no principle of classification affecting the fossiliferous slates. Before I quit this subject I may just remark, that where the granite rises through the porphyry there are beautiful and complicated mineral results. Both the porphyry and granite are changed, but the demarcation may be pretty nearly traced, as the main masses are not confounded. About a mile north of Shap Wells the granite appears to have cut off the limestone. It is surmounted by a micaceous glimmering slate (like that so commonly seen close to the granite of Devonshire and Cornwall), which in one place is riddled through by granite veins*. Farther on the ascending section these granular and micaceous slates appear to pass into a hard splintery rock (in some places approaching the character of a felstone slate) of great thickness. These hard slates are only the Coniston flags (No. 2) altered by the granite, and, as is well known, they are traversed by one or two dykes of red quartziferous porphyry of a later date. In the long range of the Coniston limestone, from Shap Wells to the banks of the Duddon, which forms the boundary of the south-west end of Cumberland, I have at present nothing to add to statements given both in former papers of our Transactions and in the abstract in the first volume of the Geological Journal †, to which I must refer. But I was anxious to visit the south-west end of Cumberland, in the hope of deciding three questions. The first is, whether the Greystone House limestone on the hills west of Duddon Bridge is a true Coniston limestone? This bed is underlaid by beds of schaalstein, porphyry, slate, &c.; and

* I believe also that the granite has pushed the upper rocks out of their bearing, so that they are now seen to the south of the line of strike indicated by the same rocks farther south-west.

† *ante cit.* page 442.

similar rocks overlie the Greystone House limestone as far as the borders of the estuary immediately below Duddon Bridge. This fact is indicated in the colours of my field map exactly as I finished this part of it in 1822. My examination during the past summer enables me to answer this question in the affirmative. The limestone, though granular and crystalline, passes into ferruginous, cellular, calcareous slabs with fossils; and the whole development of the group (with the exception of a partial mineral change caused by the association with igneous rocks) is exactly like that of the Coniston limestone, and is very nearly on its line of strike, only a slight deviation having been produced by the valley of the Duddon. These alternations of fossiliferous and igneous rocks are anomalous in this part of England; but the very anomaly brings the formation I am describing into more intimate comparison with the rocks of the same, or nearly the same age in North Wales. Assuming the truth of what has been stated, it follows that the limestone must have been shifted by a vast fault and break of the whole series of strata, more than two miles from its original strike. Those who have studied the great dislocations of the strata near Coniston Waterhead will have little difficulty in admitting what is here stated*.

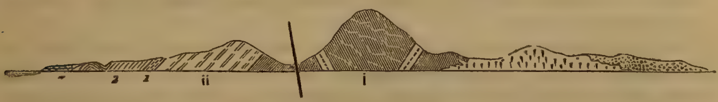
The second question I wished to examine was this,—Is there in the structure of the neighbouring county anything to explain this enormous Greystone House fault? I have already in another place answered this question in the affirmative. Immediately to the west of Greystone House, the rugged hills of green slate and porphyry rise to an elevation of about 1500 feet, and are penetrated by dykes of quartziferous porphyry (π). Similar slates and porphyries are continued farther south at a much lower level, and their beds are shattered in many directions: they then form the well-defined ridge of Millam Park, and range towards the sea along that ridge with a more regular strike, and a dip towards the south-east. Commencing among the shattered masses of slate and porphyry above noticed, and on the west side of the Greystone House fault (which runs nearly north and south), there runs a second enormous fault south-east and north-west down the Whitchamp valley as far as the sea-coast. On the north side of this second fault rises the contorted Skiddaw slate of Black Coomb†, which contains mineral veins (with lead, cobalt, &c.), is pierced by dykes of quartziferous porphyry, and at its northern end is altered by and jammed against the granite of Bootle. Close to the junction the altered Skiddaw slate is pierced with fine veins of true granite, rivalling some of the corresponding phænomena of Cornwall. The upheaval of the system of Black Coomb produced therefore, first, the great Whitchamp fault; and secondly, not being powerful enough to break through the superincumbent slates and porphyries farther to the north-east, shattered a portion of them to

* This enormous fault, produced by an upcast to the south, has been described in my former papers, and is laid down on the coloured county map in the possession of the Geological Society.

† See the annexed diagram, in which the rocks intersecting the slates (i) are of this porphyry.

fragmentary masses, and then tore the whole system of Millam Park bodily from the other rocks of the same age, and carried them full two miles to the south-east of their original strike; thus producing the second or Greystone House fault, which is marked on the surface by the sudden great shift of the Coniston limestone, as indicated in the previous description. My present limits preclude any further details, but the accompanying section will I trust make this short description intelligible.

3. Section across Black Coomb.



The third question I was anxious to solve was this,—Is the Coniston limestone continuous, so as only to disappear (along with all the other rocks) under the drifted matter which fringes the south-west coast of Cumberland? Or is it degenerate, appearing only here and there, in discontinuous concretionary masses, before it is finally cut off near the coast? Judging only by my remembrance of what I saw in 1822, and by the colours laid on my map at that time, I should have said that the Coniston limestone was continuous, and that so far from being degenerate at its south-western extremity near the coast of Cumberland, it was much thicker there than in any other part of its range from thence to Shap Wells. From the marshes south-east of Wander Hill to the pastures south-west of Beck Farm (a distance of full two miles), the Coniston limestone group is magnificently developed, having an aggregate thickness more than double that of the same group (including the overlying calcareous slate) in its range through Westmoreland and a part of Lancashire. There is a great open quarry behind Beck Farm, in thick beds of nearly vertical black limestone with white veins. They form the base of the series, and counting from them to the highest calcareous beds with bands and concretions of limestone, we have a thickness of full 600 feet. Under this limestone is a fine schaalstein passing into porphyry; its beds are perfectly parallel to the limestone, and for some depth below it contain the well-known Coniston fossils. I think this fact of importance, as it shows the uninterrupted continuity of the porphyritic and overlying system. At Water Blain the limestone is cut through by a fault, marked a narrow marshy valley, beyond which the limestone is contorted and traversed by thick veins of red oxide of iron. In another quarry the limestone rests on schaalstein, and is partially altered and penetrated near its base by flakes of serpentine.

Before I quit this discussion on the Coniston limestone, I may be permitted to recall attention to the ridge of High Haume (south of

Dalton), on the other side of the estuary of the Duddon. The rocks are there in a vertical position; and, crossing from the shore of the Duddon estuary towards Dalton, we have the following sequence:—

(1.) Sharp ridges of porphyry and schaalstein (exactly like those under the Coniston limestone).

(2.) Beds of dolomite, broken and shattered, with *Favosites fibrosa* (but fossils extremely rare).

(3.) Calcareous slate, with many fossils of the Coniston limestone.

(4.) Thin bands of schaalstein, slate and porphyry.

(5.) Obscure bands of vertical slate, ill-exposed, and with no well-defined fossils.

Taking the mineral structure and fossils into account, I had no hesitation, during my preceding visit in 1844, to class a part of this calcareous mass with the Coniston limestone. From the great thickness of the shattered dolomitized limestone, I was disposed to think it probably a mass of mountain limestone (for that formation is close at hand) entangled among the porphyries. I now feel assured that it is only an altered form of Coniston limestone, and its thickness is perhaps not greater than that of the same limestone on the Cumberland side of the Duddon estuary. Let it be borne in mind that there is the enormous dislocation already alluded to, and that we have in this very district the indications of great but anomalous eruptions of contemporaneous porphyry both immediately before and after the formation of the Coniston limestone, and all difficulty will, I think, vanish. With the exception of the dislocated mass above described, there are no Lower Silurian rocks to the south of Duddon Bridge. The statements in the abstract of my former paper amply define the general age of the Coniston limestone, and enable us to class it with the highest portions of Caradoc sandstone.

2. *Coniston flags.*—Respecting this group I have not many details to add to those of my former paper. It forms the true base of the Upper Silurian rock of this part of England. I have now traced it through parts of the valleys of Dent, Sedbergh, and Ravenstone Dale, on the eastern skirts of the fossiliferous slates, and in several places it contains *Cardiola interrupta*, along with the Upper Silurian fossils (*Graptolites ludensis*, &c.), mentioned in the abstract of my paper of last March. There can therefore be no doubt about its true place in the series. Among the highest beds of this group on the road between Hawkshead and Coniston are *Orthoceratites subundulatus*, Portlock, and another species not yet described.

3. *Coniston grit.*—The beds of this group, consisting of hard grits, &c., have a remarkably uniform character, considered as a whole,—only at their northern end they are degenerate so as to give a less impress to the features of the country. They reappear in the great undulations of Howgill Fells and Middleton Fells, &c. Throughout they show a remarkable association with spherical concretions often more or less calcareous, in which respect they offer analogies with many of the harder Upper Silurian grits of North

Wales*. Fossils are extremely rare in this group; but, after a careful search, some have been discovered. Among these are *Cardiola interrupta*, *Graptolites ludensis*, and fragments of Trilobites. To which may be added, *Orthoceratites Ibex*, and *O. subundulatus* of Casterton Low Fell which belongs to this group.

4. *Ireleth Slates, &c.*—These beds are thus subdivided:—

δ. Coarse slate and flags, &c.
γ. Upper or great Ireleth slates.
β. Upper limestone.
α. Lower Ireleth slate.

To enter on any elaborate description of this most complicated group would involve me in almost endless details, and I must content myself with little more than an enumeration of leading points, and refer to sections.

4 α, or *Lower Slates*, occupies a band of very highly inclined beds more than half a mile broad, between the upper limestone of Tottlebank Fell and the zone of the Coniston grits. Under the line of the same upper limestone (β) there is at least an equal thickness of slaty beds in the Ireleth country, on the south side of the Duddon estuary. I refer the slates of Bannisdale Head and Bretherdale to this sub-group. In general mineral structure it is almost identical with the group (δ) of higher slates, and there is indeed no definable difference. I know of no fossils in this group in the Ireleth country except *Graptolites ludensis*; but, from the general absence of quarries, they may exist and yet have escaped notice.

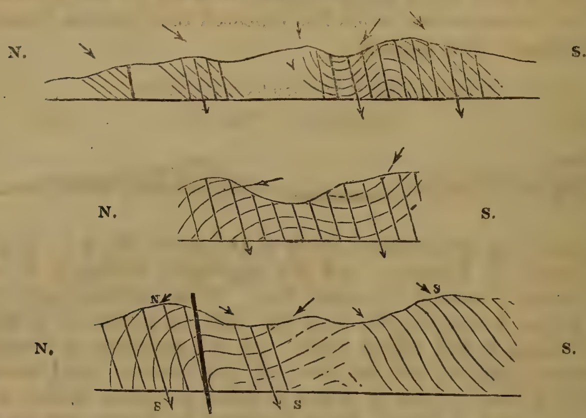
4 β, or *Upper Limestone.*—This limestone appears in five places on the south-east side of the Duddon Sands. In this part of the range it is of considerable thickness, and is still worked at Meer Beck in a fine open quarry †. Most of the old quarries are deserted, as good mountain limestone is found by the sea-side close at hand, for economical use. Farther towards the north the band appears to thin out; but it re-appears on the south face of Tottlebank Fell, in the places indicated in my former paper. It is there very degenerate. The limestone is shelly, but extremely impure. It is composed of irregular discontinuous concretions, and it dies away on its line of strike before it reaches Coniston Lake, and is not seen again, in any appreciable form, farther towards the north-east. Fossiliferous bands (with *Terebratula navicula*, &c.) do however break out farther to the north-east, nearly on the strike of this limestone, *e.g.* on the right side of the road from Windermere Ferry to Hawkshead.

* These balls, both in the grits and slaty bands, are of various sizes,—sometimes true septaria, sometimes filled with earthy ferruginous rotten-stone. They follow the beds and not the cleavage planes, and among the more slaty masses they are spheroidal, with their longer axes in the direction of the beds. On the contrary, in the Millam quarries, the calcareous concretions of the Coniston limestone are formed on the cleavage planes, and not on the beds.

† In one quarry there occur numerous specimens of a square-stemmed Encrinite (*Tetracrinites* ?).

4 γ. The great Ireleth slate quarries were noticed in my former paper. The whole hill, in which these quarries are very largely worked, is thrown into most complicated contortions. But through all these complicated curves the planes of slaty cleavage pass continuously, and almost without any deviation in their strike and dip. I hope to return to the description again, in a paper devoted to the examination of the phænomena of slaty cleavage. But I subjoin several diagrams to convey some notion of the physical conditions of these most instructive quarries.

4. Ireleth Slate Quarries.



Note.—In the above diagrams the arrows below the base line point to the direction of the cleavage planes and those above the section to the bedding.

Most of the beds show spherical concretions,—sometimes filled with an earthy ferruginous matter like the Derbyshire rotten-stone; sometimes in the form of septaria, with calcareous veins. In these balls are found a few ill-preserved fossils, such as Encrinite stems, Graptolites, corals, and Orthoceratites. Mr. Salter has identified one Orthoceratite with *O. subflexuosum* of Münster. Of Graptolites there are probably two very nearly allied species,—one is *G. ludensis*. Among the corals is *Favosites alveolaris* and a *Cyathophyllum*.

4 δ. To the description of the coarse upper slates I have little to add to the details before given. Many parts of it can hardly be distinguished from the preceding group. It contains numerous concretionary balls, with *Graptolites ludensis* and corals like those of the preceding sub-group (γ). It also contains (though rarely) *Cardiola interrupta*, as is stated in the published abstract of my former paper. The previous descriptions apply only to the country of Low Furness. To assist in making them understood I here give two sections,—one from the Coniston limestone at the south-west end of Cumberland, thence across the Duddon estuary, and over the hills of Furness to the sea near Ulverston (see diagram 5).

5. MILLAM, through DUDDON SANDS to the sea near ULVERSTON*.

The other section (No. 6) commences with the same limestone, and crosses the sands about two points of the compass farther towards the south, so as to reach the south-east shore on the south side of a great fault or contortion which has repeated the Coniston limestone in High Haume near Dalton.

6. MILLAM through DUDDON SANDS to DALTON.

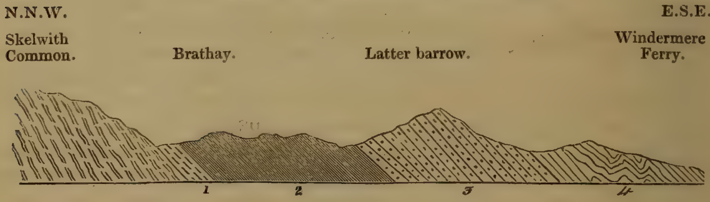
The preceding descriptions apply to the group No. 4 ($\alpha, \beta, \gamma, \delta$), as developed in Furness; and the aggregate thickness is very great—certainly several thousand feet. If the section were prolonged across Leven Sands, over the hills to Cartmell, it would probably bring in still higher beds. All the accidents of structure are however repeated, and are precisely like those on the Ulverston side of the Sands. Again, it is easy to make a section farther north from the Coniston limestone down Russland to Newby Bridge, and thence as far as Lindal. The lower part of such a section would give the groups 1, 2, 3, 4, in great perfection and clearness, and would cross three distinct lines of porphyry dykes; and near Newby Bridge the section would terminate in some part of the group 4 δ. This last part of the series has however very few fossils, but in the abstract before referred to I have already mentioned *Cardiola interrupta*. Starting with this section the strike is north-east; at Newby Bridge the strike is various, and the masses are enormously shifted at the intersection of three valleys. The prevailing strike is about N.N.E. or north by east; thence passing over the ridge to Lindal there are perhaps twenty anticlinal and synclinal lines. At Allithwaite the chain is broken, and beyond that village, down to Lindal, the strike becomes north by west or N.N.W. I conceive it therefore almost impossible to connect this end of the section correctly with any section from Coniston down Russland to the foot of Windermere. Still, on the whole, the sections are in the ascending order towards the south-east, and we gradually reach the upper limits of No. 4.

* It is proper to state that in this and some of the other diagrams illustrating the present memoir, the appearance of a want of conformability (*e.g.* between 4 β and 4 γ *supra*) is an error in the engraving. *All the beds*, from No. 1 to No. 5 inclusive, are in fact conformable throughout the district.

Nor is this the only difficulty. From the absence of the calcareous band (4 β), all the subordinate groups are packed in one mass; and the impress of slaty cleavage, notwithstanding the extraordinary contortions and dislocations, affects them all. These cleavage planes strike, in almost undeviating lines, through all the complicated curves and broken masses, in a direction on the average within a point of magnetic east and west. In the Ireleth ridge the cleavage planes hang toward magnetic south; but further north, the same planes (nearly with the same strike) hang within a point of magnetic north, generally inclining towards true north. I think these phænomena theoretically important, and I hope to return to them in a future communication.

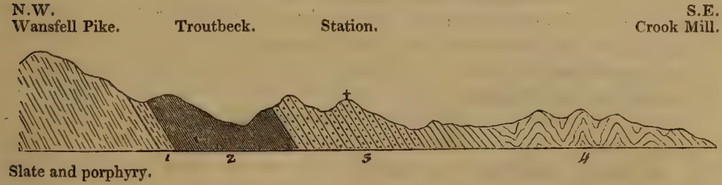
These reasons are sufficient, mineralogically, for grouping together all these slaty masses over the hard grits (No. 3). Neither do the fossils indicate the expediency of any further subdivision under the name of Windermere rock, or any other local name. The more slaty masses out of which roofing-slate is extracted, may in a general way follow particular zones, but they are not continuous, and I believe they often shift their parallels. This is the case in the older Cumbrian slates, and also, I believe, in the group I am describing (No. 4 γ). Still we may in an approximate way follow on the strike the lower slates (4 α), and the higher (4 γ). The latter I would place near the foot of Coniston Water, and thence across Hawkshead valley to the shore of Windermere, a little below the Ferry. This is, I think, nearly the range given in Mr. Sharpe's last abstract. But if this be true it follows that the slaty beds extending to Latterbarrow must represent the group (4 α).

7. SECTION from SKELWITH COMMON to WINDERMERE.

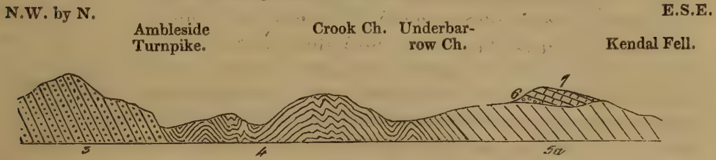


Now in this group we have fossils; and in some bands on the right-hand of the road from the Ferry-house to Hawkshead, we find several species of fossils, and the *Terebratula navicula* in vast abundance. I do not contend that the bands with *T. navicula* exactly represent (4 β) or upper limestone; neither would I bring them into exact comparison with the Aymestry limestone of Siluria. The comparison would be too wiredrawn to be of any use; and, by like reasoning, we might prove the existence of three or four bands of Aymestry limestone on different geological parallels. Following the several groups along the line of strike over Coniston Water and Windermere, and thence through an undulating country of singularly contorted strata into the valleys of Kentmere and Long Sleddale, and to Bannisdale Foot, on the road from Kendal to Shap, we have repetition upon repetition of the same phænomena. None of the groups die away; and there is no unconformable overlap (as has been stated) whereby the highest group (4 δ), under the name of Windermere rock, is made to pass over the edges of the older groups α, β, γ. The hypothesis is, I think, positively contradicted,

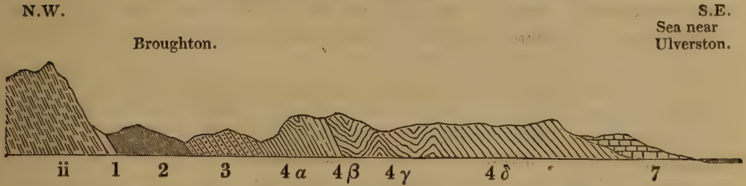
8. Section from Wansfell Pike to Crook Mill.



9. Section through Crook and Underbarrow to Kendal.



10. Section from near Broughton to Ulverston.



both by the sections and the groups of fossils. I cannot describe this complicated region in detail; but I appeal to the accompanying sections 7, 8, 9, 10, and to the list of fossils published in the abstract of my paper before referred to*. Beyond Bannisdale we become entangled among a series of undulations and breaks connected with the disturbances on the eastern side of the great fault of the Lune, which will be described presently. I may also here refer to the coloured map of Westmoreland†. The colours are meant to illustrate this paper, but the phænomena are only local. Were I employed in colouring a geological map of England on the scale of that by Mr. Greenough, I should still use one simple colour for the whole series of four groups, No. 1 having a distinct colour, as it would I think be impossible to follow these subdivisions from one county to another in the subordinate details, so as to lay them down on a map, however great the scale.

* Journal, *ante cit.* vol. i. p. 442 *et seq.*
† Presented to the Geological Society.

5. *Upper Slate of Kendal and Kirkby Moor.*—This group is divided into three sub-groups, 5 *a* surmounted by 5 *b*, and 5 *b* terminating in the ascending order with a red, grey and greenish flagstone (5 *c*), overlaid by conglomerate of the old red sandstone.

(5 *a*.)—The lower subdivision is ill-defined, especially at its lower extremity, because it forms a passage (both in its mineral structure and its fossils) into No. 4. If we commence near the ridge (above alluded to at Lindale), and cross the marshes to the great outlier of Witherslack (mountain limestone); or if we cross from Underbarrow by the turnpike-road to the great limestone outlier of Kendal Fell; or lastly, if we start from Bannisdale Foot from an ill-defined base affected by the great troubles of the Lune, in each of these cases we cross the several beds of the sub-group 5 *a*.

The lower beds are affected by slaty cleavage, but among them occurs the *Terebratula navicula*. The upper beds are less and less slaty, and contain so many fossils of the well-defined upper group between Kendal and Kirkby Lonsdale, that my friend Mr. Salter could hardly make out any palæontological difference between this group (5 *a*) and the upper (5 *b*). But considered in its details, there is a difference. The upper part wants the hard micaceous gray and greenish-gray sandstones with the species of large *Avicula*, *Cypricardia*, &c.; and it contains abundantly several fossils, such as *Asterias*, *Ophiura*, &c., very rarely if ever found in the hills between Kendal and Kirkby Lonsdale.

The best illustration of this ill-defined sub-group is between Underbarrow and Kendal Fell, and I hope hereafter to describe this section in more detail (see *ante* fig. 9). It is enough for my present purpose to mention the following facts.

1. Commencing at Underbarrow among the faulted beds of the valley, we have slate and flag, with a rude cleavage whose direction is magnetic north. In this series is *Terebratula navicula*. This species, counting from the beds north-east of Windermere Ferry, must therefore have a very great vertical range. These beds terminate in ascending order near a farm called High Thorns.

2. A thin bed with *Asterias* (six or seven feet), above which the *Terebratula navicula* is not found. [Here is the last appearance of *Turbinolopsis.*]

3. Flags, *sheer bate* (*i. e.* without cleavage), some red calcareous bands with very many fossils. Many Trilobites (one like *Calymene Blumenbachii.*)

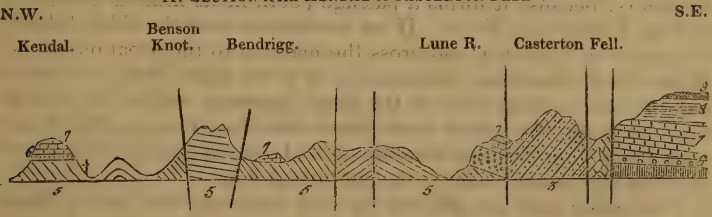
4. Striated hard grits and *sheer bate* flags, with many fossils like those under the great Avicula beds of Benson Knot, on the north side of the Kent.

The Asterias beds (No. 2 of this section) are found at Docker Park, in the beds under Benson Knot, in the valley above Kendal near Redman Tenement, and in the Sprint rivulet about a mile below the Tenement. Here, therefore, we have a passage into the upper and higher sub-group 5 *b*.

(5 *b*.)—Respecting this group there has been no difference of opinion. It must be nearly on the parallel of the Upper Ludlow, and

it ends near Kirkby Lonsdale with a tilestone (5 *c*), the upper part of which (on the banks of the Lune) contains red calcareous concretions, immediately under Red Scar (old red sandstone). The map and the accompanying section (diagram 11) will explain the manner in which

11. SECTION from KENDAL to CASTERTON FELL*.



this formation has been shattered into vast fragmentary masses. The collocation of the masses can only be explained by the interference of two or more lines of dislocation. But among all these dislocations, we may often trace the rudiments of the original north-east strike of the Lake mountains. As far as I know the sections, no older beds are brought up between Kendal and Kirkby Lonsdale. I have not at Lupton Fell, or anywhere else in this district, seen a trace of the groups of (No. 4): all here is Upper Ludlow. I may here call attention to a patch of mountain limestone (at High Bendrigg) which has been laid bare by the bursting of the canal reservoir, and is a striking instance of the vast denudations and convulsions which have affected this singularly broken region. A large list of fossils obtained from this sub-group has already been given, and I could now add considerably to it. In one word, then, the whole fossiliferous series above-described begins with rocks of the Lower Silurian type, which are only a few hundred feet thick (200 or 300 feet on the average, and 600 feet at the maximum), of the age of Llansaintffraid and Mathyrafal beds, and these are not, as I once supposed, on the parallel of the Bala limestone. All the other rocks are Upper Silurian, and there is no unconformable overlap of Windermere rocks to be distinguished from the general series from No. 2 up to No. 5. The subdivisions of the groups do not resemble those of Siluria, neither does the minute arrangement of the species; but there is a general resemblance amongst the species and Upper Siluria and Westmoreland, which considered as one great group, are almost identical, and both end with the same mineral type, viz. a red flagstone or tilestone.

Lastly, the development of the Upper Silurian series (not resembling that observed in Siluria) does, on the other hand, resemble that in South Wales, nine-tenths of the higher slate mountains of which, I doubt not, will prove Upper Silurian.

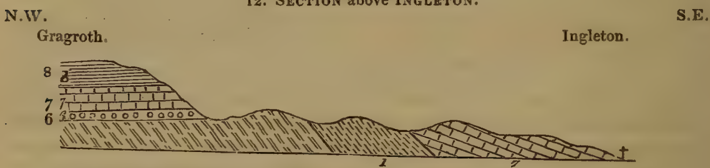
* In this diagram the number (5) refers to the upper sub-group (5 *b*), and the lines projecting beyond the outline of the section represent the faults. The number 8 refers to the great limestone shale ('Yoredale series' of Phillips), and number 9 to the lowest millstone grit.

§ 3. *Structure of the Mountain-chains of Howgill, Ravenstonedale and Middleton, on the east side of the Valley of the Lune.*

I will not here detain my readers with any account of the picturesque features of these beautiful mountain-chains, or my rambles through their defiles and precipices. The great undulations of the district are among the most remarkable I have ever studied; and I would also refer to that break of the strata which ranges up the valley of the Lune, and in the upper part of the valley deflects towards the north-west, and is connected with a great trouble which brings up the hard grits (No. 3) at Whinfell Beacon.

The great difficulty among these extraordinary undulations is to find a true geological base-line on which we may construct a regular and consistent system. Indications of such a base-line I have already pointed out in my former paper; viz. the appearance of Lower Silurian fossils near the range of the great Craven fault through the valley of Dent. A careful examination of the whole fault, and of the slate rocks near it, enables me now to state that there is a good base-line nearly all along the eastern skirts of the troubled district, that base being the Coniston limestone (No. 1). The evidence will be best understood by sections.

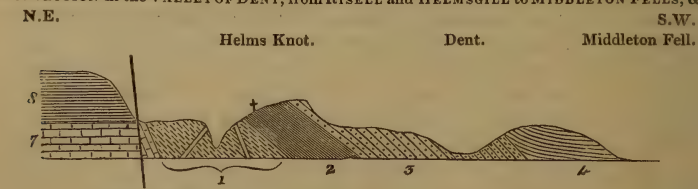
12. Section above Ingleton.



ii. Green roofing slate.

This section unfortunately gives us no fossils*.

13. Section in the Valley of Dent, from Risell and Helmsgill to Middleton Fells, &c.

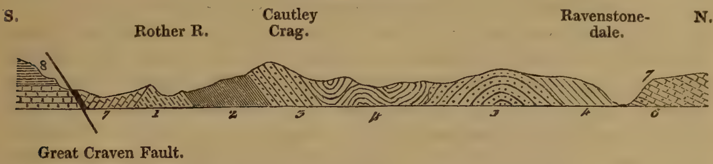


Craven Fault.

8. Limestone shale.
7. Mountain limestone showing the passage of the Craven fault.
4. Slate, &c. of Middleton Fell.
3. Hard grits—at bottom passing into flagstone, and with many specimens of *Cardiola interrupta* and *Graptolites ludensis*; together with three species of *Orthoceratites, Spirorbis Lewisii, Alveolites*, &c.
2. Calcareous flagstone with *Graptolites ludensis* and *Cardiola.*
1. Shale and limestone with fine series of Coniston fossils intersected by porphyry dykes.

* The Craven fault must pass somewhere between the two masses of mountain limestone to the extreme left and extreme right of the section, but its exact place is not laid bare.

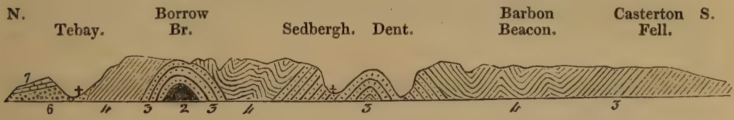
14. SECTION from the higher part of the VALLEY OF SEDBERGH, over CAUTLEY FELLS to RAVENSTONEDALE.



8. Limestone shale overlaid by millstone grit.
7. Mountain limestone broken by the Craven fault.
4. Contorted slates, &c., ending with old red (6) and mountain limestone of Ravenstonedale*.
3. Hard grits.
2. Flagstone with Graptolites:—Orthoceratite with an encrusting coral.
1. Calcareous slates and limestone with fossils. A little above the line are many porphyry dykes, and farther on the strike of the same beds, a magnificent series of Coniston fossils, perhaps the richest deposit of this age in the north of England.

These are instructive sections, and tell a very plain story. They enable us also to interpret other sections, which might be considered doubtful and obscure without their help.

15. Great North and South SECTION from TEBAY to CASTERTON FELL.

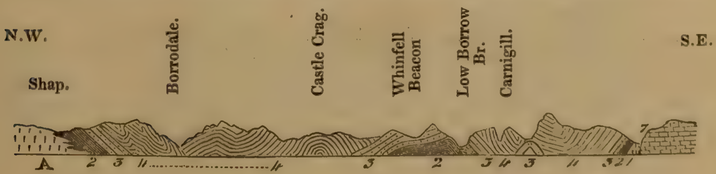


From this section it appears that the Coniston grits (3) and Ireleth slates (4) are repeated by great undulations. In one spot the calcareous flag (No. 2) (with *Graptolites ludensis*) makes its appearance; and the whole series at the north end is overlaid by old red conglomerate (6) and mountain limestone (7).

In the grits (No. 3) of Casterton Fell are *Orthoceratites subundulatus*, *O. Ibex*, and *Cardiola interrupta*.

In the slates of Middleton Fell and Howgill Fell (No. 4) are *Avicula*, a small species; *Orthoceratites subundulatus*, a coral resembling *Monticularia* and *Alveolites fibrosa*.

16. Great connecting SECTION from the SHAP GRANITE to BAUGH FELL above SEDBERGH.



4. Ireleth slate series.
3. Coniston grit.
2. Coniston flag much indurated near the granite.
A. Shap granite throwing veins into No. 2.

* At the end of the slate series (4) in Ravenstonedale *Calymene* (*Downingia?*) occurs.

The north-west end of this section which passes through Nos. 2, 3 and 4 of the tabular section (see page 108), is intersected by three or more porphyry dykes; and at its south-east end it traverses the Howgill range, and descends into the valley above Sedbergh through the beds described in section 14. The whole country through which these sections pass is extraordinarily faulted and contorted, and the higher elevations, which are traversed by numerous porphyry dykes, exceed two thousand feet. Among the valleys indenting Howgill Fells is some wild and noble scenery, with two of the finest waterfalls in the north of England Thus it appears, that in the remarkably contorted chains east of the great Lune fault, we have No. 1, 2, 3 and 4 of the tabular section in regular order, and that no higher rocks appear in the chains, which at both ends are overlaid by the conglomerates of the old red sandstone and by mountain limestone.

January 21, 1846.

Alfred Tyler, Esq., and Bland Hood Galland, Esq., were elected Fellows of the Society.

The reading of Professor Sedgwick's communication was resumed and completed.

Part II.

The former part of my paper, containing numerous detailed sections, did not include the conclusions I wished to draw from them. I there described the whole series of fossiliferous slates extending from the Coniston limestone to the valley of the Lune, as subdivided into five primary groups, viz.:—

5. Upper Ludlow rocks, including tilestone, extending from Kendal to the banks of the Lune, near Kirkby Lonsdale.
4. *Ireleth slates*, divided into four sub-groups (α, β, γ, δ).
3. *Hard gritty beds* approaching a conglomerate form, with subordinate slaty masses, having numerous spherical concretions arranged parallel to the beds. Fossils rare, but of Upper Silurian species.
2. *Coniston* or *Brathay flagstone*, having Upper Silurian fossils, and developed to a thickness roughly estimated at 1500 feet. The mineral structure almost identical with that of the flagstones of the Upper Silurian rocks of Sir R. Murchison, and yet more nearly resembling the Lower Denbigh flagstones of North Wales.
1. *Coniston limestone and calcareous slate* having Lower Silurian fossils.

Respecting the upper part of the great formation of the Ireleth slates (No. 4 δ) there is no difference of opinion, as it contains several well-known Lower Ludlow fossils, and has already been compared, in a general way, both by Mr. Sharpe and myself, with the Lower Ludlow rocks. It forms a part of his Windermere rocks.

I formerly considered the three lower sub-groups (4 α, 4 β, 4 γ) as Lower Silurian; but I did so before I had re-examined the country (the most important part of which I had never seen since 1822), and I was, I believe, misled by confounding the High Haume limestone (south of the Duddon) with the upper calcareous band (4 β). I need not repeat what I have before stated on this head; but as Mr. Sharpe still appears to adhere to the supposition that these three lower sub-groups are *Lower Silurian*, I have lately re-examined my fossil evidence, as well as my field sections; and I adhere to my previous conclusions. In the first place, there is no evidence of any unconformable overlap (as stated, if I mistake not, in Mr. Sharpe's paper,) among the beds of the four sub-groups, and they form one unbroken continuous mass. And in the second place, the fossils of the four sub-groups compel us to class them all as one formation—nearly on the parallel of the Lower Ludlow rocks. The fossils of the rocks north of the Ferry House at Windermere have been re-examined by my friend Mr. Salter; several large fossiliferous masses which I brought away from these rocks have now been broken up, and the following is the list of fossils Mr. Salter has derived from them.

List of Fossils from the Rocks north-east of the Ferry House.

1. *Encrinites*, one or two species. One remarkable undescribed species also found in the valley of the Kent above Kendal, just under the Upper Ludlow rocks.
2. Fragments of a *Calymene*.
3. *Turbo carinatus* or *corallii*.
   Turbo? like a species in the Upper Ludlow of Kirkby Moor.
   Turritella obsoleta.
   ——— *conica*.
   Terebratula semisulcata (*T. lacunosa* of the Ludlow rock in the 'Silurian System').
   Orthis orbicularis.
   ——— *lunata*.
   Leptæna lata.
   Nucula, resembling *N. ovata*.

Here are twelve species—none of which are known Lower Silurian, and eight of which are known Upper Silurian species. And to this list we may add *Terebratula navicula*, obtained from the immediate neighbourhood. It appears therefore that there is no room for doubt; for these fossils are all derived from the *lower part* of the great group (No. 4).

It was however stated that the upper limestone, near Coniston Water-foot, contained Lower Silurian fossils; and the authority of Mr. J. Marshall was appealed to. Now I examined this part of the country during last summer in company with Mr. J. Marshall, and I venture to affirm that he did not show me a single Lower Silurian fossil in this *upper limestone*; neither did he appear to have ever seen any. In quoting his authority there must, therefore, have been some mistake. Of the singular High Haume limestone I may just remark—that it is mineralogically unlike this upper limestone—that it is associated with a different series of rocks—that it contains a distinct series of fossils (viz. Lower Silurian), and that it is not on the line of strike of the upper limestone. But if we endeavour to identify the two limestones, (as I did myself in 1822, before I had studied the structure of the neighbouring country, or knew the fossils,) what then follows? That through a thickness of not less than 4000 or perhaps 5000 feet, there is an utter confusion of Upper and Lower Silurian types. I do not accept this conclusion: and I have now gone over the reasons for the classification I adopted in 1844, and confirmed by my examination of the same country in 1845.

I next examined the rocks of Ravenstonedale, Howgill Fells, and Middleton Fells. Their geological base is formed of a calcareous slate with impure beds of limestone, which in two or three places (especially Helmsgill in Dent, and Ravenstonedale, above Rother Bridge,) contain many fossils. I collected in about an hour at one small quarry in Ravenstonedale not less than twenty-five or thirty species*. From the very near agreement of these with Coniston limestone (Lower Silurian) fossils, we have a true geological base-line for the contorted region of Howgill Fells, and we have no lower rocks brought up in that mountainous region. Were these rocks of Ravenstonedale by themselves, and dissociated from the upper groups, there might perhaps be some doubt of their exact age. But they pass upwards into the most characteristic Coniston flags, with *Graptolites ludensis* and *Cardiola interrupta*; and these flags are in their turn surmounted by the hard grits (2) and the Ireleth slate (4). Hence the Howgill Fell system is only a repetition of the four lowest groups on the north-west side of the great fault of the Lune, folded over and over again by vast local undulations; and hence also it follows that the highest rocks of the Westmoreland series occur in a kind of irregular hollow or basin, with older rocks expanded along their whole eastern extremity: but there is no direct and unequivocal proof of any want of conformity in any part of the series till we reach the old red sandstone and the carboniferous limestone.

* Mr. Salter has given me the following extract from his list of these fossils:—

Orthis Actoniæ.
——— *flabellulum.*
——— *elegantula* (formerly *O. canalis*).
——— *alternata*, &c.
——— like *O. Pecten* (repeated at Coniston).
Leptæna transversalis.
———— *depressa.*

All the above are known Coniston fossils. The Ravenstonedale list also resembles the Coniston in the rarity or absence of certain fossils which abound at Bala, e. g. *Orthis vespertilio*, *Leptæna tenuistriata*, *Crania catenulata*, and a new species of Orthis. To these may be added some peculiar species of univalves and six or seven species of bivalves which occur neither in the Caradoc of Sir R. Murchison nor in the Coniston limestone.

The anomalous position of the masses has been probably caused by great faults and partial dislocations. I here subjoin a comparative view of the fossils in the Upper and Lower Silurian rocks of the country here described.

Comparative view of the Fossils in the Upper and Lower Silurian Rocks of Westmoreland.

Orders.	Species peculiar to Upper Silurian.	Common species.	Species peculiar to Lower Silurian.
Pisces	3 ?	—	—
Cephalopoda	17	1	3
Gasteropoda, Pteropoda, &c.	17	1 ?	2
Lamellibranchiata	34	—	—
Brachiopoda	15	2	19
Tunicata	2	—	1
Crustacea	5	1	11
Annelida	4	—	3
Echinodermata	4	—	2
Zoophyta	7	5	11
Total peculiar to Upper S.	108	10	52
— common species	10		
— peculiar to Lower S.	52		

170 + 180 (Welch.) = 350 species { in North Wales and Westmoreland.

To these may be added from other localities about ... } 150 species.

Probable total of British Silurian species described ... } 500*

When it is considered what a fossil impress is given to these old rocks by the Cephalopoda, Gasteropoda, Lamellibranchiata and Brachiopoda, and that of these four families we have eighty-three species in the Upper Silurian rocks, and twenty-four in the lower, and only three species in common, the list shows a most marked difference between the two systems. On the whole, the list indicates a progress towards a higher organic structure as we ascend from the lower to the upper rocks. Again, the Crustaceans peculiar to the old rocks began in the earliest time, reached their maximum of development at a very early period, and then began to decline, so as not to pass the carboniferous epoch. Lastly, I may remark that the difference indicated in the list between the Upper and Lower Silurian fossils of the Lake mountains is probably greater than will be found true on further examination; because most of the fossils have been derived from the two extremes of the general section, viz. No. 1 and No. 5 of the tabular list, the intermediate parts not having been so well explored by the fossil collectors.

In confirmation of the preceding view, I subjoin another interesting table, supplied by Mr. Salter from Sir R. Murchison's descriptive lists.

* Several new species have been discovered since this list was made out.

Synopsis of the Silurian fossils as given in Sir R. Murchison's Work.

Of 267 species of *Mollusca* and *Articulata* described from the Silurian rocks,

106 are found in the	Ludlow series,	and 83 are	peculiar to it.
55	" Wenlock limestone,	" 30	"
41	" Wenlock shale,	" 21	"
75	" Caradoc,	" 40	"
39	" Llandeilo flags,	" 15	"

	Species common to the various parts of the series in the				
	Ludlow.	Wenlock limestone.	Wenlock shale.	Caradoc.	Llandeilo flags.
Ludlow rocks	...	19	15	2	1
Wenlock limestone	19	...	15	7	3
Wenlock shale	15	15	...	10	5
Caradoc	2	7	10	...	20
Llandeilo flags	1	3	5	20	

Note.—In this synopsis the corals are rejected as too widely spread; the Crinoidea as being imperfect, and therefore difficult of identification, except in the Wenlock limestone; so that Trilobites and shells only are taken for the comparison.

It appears from the other tables, that out of fifty-five species in the Wenlock limestone, nineteen are common to the Ludlow series and fifteen to the Wenlock shale; and that out of forty-one species in the Wenlock shale, fifteen are common to Lower Silurians, ten being Caradoc and five Llandeilo species.

6. If we take the Wenlock limestone and Wenlock shale together, we have only sixty-four species, nineteen in common with Ludlow rocks and nineteen with the Lower Silurians; or in other words, about one-sixth of the whole Ludlow series, and more than one-fourth of the Lower Silurians. The Wenlock series is therefore truly intermediate; but it is very imperfectly represented in the north of England for want of any rich bands of limestone of the Wenlock age.

To the comparisons I have instituted in former communications between the Upper Silurian series of Westmoreland and North Wales I have little to add. The lower part of the Denbigh flags appears to be exactly on the same level with the Coniston flags (No. 2), and the whole development of the Upper Silurian rocks in North Wales (with many points of local difference) has many points of general resemblance. The sequence in Westmoreland is however more perfect than in North Wales, and in neither county is the development at all resembling that of Siluria. Beautiful as the sequence of that county is, it is not the true mineral type either for England, Wales, or Ireland. As a general rule, I believe that all limestone bands below the carboniferous series are mere local phænomena, appearing at intervals, which are perfectly irregular in countries remote from one another. This remark is meant to include Devonian limestones, and all Silurian limestones, both upper and lower, and many other limestones far below those which mark the beautiful sections of Siluria. Hence we can only identify large subdivisions; and any attempt at the comparison of subordinate parts must often end in positive error. Whether this remark applies to the older rocks of

North America, I do not presume to judge; but it applies to the general European type as far as I have any knowledge of it.

South of the Berwyn chain and the valley of the Upper Severn, the comparison of the Westmoreland sections with the Upper Silurian rocks is more difficult. They there appear partly as flagstones, but more generally as coarse greywacke and greywacke slate, in vast alternating masses thrown into continual undulations. These undulating masses run far towards the south, and, if I mistake not, cover very large tracts of the higher parts of South Wales. Mineralogically they are almost identical with the hard grits (No. 3) and the Ireleth slate (No. 4) of the sections of Westmoreland and North Lancashire. I formerly identified them in the countries above mentioned under the name of Upper Cumbrian. During the past summer, Mr. Salter, at my suggestion, paid a visit to the part of Wales last indicated, and the result of a traverse he made from the neighbourhood of Builth to Aberystwyth was rather negative than positive. He found hardly any fossils* ; and he was thus unable to separate the great series of undulating strata, including Plynlimmon, from the undulating grits and slates at the south end of the Berwyn chain. This was what I expected, and what I had before affirmed as probable; and it induces me to place (at least provisionally) all the Plynlimmon system among the Upper Silurian rocks of Sir R. Murchison; and I believe (though I must acknowledge upon a very imperfect examination, carried on only during a few days in 1832) that the same upper rocks extend much farther south, and occupy by far the greater part of the higher regions of South Wales; of course excluding from this remark the country of the Old red sandstone and the carboniferous series. But how reconcile this with the statement more than once made by Sir H. De la Beche, that the *Llandeilo flag* was repeated more than once in the undulations of South Wales, and far to the north of the line of Landeilo flag drawn on Sir R. Murchison's map? The answer to this question involves another—what is the age of the Llandeilo flag?

Sir H. De la Beche has stated repeatedly that the *Asaphus Buchii* is found in some parts of South Wales among Wenlock shale fossils: and among the highest beds of the Caradoc sandstone, just where at Mathyrafal it passes into the upper flagstone, Mr. Salter, in the year 1843, pointed out to me three or four good Wenlock shale fossils, which also occur in the Llandeilo flag†.

* A Lower Silurian *Pleurotomaria* however occurred at Dol-fan.

† The following species are common to the Mathyrafal series and the Llandeilo beds :—

Orthis lata.	*Atrypa lens.*
Atrypa crassa.	*Leptæna transversalis.*
—— *undata.*	—— sp. n.
—— *globosa.*	

The following are common to Wenlock and Llandeilo beds :—

Orthoceratites subflexuosum.	*Leptæna euglypha.*
—— *annulatum.*	—— *transversalis.*
Orthoceratite. A smooth species (s. n.).	*Calymene Blumenbachii.*
Lituites Cornu Arietis.	*Trinucleus Caractaci.*
Leptæna depressa.	*Paradoxites bimucronatus*, &c. &c.

At the time, this surprised me greatly; but the fact is quite in harmony with the statements of Sir H. De la Beche. All the sections of the Silurian system south of the Severn are made on the hypothesis that the mountains on the north-west side of the lines of section are older than the Silurian rocks. Now, as a general rule, this hypothesis is not correct, and it in some measure vitiates the base-lines of the several sections, and so destroys a part of their meaning. But the section at the east side of the Berwyns, ending with Craig y Glyn, is appealed to by Mr. Murchison as proving the low position of the *Asaphus Buchii* and the Llandeilo flag. For several years I myself put this interpretation upon the section in question. But since a doubt has arisen about the age of the Llandeilo flag, Mr. Salter has re-examined the specimens both from Craig y Glyn on the east flank of the Berwyns, and also from one or two localites near Grat Arrenig and in the Rhiulas limestone; and he now retracts his identification of any of the fragments with *Asaphus Buchii*. The only fragments he can identify belong to *Asaphus tyrannus*, which certainly has a very low range among the fossiliferous slates. The evidence therefore supplied by my sections in North Wales gives us no help in determining the age of the Llandeilo flag. Mr. Salter also examined during the past summer one or two sections of the Silurian series of South Wales. I cannot give his remarks in detail; but I may state the result of them. They go to prove either that the Llandeilo flag is not inferior to the Caradoc sandstone (*e.g.* at Builth), or that it is associated with the upper part of it, a part containing several fossils of the Wenlock shale or limestone. Hence, coupling these remarks with what has been stated by Sir H. De la Beche, I should class the Caradoc sandstone and Llandeilo flags of South Wales, the Caradoc sandstone of the Malverns, that on the south-east side of the Berwyns, and lastly, the fossiliferous bands of Glyn Ceiriog and Mathyrafal, all in one group, and compare it with that of the Coniston limestone; perhaps including with the Coniston limestone also the Coniston flags*. If this view be correct, we cease to be surprised at finding the Llandeilo flags among the great folds and undulations of the Upper Silurian rocks of South Wales. The *Calymene Blumenbachii* ranges from the Ludlow and Wenlock limestone down to the rocks under the Caradoc sandstone, &c. The *Trinucleus Caractaci* is a most abundant Caradoc sand fossil, yet it ranges into the Wenlock shales under Wenlock Edge; and were I to seek for the *Asaphus Buchii*

* Of 45 species of Trilobites and shells found in the Llandeilo flags—
3 are Wenlock species exclusively.
10 common to Wenlock, and the Glyn Ceiriog and Mathyrafal series.
10 Mathyrafal and Glyn Ceiriog.
1 Coniston only.
1 Irish Wenlock—Kerry.
5 found in the Caradoc.
—
30, leaving 15 as peculiar to it.

Only 9 Coniston species are contained in the Llandeilo series. The additional species were added by myself (39 is Sir R. M.'s number) at Builth last year.—J.W.S.

in the Cumbrian mountains, it would be among the flagstones associated with or overlying the Coniston limestone*.

Though there are several remarkable species of mollusca and crustacea common to the Wenlock, Caradoc and Llandeilo series, there are other beds far below them which, I believe, contain none of these common species. These beds are subordinate to the most remarkable physical group of England. I have in former papers called it the *Protozoic group*; or the lowest and greatest division of the rocks with Lower Silurian fossils. Now that I have no evidence of the existence of *Asaphus Buchii*, and other Llandeilo characteristic fossils in this vast group, I am no longer embarrassed for its name. I cannot speak of a *Cambrian system*, with peculiar fossils found in no other; but I may speak of the lower or great *Cambrian group*; and it is, I think, on very probable evidence, placed on the same level with the green slates and porphyries of Cumberland, which I once called the great *Cumbrian group*. In this great Cambrian group began the lowest fossil species we know in the British Isles. Many of the lowest species lasted throughout the whole Lower Silurian period; but new species were added, as conditions gradually changed, during the epochs marked in the ascending sections; so that the lower fauna reached its maximum of development in the Caradoc sandstone and Llandeilo flagstone. Afterwards the fauna underwent a much more rapid change, certain tribes of *Brachiopoda* diminishing in numbers, and being replaced by other forms, while, as far as our evidence goes (at least in the north of England), the *Lamellibranchiata*, though beginning low in the Cambrian group, also formed a more important part of the fauna of the Upper Silurian rocks. Geology tells us of the successive revolutions and changes in the crust of the earth. Organic changes are our surest guides in making out this history; but they form only a part of our evidence, and the great physical groups of deposits, however rude and mechanical, are historical monuments of perhaps equal importance in obtaining any true and intelligible history of the past ages of the earth; and after we have descended through a certain number of stages, they become indeed our only monuments and indexes of past events. This is true in North Wales,

* Of the Coniston Lower Silurian fossils (including Helmsgill, &c.) we find in North Wales—

Peculiar to the Bala limestone and beds below it	6	species.
Common to the Bala series and the passage beds	16	„
Peculiar to the passage beds	17	„
Peculiar to Westmoreland	21	„
	60	

By 'passage beds' are meant the highest beds of the Caradoc sandstone (*e.g.* those of Glen Ceiriog, &c.), which form a passage into the Upper system.

Of the 21 species which are peculiar to this series in the north of England, two occur in the beds on top of the Berwyns (Rhiwargor); two in Ireland, in beds referable to Wenlock limestone and shale; and three are characteristic Wenlock fossils, namely *Cyathophyllum cæspitosum, Cornulites serpularius, Tentaculites ornatus*.

Of course this list is not absolute; and the probability is, I think, that there will be no species "peculiar to the Bala series" when we know more.—J. W. S.

and still more emphatically in Cumberland, where the Skiddaw slate is without fossils.

Taking the whole view of the case therefore as far as I know it, I would divide the older palæozoic rocks of our island into three great groups—each (in local descriptions) to be further subdivided. They would then stand thus:—

3rd, Upper group, or *exclusively Upper Silurian.*
2nd, Middle group, or *Lower Silurian*, including Llandeilo, Caradoc, and perhaps Wenlock.
1st group, or *Cambrian.*

This arrangement does no violence to the Silurian system of Sir R. Murchison, but takes it up in its true place; and I think that it enables us to classify the old rocks in such a way as to satisfy the conditions both of fossil and physical as well as of mineralogical development.

The general conclusions which I obtain from the details given in the former paper and the present one are briefly these:—

The fossiliferous slates, extending from the Coniston limestone to the valley of the Lune, are subdivided into five formations or primary groups.

5. Coarse slates, generally without transverse cleavage planes, grits, flagstones, &c., divided into three sub-groups.

γ. Greenish-grey and red flagstones (*tilestone*).
β. Grits and slates without true cleavage planes, with numerous Upper Ludlow fossils.
α. Coarse slates passing downwards into 4 δ.

4. A formation of very great thickness (*Ireleth slates, &c.*), divided, for convenience of description, into four sub-groups:—

δ. Coarse slates and grits,—often passing into the structure of the lower sub-groups, and not to be separated from them.
γ. Upper or great Ireleth slate zone.
β. Upper limestone.
α. Lower Ireleth slates.

Respecting the upper part (δ) of this great formation there is no difference of opinion. It contains beds of *Terebratula navicula* and several other well-known Lower Ludlow fossils; and has already been compared, in a general way, with the Lower Ludlow rocks, both by Mr. Sharpe and myself.

3. A great deposit of hard gritty beds, sometimes even approaching a conglomerate form, with subordinate slaty masses, and with numerous large spherical concretions arranged parallel to the beds. The fossils are very rare in this group, but among them are *Graptolites ludensis*, *Cardiola interrupta*, *Orthoceras ibex* and *O. subundulatum*. All the species are Upper Silurian.

2. *Coniston Brathay flagstone.* Thickness roughly computed at 1500 feet. Its most characteristic fossils are *Graptolites ludensis,*

Cardiola interrupta, Orthoceratites (including *Creseis*), and a few Trilobites. The species are all Upper Silurian,—using that term in the sense given to it by Sir R. Murchison. The mineral structure of this formation is almost identical with that of the Upper Silurian flagstones of the Lower Severn, described by Sir R. Murchison, and still more exactly identical with the lower Denbigh flagstones described in my paper on North Wales.

1. *Coniston limestone and calcareous slate.* On an average not more than 200 or 300 feet thick; at a maximum (in Millam) about 600 feet thick. The fossils of this group are Lower Silurian, and I need not repeat the well-known list of species.

The whole series is overlaid unconformably by the old red sandstone and mountain limestone.

Note.—It is right to state that in this paper the localities of Wenlock fossils and those of Llandeilo flags, &c., are taken from Sir R. Murchison's descriptions (excluding Marloes Bay). One or two species were added from Builth by myself.—J. W. S.

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2. *On the Strata called* "Jackstones" *at* Merthyr Tydvil. By Jos. Dickinson, Esq., F.G.S.

Considering these stones in connexion with the ironstones and other strata with which they are associated, they are chiefly remarkable for the peculiarity of their structure and the great quantity of carbonate of lime which they contain. Few of the ironstones and scarcely any of the other strata in the coal-measures in this locality contain five per cent. of carbonate of lime, whilst these Jackstones contain forty-five.

Their usual structure is conical, the stones being made up of a series of distinct cones with serrated edges inserted into each other, having the apex of each cone directed towards the top of the stratum, although this is not invariably the case. The height of the cones is various, but those most perfectly formed seldom exceed four inches. Towards the upper and lower surface of the stratum, the conical structure frequently disappears and an even arrangement ensues.

These stones are disposed in seams similar to those of clay ironstone. They are of a brown and sometimes of a grey colour. They generally lie underneath and in contact with ironstone, and occasionally they intervene as a band in the middle of a seam, in which case, as well as in the former, there is generally a distinct line of division at the junction of the two stones. In many examples, however, the two stones blend imperceptibly with each other.

The thickness of a stratum of Jackstones seldom exceeds nine inches, and probably not more than three or four different strata could be enumerated in one section. They are generally situated amongst the ironstones lying below the workable coal-seams, the lowest of which is about 210 yards above the mountain limestone.

The analysis of one of the commonest specimens is—

Moisture	1·0
Carbonaceous matter	1·0
Alumina	10·2
Silica	10·8
Proto-carbonate of iron	27·5
Carbonate of lime	45·0
Carbonate of magnesia	3·8
	99·3

From their containing iron and lime, they are partially used in the blast furnaces at the iron-works; they have been also used in the manufacture of a cement; and in the neighbourhood of the mines they are employed to repair roads, for which purpose they are well adapted.

3. *Notices of some Fossils found in the Coal Formation of* Nova Scotia. By John William Dawson, Esq.

Plate VIII.

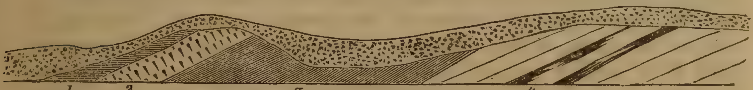
1. *Ichnolites.*—The coal-formation of Nova Scotia has already yielded ichnolites of three species, specimens of which, all unfortunately very imperfect, have been presented to the Geological Society by Mr. Logan and the writer of the present paper*. Desiring to add to the value of this discovery, I spent several days of last summer in a careful re-examination of the red sandstones at Tatmagouche, which had formerly afforded these fossils, and in exploring some other localities in which beds of the same age appear. The results of these examinations are, *first*, the discovery of a few additional footmarks of one of the species of which specimens were sent last winter to the Geological Society. These new specimens are not however more distinctly marked than those formerly found at the same place. *Secondly*, the discovery, in a bed of coarse reddish shale immediately overlying the bed containing ichnolites, of some coprolitic bodies, probably of common origin with the footsteps. One of these coprolites, on analysis, was found to consist chiefly of carbonate of lime and argillaceous matter, with a considerable proportion of phosphate of lime, and traces of chlorine and organic matter. The figure of a well-marked specimen is given in the accompanying Plate, fig. 1. *Thirdly*, a confirmation of my previous belief of the carboniferous date of these beds with footmarks, by finding in them impressions of a species of *Neuropteris* common in our coal-formation, and fragments of *Sternbergia* and of a lycopodiaceous plant found in carboniferous beds, in various other parts of this province. *Fourthly*, having exposed larger surfaces of the sandstones on the banks of the French river of Tatmagouche than I had previously seen, I was struck with the vast abundance and great distinctness of the worm-tracks and casts of worm-holes, which cover the sur-

* *Vide* Quarterly Journal of Geol. Soc. vol. i. p. 326.

faces and penetrate the thickness of many of the beds. Many of these worm-tracks are marked with striæ, probably produced by the *setæ* of the worms. Beds similarly marked are seen in several places near Tatmagouche; and on the western side of the neighbouring promontory of Malagash, where the strata of the coal-formation have been thrown into a vertical position, large rippled and worm-tracked surfaces are exposed in the perpendicular face of the cliff. These ancient shores or banks, swarming with worms, were probably the feeding-grounds of the animals, a few of whose footmarks their surfaces have retained.

2. *Coniferous wood.*—At a particular level in the lower part of the newer coal-formation, calcareous petrifactions of coniferous wood are very abundant, in some instances appearing to have belonged to extensive rafts of drift-wood. A bed of sandstone, containing one of these petrified rafts, is well exposed on the shore between Cape Malagash and Wallace Harbour, and is there associated with a bed of gypsum, and a thin layer of limestone containing a few marine shells, of species found also in the lower carboniferous rocks; the whole forming a peculiar and unusual association of fossils, and affording the only instance that I have yet observed, of the occurrence of lower carboniferous shells at a level higher than that of the great coal-measures (as shown in the annexed section).

SECTION of Carboniferous Rocks at M'KENZIE'S MILL near WALLACE HARBOUR.



4. Grey sandstones with *Calamites* and trunks of *Coniferæ*.
3. Reddish clay and shales.
2. White granular gypsum.
1. Limestone with *Terebratulæ*, &c.

In the bed of coniferous wood at Malagash, the structure of many of the trunks has been very perfectly preserved; and slices exhibit very distinctly polygonal discs on the walls of the cells, like those of the genus *Araucaria*. On comparing slices from this locality with others of specimens from different parts of this country, which had not previously afforded very satisfactory results, it appears that the species of coniferous trees most abundantly found in the coal-formation of Pictou and Cumberland counties have the structure of the Araucarian pines. I have hitherto found no specimen exhibiting the discs of ordinary pines. On the weathered ends of trunks of Araucaria, in the sandstones at Pictou and near Wallace, rings of growth are often very apparent; and in some instances, the layers of yearly growth having separated in the progress of decay, as is often seen in recent wood, they have left vacant spaces, occupied in the fossils by calcareous spar. In a transverse slice the rings of growth can easily be seen with the naked eye. They do not exceed in width those of vigorous individuals of many recent coniferous species, but their limits are much less distinctly marked than in any Coniferæ now growing in this climate.

It is perhaps worthy of notice, that the alteration effected from the original structure of these calcareous fossils, consists merely in the filling up of the cavities of the cells with carbonate of lime, and in the carbonization of their walls. When fragments are exposed to the action of diluted hydrochloric acid, the calcareous matter is removed, and a flexible carbonaceous substance, retaining the form of the fragment, remains. This residual woody matter burns like touch-wood, and leaves a very little white ash.

Coniferous wood is not unfrequent in the nodules of ironstone, included in the great coal-bed at the Albion mines. After preparing a great number of slices from these nodules, I have found them in general to contain wood showing coniferous structure, and in a few instances having the polygonal discs of the cells preserved. More rarely they afford fragments with the structure of Stigmaria. The wood contained in these nodules of ironstone is usually in the form of small rectangular pieces, similar to those which now result from the slow decay of coniferous wood on the surface of the ground; and it can scarcely be doubted that they are of the same nature with the less perfectly preserved fragments of similar form, which, in the state of mineral charcoal, abound in the surrounding coal. If this view of the nature of the mineral charcoal be correct, we learn from it, that the coal-beds containing these fragments were accumulated under circumstances which permitted the decay of great quantities of the most durable kinds of wood in the open air, and the partial dispersion of their remains. These conditions of decay and accumulation of vegetable matter are at present found only in wooded swamps occasionally overflowed by water.

3. *Stigmaria.*—At the extremity of Malagash Point the shore affords a section of rocks of the newer coal-formation, consisting of red and grey sandstone, shale, thin beds of limestone, and a small bed of coal. In one of the beds of shale I discovered a fossil stump of a tree, having connected with it roots with regular scars like *Stigmaria.* The trunk of the fossil was nearly at right angles with the plane of the containing beds, which are inclined at an angle of about 50°*. It was imbedded in coarse dark shale, and rooted in an indurated clay of the same colour. It was not more than one foot in height, being cut off by a bed of dark laminated shale, with impressions of fern leaves. A portion of one of the main roots, ten inches in length, was seen to be attached to the stump, and other portions, whose actual connexion could not be seen, appeared in the surrounding clay. All of these roots show, more or less distinctly, the regular scars and eccentric pith characteristic of Stigmaria. The whole fossil is a cast in dark indurated clay; the trunk however shows three well-defined parts. These are, first, an external coaly envelope or bark irregularly corrugated; secondly, the stony cast, whose surface shows rather indistinct, alternate, smooth and rough vertical stripes; and thirdly, an eccentric core, probably corresponding with that of the roots and having large transverse promi-

* I saw no other fossils in this bed, only a small part of which was exposed.

nences, which appear to have been connected with fibres or bundles of vessels, whose remains extend outward and downward through the outer part of the cast. I have sent with this paper specimens of the trunk and roots, and a sketch of the fossil as it appeared when *in situ* (fig. 2), trusting that, when examined by more competent botanists, they may give interesting information respecting the nature and affinities of Stigmaria. I also send a figure of a specimen of Stigmaria (fig. 3), seen in a bed below the roots above described, whose rootlets have penetrated two thin beds of sandstone and a bed of shale.

4. *Sternbergia.*—Fragments of plants of this genus are frequently found in the sandstones of the Pictou coal-field, usually in beds which also contain Calamites. They are in the state of stony casts, always invested with a thin bark or coating of lignite, whose outer surface is smooth and without transverse wrinkles. The inner surface of the coating of lignite has longitudinal ridges which adhere strongly to the surface of the transversely striated cast, and leave marks or small furrows when removed. Though specimens of this kind are not rare, and vary in diameter from half an inch to two and a half inches, I have seen none with any trace of roots, leaves or fruit, or even of a conical termination ; all are cylindrical fragments, and so similar in their markings, that they may have belonged to one species. Transversely ridged stems, of a character very different from the above, are however occasionally found in the carboniferous beds of this province. These are stony casts, having irregular and often large transverse markings, and enclosed in a thick coat of lignite or fossil wood. In two specimens of the latter kind, transverse sections of the portion with structure, show cellular tissue apparently with medullary rays, and much resembling the wood of Coniferæ.

The fossils last mentioned are probably, as suggested by Mr. Dawes with reference to the British species of Sternbergia, casts of the pith of trees. It appears evident however, that the first-mentioned species (named I believe *Artisia approximata* in Mr. Lyell's list) was a plant having a very large pith and a comparatively thin woody envelope—in short a gigantic rush-like plant, perhaps leafless and nearly cylindrical, like some modern species of Juncus. To show the rush-like character of this curious fossil, I have sketched (fig. 4) a specimen from the Pictou coal-field, and a portion of the stem of a common species of Juncus from a swamp near Pictou ; both showing the transverse structure of the pith, the marks left in it by the internal ridges of the envelope, and the smooth or longitudinally striated outer surface.

The above notices of some of the fossils of the coal-formation of Nova Scotia have been selected from the results of my late observations, from a belief that they may be serviceable in the elucidation of important geological questions now in process of discussion, and intimately connected with the palæontology of the coal period.

EXPLANATION OF PLATE VIII.

Fig. 1. Coprolite from the carboniferous sandstone of Nova Scotia.
2. Fossil trunk *in situ* having roots resembling Stigmaria (Malagash).
1. Dark grey shale with fern leaves.
2. Ditto coarse shale.
3. Hardened dark-coloured clay.
4. Limestone.
a. Attached roots.
b. Roots not attached.
c. Bark.
d. Ligneous surface.
e. Core and attached fibres.
3. Stigmaria with rootlets penetrating sandstone and shale (Malagash).
1. Shale.
2. Sandstone.
4. Sternbergia from the Pictou coal-field, and recent *Juncus effusus* with part of the pith uncovered.
a. Stony cast of pith.
b. Coat of lignite.

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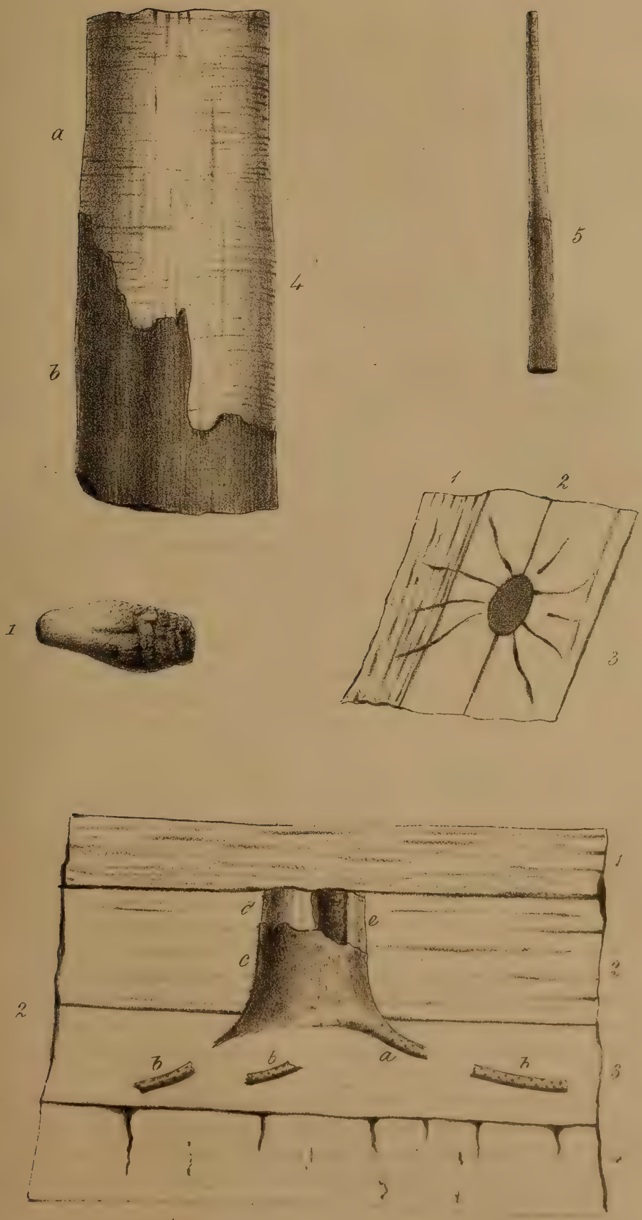
4. *Notes on the Fossil Plants communicated by Mr. Dawson from* Nova Scotia. By C. J. F. Bunbury, Esq., F.G.S.

The observations of Mr. Dawson on the fossil roots having the characters of Stigmaria are curious and important, as corroborating the statement communicated by Mr. Binney to the British Association in June 1845, respecting the tree with similarly marked roots which was discovered at St. Helens in Lancashire. Mr. Binney's statement, clear and positive as it seemed, has nevertheless been doubted by some of our most eminent geologists, who have believed the connexion of the supposed stem and roots to be merely apparent or accidental; and it is possible that similar doubts may be thrown on Mr. Dawson's observations. He appears however to have satisfied himself, that one of the Stigmaria-like specimens now before us did actually proceed in the manner of a root from the base of the stem. These specimens differ in some degree from the best-characterized forms of Stigmaria, their scars not having the distinctly circular and umbilicated form that is usual in that fossil: the appearance is as if the leaves or rootlets (whichever they may be) had not been disarticulated, but broken off abruptly; yet the symmetrical quincuncial arrangement of these scars, the presence of the excentric axis, and the general appearance of the fossils, leave no doubt that they are referable to the supposed genus *Stigmaria*. It has been urged, that the symmetrical arrangement of the scars is a fatal objection to the idea that these bodies were roots, which never emit their fibres with any degree of regularity; but, unless we suppose that Mr. Dawson has been deceived by appearances, this argument, drawn from the analogy of existing plants, must yield to the positive result of observation. It would not be the first instance in which the progress of discovery has revealed striking exceptions to what had been supposed general laws of structure. Exact and multiplied observations are certainly necessary to establish the existence of



Fossils from the Nova-Scotia. Coal formation

(Mr. Dawson.)

such anomalies; but every new fact recorded by skilful observers, and bearing on a question of this kind, like that now communicated by Mr. Dawson, is of great value.

Whatever may be the case with regard to the Lancashire plant, I see no proof, either in Mr. Dawson's specimens, or in his drawing or description, that the fossil tree described by him was a *Sigillaria*. I can find no trace either of the regular flutings, or of the well-defined leaf-scars, characteristic of that genus. If indeed the Sigillariæ were Dicotyledonous trees, having the ordinary Exogenous mode of growth, it is clear that these superficial markings would be obliterated by the increase of the stem in diameter, and would disappear from the older parts of it, as happens in the Pines and Firs. But M. Adolphe Brongniart expressly states that the Sigillariæ present the same appearances, the same furrows and leaf-scars, in the lower parts of their stems as in the upper, and do not appear to have increased in diameter by successive additions to the exterior, after the manner of Exogens. It was partly on this ground, indeed, that he originally maintained that they could not be Dicotyledonous trees, but were of the nature of arborescent Ferns; and even after the examination of a specimen showing internal structure had induced him to admit that they belonged to the Exogenous class, he still dwelt on this peculiarity as removing them from the generality of plants of that class, and bringing them near to the Cycadeæ. In the figure which he has given of the base of a stem of Sigillaria* found at Anzin, we see in fact the furrows and vascular scars represented as very distinct and perfectly regular. It is possible that the various plants comprehended under the name of Sigillaria may differ in this respect; if not, we must admit that the Stigmariæ described by Mr. Dawson, though they might be roots, were not the roots of a Sigillaria.

Supposing it proved that the fossil called Stigmaria was really the root of a tree, (and although the question cannot yet be considered as definitively settled, I think that the positive and independent statements of two such experienced observers as Mr. Binney and Mr. Dawson give very great support to that opinion,) supposing this proved, there still remain some obscurities to be cleared up in regard to this singular production. In particular, what can be the nature of that strange dome-shaped centre, figured in the 'Fossil Flora,' vol. i. t. 31, and vol. ii. pref. p. xiii? Is it the base or stool of a trunk broken off near the root? The figure given in the preface to the second volume of the above-quoted work does not ill agree with this supposition; and it is possible that the "wrinkled appearance, with indistinct circular spots," which the upper surface is there said to have exhibited, may have been deceptive or accidental. Dr. Lindley, who seems to have been the first to hint† that Stigmaria might possibly be the root of Sigillaria, compares the dome-like centre and radiating arms of Stigmaria with the roots and base of the

* Hist. des Vég. Foss. vol. i. t. 160.

† Penny Cyclopædia, art. Coal Plants, published 1837.

stem of *Sigillaria pachyderma*, as figured in the 'Fossil Flora,' t. 54; and thus appears to suggest the same explanation of the nature of that anomalous dome as is here proposed. It may be observed, that in the figure last quoted the stem of *S. pachyderma* is represented as divided into several portions by apparent joints, the lowermost of which, occurring just above the roots, leaves the portion below it in a form very well adapted to the hypothesis in question; but I am not aware that anything similar has been noticed by others in any species of Sigillaria; and perhaps the appearance of articulations in that instance may be occasioned merely by the mineral structure of the stone of which the cast was composed.

The "transverse prominences," noticed by Mr. Dawson as proceeding from the "core" or excentric axis of the upright stem, are doubtless of the same nature with those which are often conspicuous on the surface of the vascular axis of Stigmaria, and which are represented in tab. 35 of the 'Fossil Flora.' They are the broken remains of vascular bundles which passed from the axis to the leaves or rootlets. A similar excentric vascular axis, with bundles of vessels proceeding from it to the bases of the leaves, is described by M. Ad. Brongniart in the only Sigillaria of which the internal structure has yet been ascertained; but, while the existence of the solid axis may very often be distinctly traced even in the stony casts of Stigmariæ, it does not appear to be so distinct in the Sigillariæ.

Before quitting the subject of these remarkable extinct forms of vegetable life, I may further observe, that the similarity of their vascular tissue to that of Ferns is not a sufficient proof of any real affinity to that tribe of plants, since Mr. Brown has ascertained that vessels of a similar structure ("*vasa scalariformia*") constitute the whole of the woody tissue of *Myzodendron**, a genus of parasitical flowering plants allied to the Misletoe, and totally dissimilar to Ferns.

Mr. Dawson's explanation of the nature of the so-called *Sternbergia* appears by far the most probable that has yet been proposed. The smooth outer coat observed by that gentleman (and of which I perceive traces in some English specimens) seems to afford an almost conclusive argument against M. Brongniart's opinion, that the transverse lines on the surface of the casts were the scars of fallen leaves. M. Brongniart appears to have been unaware of the existence of this smooth carbonized integument; it is slightly noticed by the authors of the 'Fossil Flora,' who however seem to regard it as adventitious, not belonging to the plant; but this, according to Mr. Dawson's observations, is by no means the case.

If a generic name be required for these bodies, that of *Artisia* ought certainly to be adopted in preference to *Sternbergia*, as the latter belongs to a genus of recent plants very different from these fossils.

In addition to the specimens described in Mr. Dawson's paper, that gentleman has sent a fragment of a somewhat anomalous appearance, of which he thus speaks in a letter to me:—

* Linnean Transactions, vol. xix. p. 231, note.

"I have sent a curious fragment picked up on the Joggins shore. It exhibits in one specimen two different forms of Sigillaria, usually I believe considered as different species. I have never seen another similar specimen, but think the association of the two forms in this piece cannot be accidental."

The specimen, now on the table, in fact exhibits on one side a sharp and distinct impression of the leaf-scars and other markings of a Sigillaria, apparently *S. scutellata* or a variety of it. The other side is plainly fluted, and has the appearance of a decorticated Sigillaria much rubbed and defaced, and with no distinct trace of the insertion of leaves. I am inclined however to believe that this singular diversity between the two sides of the specimen is accidental. It will be observed that that side on which the markings are sharp and distinct exhibits, *not* the original surface of the stem, but an impression of it, as is evident from the leaf-scars being situated in hollows or depressions, and from the narrow prominent ridges between them, where we should expect to find furrows: in short, all the markings are *in reverse*, as compared with what we see in perfect specimens of Sigillariæ. I conceive therefore that this cannot be really a portion of a stem exhibiting different characters on opposite sides. I am rather inclined to think that the clay of which this specimen is composed may have been moulded within the bark of a decayed stem of one Sigillaria, which gave it the simply fluted appearance, and, while yet soft and moist, may have received an impression on the other side from the external surface of a different stem. But I propose this explanation with much hesitation and doubt, as it is certainly very remarkable, under this supposition, that the ridges and furrows on the two opposite sides should so exactly correspond in direction.

February 4, 1846.

P. W. Barlow, Esq., F.R.S., and Dr. George Buist were elected Fellows, and M. F. Dubois de Montpereux of Neuchâtel a Foreign Member of the Society.

The following communications were read :—

1. *Observations upon* Sternbergiæ. By John S. Dawes, Esq., F.G.S.

This communication had reference to the remarks offered by Mr. Dawson in his memoir, read at the last Meeting of the Society, on Fossils from the Carboniferous Rocks of Nova Scotia. The author does not agree in the conclusion of Mr. Dawson, that herbaceous Endogens may sometimes have produced the columnar forms usually referred to the pith of coniferous and other large trees. He thinks that although the appearance in question may indicate that the fossil is not that of a true Dicotyledon, it must still have been the interior cellular portion of an arborescent plant like Lepidodendron, the supposed bark being the vascular system or sheath surrounding the pith, which has adhered during decay to the medullary column, and sometimes become changed into coal. Examples of this condition were exhibited.

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2. *On the Tertiary Formations of the* Isle of Man. By the Rev. J. G. Cumming, M.A.

[This memoir forms the second part of the author's communication on the Geology of the Isle of Man. It is unavoidably postponed till the next number of the Journal.]

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

26TH FEBRUARY, 1846.

AWARD OF THE WOLLASTON MEDAL AND DONATION FUND.

AFTER the Reports* had been read, and before delivering the Medal to Dr. Fitton to forward to Mr. Lonsdale, the President said:—

GENTLEMEN,—You have been informed that the Council have awarded the Wollaston Palladium Medal and the proceeds of the Donation Fund for the present year to Mr. William Lonsdale, for his many valuable contributions to Geological science, and more especially for his descriptions of the Corals in the Silurian System and Devonian Rocks, for his late report in the first volume of our Journal on the Corals from the Tertiary formations of North America, and for his description of the Corals from the Palæozoic formations of Russia.

It would have been gratifying to you all, as I am sure it would have been to myself, to have seen our old and valued friend present in this room, to receive this acknowledgement of the high estimation in which he is held by that Society with which he was so long connected, and of the great value they attach to his important zoological and palæontological researches since his retirement. But, I am sorry to say, it is the state of his health which prevents his being here; and I fear there is too much reason to believe that his strength would scarcely have been equal to the exertion and excitement of coming to London on such an occasion. But I cannot help suspecting that another cause has not been wholly inoperative,—I mean that singular modesty, that unwillingness to bring himself forward, which, while it adds a grace and dignity to his character in the eyes of those who know him best, conceals from many his great accomplishments as a man of science, and his powerful and original mind. His absence therefore, in one sense, is not to be regretted; for it enables me to give utterance to expressions which I could not have ventured to use in his presence, from the certain knowledge that in doing so I should have given him pain.

Mr. Lonsdale was elected Curator of our Museum in 1829; he was well known by many to possess qualities that eminently fitted him for the office, and early in the spring of that year he had con-

* These Reports, &c. are inserted at the commencement of the present volume of the Proceedings and Journal.

tributed an important paper "On the Oolitic District of Bath," which is published in the third volume of the second series of our 'Transactions.' He was not at that time a Fellow of the Society, and the paper was communicated by Dr. Fitton, who has been requested by his friend to attend this day as his representative. In 1832 the Council, perceiving that the incessant labour and close confinement to which, notwithstanding every remonstrance on their part, he subjected himself in the service of the Society, imposed a duty upon him, the performance of which they hoped might renovate his health, by awarding to him the proceeds of the Donation Fund of that year, with a request that he would "in the ensuing summer continue his researches in the oolitic formations, and endeavour to detect the variations of mineral and zoological characters which mark that series in its range to the north of England." He complied with the request, and in the following December he communicated his observations in a paper entitled "Report of a Survey of the Oolitic Formations of Gloucestershire." He continued these researches in 1836, when he was again urged to travel for the sake of health; but although every one else, in all probability, would have found the results of his observations highly valuable, he did not himself consider them sufficiently so to lay them before the Society in any written communication: all that we have obtained of them is a donation he has just made to us of several sheets of the Ordnance Map, on which he has marked his observations during a series of oblique traverses, from the limit of his survey in 1832 to the Humber. His devotion to the affairs of the Society left him little leisure for work in the field, but his mind was always directed to researches in our Museum, especially in departments of palæontology, in which he knew that much was to be done. Many of those who had been working in the field, and submitted to him questions of difficulty in the determination of the fossils they had collected, must remember the valuable assistance he so willingly rendered them. In March 1840 he read a paper to us, which he entitled "Notes on the Age of the Limestones of South Devonshire," containing some new and curious results, the fruit of minute and careful examinations of the fossils in these rocks, and constituting a very important part of that body of evidence which led Professor Sedgwick and Sir R. Murchison to propose that division of the Palæozoic formations, which, adopting their term, we now class as the Devonian system.

In 1842 the enfeebled state of Mr. Lonsdale's health compelled him to resign the office in the Society, which for thirteen years he had filled with so much honour to himself and advantage to us. He retired to the south of Devonshire, devoting much time to the living corals on that coast; and some time afterwards removed to Bath, where he now resides. So far as his delicate health will allow, he in his retirement enjoys repose, but not inglorious ease; for he passes his time in philosophical researches which materially advance the science to which a great part of his active life had been devoted. The investigation of Fossil Polyparia is the subject to which his attention has been directed, they having long before been objects of special interest to him; and in this department he has made himself unquestionably the highest authority in England. He has already embodied the results of his examination of fossil corals that have been submitted to him from various parts of the world in six separate communications, in which the determinations, whether generic or specific, have been deduced from a most diligent examination of the component structures, and where, with his characteristic fidelity and modesty, he has shown a careful regard to the labours of others, so far as their works were accessible to him. These communications have been,—1st, On Six Species from the Upper Cretaceous Beds of New Jersey; 2ndly, On Ten Species from the Miocene Tertiary Formations of North America; 3rdly, On Twenty-six Species from the Eocene Tertiary Formations of the same country; 4thly, On Six Species from the Palæozoic Formation of Van Diemen's Land, in the Appendix to Mr. Darwin's work on Volcanic Islands; 5thly, On the Corals of the Palæozoic Series of Australia and Van Diemen's Land, in the work of Mr. Strezlecki; and 6thly, On some characteristic Palæozoic Corals of Russia, in the Appendix to the first volume of Sir Roderick Murchison's great work on that country. His contributions to the works of Mr. Darwin and Mr. Strezlecki are peculiarly interesting, as being the first descriptions of corals from the palæozoic rocks of the southern hemisphere, some of which are at present peculiar to Australia.

Turning then to Dr. Fitton, the President continued,—I am happy to place in your hands, for your friend, this Medal, and this other part of the Award; for no one better knows, or is more capable of appreciating, the great scientific attainments of Mr. Lonsdale; nor can any one be more thoroughly acquainted with, or more justly estimate his high moral qualities.

On receiving the Medal Dr. Fitton replied on the part of Mr. Lonsdale:—

Sir,—I have been requested by Mr. Lonsdale, on receiving from your hands the Medal which the Council of the Society has awarded to him, to express to you and to the Society his deep sense of the honour which this mark of your approbation conveys; and if I were to act under the impulse of his own feeling, I believe that I should be called upon to add, that you have overrated his merit. But I cannot allow myself to go so far, even as the representative of my friend, since I firmly believe that the Society will have but one opinion upon this subject, and that the honour is most justly bestowed.

In the paper by which the Donation entrusted to us by Dr. Wollaston was announced (or rather his "*Bequest*," for it was one of the last acts of his life), the illustrious donor appears to have foreseen that in the allotment of its produce, personal attachment might possibly influence our judgement in favour of our officers who distinguish themselves in the discharge of their duties; for while he leaves to the Council the disposal of the fund, "in such a manner as shall appear conducive to the interests of the Society in particular, or of the Science of Geology in general," he has expressly added, that "this latter application of it, to the purposes of science, will in his opinion be most creditable to the Council." I am therefore happy that circumstances, in a great measure accidental, have delayed the award of this Medal to Mr. Lonsdale till some years after his retirement from office; and that during that interval the new and additional claims arising from his productions have been such as to demand this decision as an act of strict judicial duty, obviously independent of the gratitude and attachment which all those who have known him justly entertain.

You have, Sir, clearly stated the specific grounds upon which the adjudication has been made; and I shall not presume to make any addition to a recital which comes with appropriate effect from the Chair: but having been so fortunate as to have had a share in the arrangements which first connected Mr. Lonsdale with this institution, and having since had full opportunities of observing the impress which his labours here received from his peculiar character and talents, during no less than thirteen years, I feel that I am called upon to express my conviction, that there never was an officer in the service of any public institution whose duties were fulfilled with greater efficiency or more beneficial results.

Of his skill and acquirements in some of the departments of natural science to which you have just referred, I am not qualified to judge; but I may perhaps be allowed to say, that in the range and soundness of his Geological views, and in exact acquaintance with the facts hitherto brought to light respecting the structure of the earth, few indeed of our number go beyond him. It was no wonder that with such a man to conduct the business of our Society, matters should go well; and for what was done during the years from 1829 to 1842, I refer to our 'Transactions,' and to the 'Proceedings' which record our daily progress. Who that is acquainted with the facts there stated will hesitate to say, that the suggestions of a man of Mr. Lonsdale's attainments, given at all times with cheerfulness and alacrity, and with a judgement which no difficulty or pressure of business could disturb, were of the greatest advantage to the inquirers whose papers were read at our meetings during that important period in our history?—I appeal with confidence to many of those by whom I am surrounded for the answer to this question; and I venture to say, that, without reference to his own specific publications, the services thus rendered by Mr. Lonsdale *to Geology*, while he seemed to be merely discharging his duties here, were of incalculable benefit to our science in the best sense of the word, and deserving of high reward.

Mr. Lonsdale's profession before we became acquainted with him had been that of a soldier. He brought with him into our service some of the best qualities of the military character,—singleness of purpose, the strongest sense of duty and subordination, with such devoted energy in the performance of whatever he undertook, as too often led him to exertions beyond his strength. His spirit "no labours could have tired," but the "frame of adamant" was wanting. Under these unsparing efforts his constitution at last broke down, and he was obliged to resign his office, in such a state of health that little hope was entertained of his recovery. But he has revived; and restored to the power of moderate exertion, he has returned to the inquiries, some of which have this day obtained your approbation. He desires me to tell you, that while strength remains to him he will continue to pursue those inquiries. He bids me also to assure you, that his retirement will be cheered and enlightened by this proof that he is remembered here; and that you will have added essentially to the enjoyment of his remaining life. I have witnessed often what he suffered in our service. He will now feel that those days of toil and nights without repose,—the drops of life drawn from his very heart,—were not expended in vain.

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

ANNIVERSARY ADDRESS OF THE PRESIDENT,

LEONARD HORNER, Esq., F.R.S. L. & E.

Gentlemen,—I congratulate you on the very satisfactory report which you have this day received from your Council on the present state of the Society. The number of our Fellows is greater than it was at the last Anniversary; and while we lament the loss of several of our Ordinary members, we have this consolation, that we do not number among them any of those known to the world as active promoters of our science; and that we have replaced our losses not only numerically, but with increased strength.

Although the active duties of a physician in great practice, rendered still more laborious to him by the large portion of his valuable time which he each day devoted to the relief of the sick poor, left little leisure to my old and excellent friend Dr. James MacDonnell of Belfast for the active pursuit of science, I cannot allow this occasion to pass without paying a tribute to his virtues, and to the ardent, I may say enthusiastic interest he took in the advancement of science, and especially in the great general views of Geology. His known attachment to the objects of our pursuit pointed him out in the early days of the Society as well-worthy of being enrolled in the list of its honorary members; and all who went to study the very interesting geological structure of the north of Ireland, and visited Belfast, were sure to receive from Dr. MacDonnell a most hospitable welcome, and much valuable information. He died last November, at the advanced age of 82; but, as I can testify by a letter I received from him a few weeks before his death, continuing a keen geologist to the last. Not many months previous he asked me to complete for him his series of our Transactions, looking forward to much enjoyment from reading them during the confinement to his room that then appeared in prospect. In 1810 he made a short communication to this Society on the remarkable circumstance of nuts with their shells quite entire, yet filled with calcareous spar, found in a stratum of submarine peat in Belfast Lough; and in 1811, another notice on granite veins penetrating slate in the Mourne mountains in the County of Down.

Theodore Monticelli of Naples, the Foreign Member whom we have lost, was born in 1759, in the celebrated city of Brundusium, the modern Brindisi. He was educated in the Benedictine College at Rome, in which Chiaramonte, afterwards Pius VII., was then a professor, and where he made so much progress in his mathematical studies as to be able, while yet a very young man, to deliver a course of lectures on Natural Philosophy at Naples. In 1792 he was elected Professor of Ethics in the University there, but soon after, getting involved in the political troubles of that time, he was thrown into prison, and was confined six years. When he recovered his liberty in 1800 he went to Rome, where he was very kindly received by his old tutor, by that time raised to the Popedom; and some years afterwards he was nominated by Napoleon to be employed with others in the re-establishment of the University and Academy of Sciences of Naples, of which latter body he was in 1808 elected Perpetual Secretary.

He about this time directed his attention with great earnestness to the study of Vesuvius, forming a very rich collection of its products. He contributed many memoirs to the Academy, in which he described the active volcanic phænomena, which he watched with unceasing assiduity, their modern products, and those of the earlier history of that celebrated mountain. In 1813 he published an account of a great eruption of that year, which he dedicated to Sir Humphry Davy, with whom he was intimately acquainted; and Davy, during his residence at Naples some years afterwards, studied the structure and phænomena of Vesuvius under his guidance. Some years afterwards Monticelli published his 'Storia de' fenomeni osservati nelle eruzioni del Vesuvio,' and in 1825, in conjunction with Covelli, his 'Prodromo della Mineralogia Vesuviana,' which deservedly added to his reputation. In 1827 he was one of a committee appointed by the Academy to draw up a geological description of the island of Ischia; a work which was accomplished, and illustrated by several topographical and geological maps, but which has not yet been published. He also drew up for the Academy a memoir, which was printed in Latin, entitled 'Commentarius in agrum Puteolanum Camposque Flegræos.' He continued to the last an ardent cultivator of science, and died Secretary of the Academy, having filled the office thirty-seven years. He was alive during the Scientific Congress at Naples last September, but was too infirm to take a part in its proceedings. He was living in retirement at his favourite Pozzuoli, and in the month of October, when a few friends had assembled to celebrate his 87th birthday, he was seized at dinner with apoplexy, which terminated his existence.

The vacancy in our list of Foreign Members (so wisely restricted to a limited number) occasioned by the death of Signor Monticelli, you have worthily filled up by the election of M. Dubois de Montpereux of Neuchâtel, whose merits as a geologist are of the highest order, as he has fully shown in his great work on the Caucasus and the adjacent lands. But it is unnecessary for me to dwell on his just claims to the honour you have conferred on him, for you will find them ably set forth by Sir R. Murchison in his Anniversary Address of 1843*.

When we review the year that has passed, we have the satisfaction of feeling that the science we cultivate has made some important steps in advance, and that our Society maintains itself in undiminished vigour. Our pursuits become more and more objects of interest among all educated classes; and the works of some of our present most active Members have largely contributed to make geological inquiries attractive to those higher minds which recoil from vague unsubstantial speculations, and to the establishment of the sound philosophical views in the history of the earth's structure, which have raised Geology to the rank of an exact science in some of its most important fundamental truths.

We have had no meeting without some valuable communication, nor without instructive conversations on the subjects of the papers read. I regret that, in those discussions, our younger Members do not more frequently take a part; I do not doubt that they are influenced by a desire of rather listening to those they look up to as the established authorities, the great doctors of our laws, whose opinions we are accustomed to hear delivered to our great benefit on those occasions; but I am sure I speak the sentiments of all the senior Members when I say, that nothing would give them greater pleasure than to see those coming forward who are to constitute the future life and strength of the Society.

Library and Museum.

By the financial statements in the Council's report you have learned, that, after providing amply for the salaries of our officers and the other branches of ordinary expenditure, and after setting aside a considerable sum to be laid out on our Library, the Council will have at their disposal a large surplus, to be expended on publications, the way of all others by which the Society can render most service to the science we cultivate. The improvements which have been made in our Library during the last year, and the excellent classed Catalogue of our books and maps prepared by our Vice-Secretary, which may very shortly be in the possession of every Fellow, and the first five sheets of which are now on your table, will render that part of our establishment far more valuable than it has hitherto been, and will lay open treasures which few of the Fellows, probably, are aware that they possess.

* Proceedings of the Geol. Soc. iv. 108.

Excellent for the purposes of study as many parts of the collections in our Museum are at present, I do not doubt that before many months elapse they will be rendered still more valuable by the plans which the Council are now carrying into execution. Our specimens of the suite of formations, with the fossil contents of each, and of the various igneous rocks, in the British Isles, will be rendered more complete and accessible. The present arrangements for the foreign specimens we possess have proved inconvenient from the great extent of cabinet-room they occupy, and from the difficulty of keeping them in order without more attendants than we can afford to employ. The Council have not yet determined how our valuable collections illustrative of foreign geology may be most usefully arranged, consistent with the means we possess of preserving that degree of order which is indispensable for the due efficiency of any plan.

It is a part of the general scheme contemplated for the Museum to have a full Catalogue for each formation or principal group, of all the known fossils belonging to it, and of the lithological characters of its prevailing rocks, both British and foreign, distinguishing the specimens in the possession of the Society, and containing a list of all the works and memoirs that treat especially of the particular group; so that any one desirous of studying it may find in the rooms of the Society all the information that has been brought to light respecting the group. When each is successively completed, as far as it is possible by the means at the disposal of the Council, it is to be hoped that the Fellows will carefully examine these Catalogues, and not only hasten to supply the deficiencies, both in specimens and books, which they will in several departments most assuredly find, but will offer such suggestions for improvement as their several experience and opportunities may enable them. By such union of strength, and such active co-operation of the Fellows, far more will be accomplished than is possible by the unaided efforts of the most active Council and the most zealous officers.

You are probably all acquainted with the valuable work of Mr. Morris,—his 'Catalogue of British Fossils.' To have rendered that work complete, Mr. Morris would gladly, I have no doubt, have given a figure of each species; but it would have involved so great an outlay of capital, and enhanced the price so much, that no probable sale would ever have saved him from great pecuniary loss. To render this Catalague more useful in our Museum, I am now preparing, with the assistance of Mr. Morris, an illustrated copy of it, which we intend to present to the Society. We take the figures from every authentic source, by cutting up the plates of works in our own possession or contributed by those who are willing to assist us. I have this day laid upon the table for your inspection the first volume of our joint work, containing the *Conchifera Dimyaria*, *Conchifera Monomyaria*, *Rudistes* and *Brachiopoda*, as a specimen of what is intended; and it will be proceeded with as quickly as our opportunities will enable us.

Quarterly Journal of the Geological Society.

The establishment of our Quarterly Journal has unquestionably been the great feature in the past year. In the earlier days of the Society, and for a period of twenty years, our 'Transactions' were the only vehicle by which the papers read before us were communicated to the public. These, by their form and the nature of the illustrations, bore so heavily upon our finances, that a volume, or even a part of a volume, could be published only at distant intervals. To remedy, in some degree, the great evil of delay, the Proceedings were instituted in 1827; and they form a valuable record of the history of the Society, and of the progress of Geology for the last eighteen years. But in order to avoid an inconvenient and even injurious effect upon the sale of our Transactions, the Proceedings consisted of very brief abstracts of the papers, and being without illustrations, in many instances they conveyed a very imperfect idea of the nature and value of the memoir. But the great delay in the publication of memoirs in full, robbing authors in some instances of the honour of priority in discovery, the uncertainty when a paper that had been read would be published, and even the doubt that was sometimes raised whether it would ever appear, very materially diminished the usefulness of the Society, and, there is too much reason to believe, cooled the zeal of many of our Members, and forced them to send their memoirs elsewhere. In a progressive science like Geology, with so many active cultivators of it in every part of the world, rapidity of publication is of the first importance, that geologists may speedily know what has been done and is doing by others; thus affording information for their guidance, not only as to what their attention should be directed, but to save them from throwing away time and labour on what had been already done. A majority of papers may be perfectly well given in the octavo form, now that the great improvements of late years make it possible to have distinct and accurate illustrations by woodcuts, lithographs, and zincographs, upon a page of that size. By the adoption of a Journal appearing at regular periods and at short intervals, rapidity of publication is secured, and with the exception of papers requiring illustrations that can only be adequately given in a larger form, memoirs will in general appear within six months of their having been read at the meetings, and sometimes even more speedily.

But the institution of the Journal has enabled the Council to extend the usefulness of the Society by the addition of what is called the "Miscellaneous Part." The diffusion of the Society's publications must always be mainly among our own countrymen, among those interested in geological inquiries at home and in our colonies, and among our transatlantic brethren, speaking the same language as ourselves. Geology now embraces so wide a sphere of inquiry and is so actively cultivated in almost every part of the civilized world, that each year gives birth to works of the highest interest, greater in number than the most diligent can overtake, even among those whose whole time is devoted to the science, unless they confine themselves to particular departments. Besides, we all know how difficult it is, even in London, to see the Transactions of foreign bodies, and especially scientific journals; and we surely, therefore, render a great service to the readers of our Journal, especially to our own countrymen, by serving up to them some of the more choice exotic fruits of the year,—some of the more valuable papers published in foreign countries; and by giving such notices of what is going on abroad as must be interesting to every geologist, together with lists of new books and memoirs. While we carefully adhere to our fundamental rule, applicable to this as well as to every other form of our publications, viz. that the Society, as a body, never expresses an opinion, I cannot imagine any possible way in which the Miscellaneous Part of the Journal can compromise either the character or proper dignity of the Society. To show how scrupulous the Council have been in the enforcement of the above rule, I may state, that when it was lately determined that the Journal was to be carried on on our own account, they instructed our Vice-Secretary, the Editor of the Journal, to abstain from the expression of his own, or any other contributor's individual opinion, in any analysis of a book or memoir he may insert in the Journal, lest, by implication, the Society might be understood to pass a judgement. Further, they have thought it advisable, for the same reason, to direct that no analysis of an English work be given, but simply an announcement of its contents.

I have been induced to make the preceding remarks on the Miscellaneous Part of the Journal, because I have heard opinions differing from those on which the Council have acted, expressed by some Fellows of the Society, for whose judgements I entertain great respect, who have said that it is a great innovation upon established custom, a departure from a sound principle, for a Society to publish, under its authority, anything beyond that which properly belongs to it as an integral part of its own proceedings. As the great purpose of our association is to promote the advancement of geological science, if a deviation from established custom will further that end, it is, in my opinion, both justifiable and expedient. If we review the history of the Society, we shall find a succession of such innovations upon established usages: the very institution of it was held by the then President of the Royal Society as a dangerous encroachment upon the province of that body; and under his influence one of our chief founders withdrew. The governments of societies, like the governments of nations, to be wise, must mark the effects and meet the demands of improved and extended knowledge; although a main prop had been removed, the new structure was not in the least shaken; its foundations were strengthened, and it has stood firm on that rock ever since; subject only to this change, that, like other rocks, by gradual elevatory movements it now occupies a higher level, to be, I trust, still further uplifted. The cultivators of other departments of science in London, following our example, instituted the Astronomical, the Zoological, the Geographical, and many other societies, all of which have proved that the productive and perfective powers of the principle of the division of labour are as conspicuous in science as they are in manufactures. I am tempted to enumerate some more of our innovations, because the wisdom of them has been proved, not only in our own body, but by their having been adopted by other societies: the change of presidency from a virtually perpetual to a biennial office—the removal of all formality more than is necessary for the conduct of business at our ordinary meetings, by discussions and conversations on the papers read —the social assembling afterwards; neither the least agreeable nor the least useful part of our evenings. Our Proceedings were first published in November 1826; the first part of the Proceedings of the Royal Society is dated November 1830; and the first part of the *Comptes Rendus Hebdomadaires* of the Academy of Sciences of Paris bears the date of August 1835.

THE SOCIETY'S TRANSACTIONS.

An idea has been entertained that the publication of our Transactions was to cease on the institution of the Journal. Such a proposal was never under the consideration of the Council, and it was always intended, that when a paper could only be advantageously given in quarto, that form should be adopted. As the best contradiction of the statement that had gone forth, your Council of the last year commenced the publication of the SEVENTH VOLUME of the Transactions with three valuable papers by Mr. Hopkins, Mr. Bain and Professor Owen.

But I must not allow you to suppose that all is prosperous with us; that nothing is wrong; or that all the Fellows of the Society may be perfectly satisfied with the efforts they have made to carry out our common object. It is my duty as your President to point out defects, as well as to put before you the favourable side of your affairs; and I am willing to hope, that it is only necessary to state what is wrong to secure an immediate remedy; especially when I know that a complete remedy is in the power of those who have made it necessary for me to say that all is not as it should be. I ascribe their faults of omission to a want of thought, and to nothing else.

From the number of copies of our Transactions and Journal still on hand, it is manifest that a very considerable number of the Fellows do not provide themselves with our publications. Now if our own Members do not patronize our works, to whom can we look with more confidence? We are strong only by united efforts; and when, in the case of the Journal especially, it is merely a question of a very small annual sum, for which, be it observed, full value is given in exchange, the many important memoirs we have published ought not to be suffered to lie dormant in our stores, when they might all be put in circulation if our own Members only were the purchasers.

Geological Survey of Great Britain and Ireland.

In his Anniversary Address of 1840, Dr. Buckland adverted to the recent establishment, by the Government of that time, of the Museum of Economic Geology. It not only received encouragement from their successors, but has been placed by them on a more enlarged and comprehensive plan. During the last year the Geological Survey of Great Britain and Ireland has been transferred from the direction of the Master General of the Ordnance to that of the Chief Commissioner of Her Majesty's Woods and Works; and that Survey and the Museum of Economic Geology are now united under one management. The establishment is supported by an annual parliamentary grant, which in the last session amounted to 8850*l.*, including the Museum of Economic Geology in Dublin; and large premises are about to be built by Government in a central part of the metropolis for the accommodation of the several departments, the extension of the Museum, and the accomplishment of other useful plans that are in contemplation. It is a reproach to former Governments that the formation of such an institution should have been left to recent times, in a country deriving so much wealth, importance and power from its mineral treasures.

When we consider the high qualifications of the officers selected by the Government for carrying out this scheme, we may look forward with confidence to their rendering important services to geological science, as well as to mining interests, the arts and manufactures. Sir Henry De la Beche is, as you are aware, the Director-general; and his indefatigable zeal and exertions, and above all the judgement shown by him in his recommendations of the other officers, cannot be too highly estimated. Mr. Andrew Ramsay is Director of the Survey of Great Britain; Captain James, of the Royal Engineers, is Director of that of Ireland; Professor Edward Forbes is Palæontologist, and Mr. Warrington Smyth, Mining Geologist for the United Kingdom; and there is reason to believe that Dr. Hooker will be appointed to the department of Botany *. Mr. John Phillips is engaged in the Survey of the North of England, and one laboratory of the Museum of Economic Geology is under the direction of Mr. Richard Phillips, one of the founders of this Society, and another under the direction of Dr. Lyon Playfair. There are besides several able officers in different departments.

You have this day had placed on your table a most valuable donation from Her Majesty's Chief Commissioner of Woods and Works, viz. twenty-four sheets of the Ordnance Map of England, coloured geologically, and about thirty large plates of Sections emanating from this establishment. They will go on publishing the Maps of the districts, and the Sections belonging to them, as the Survey of each is completed. They are to publish Memoirs drawn up by different persons engaged in the Survey, and two volumes of these are now in the press, one of them in a very advanced state.

* Dr. Hooker's appointment has since taken place.

They have begun a series of figures of fossil shells, drawn and engraved with the utmost care; and every plate will be sold separately, at a very moderate price.

For the last eighteen years it has been the custom for your President at each anniversary meeting to read an Address, the main feature of which has been a sketch of the progress of Geology during the preceding year. This plan was conceived and first carried into execution by our valued associate Dr. Fitton, who for many years has been, and, I am happy to say, still continues to be, one of the main supports of this Society. It was a plan calculated to be useful in many ways; and the future historian of the progress of Geology will find in the admirable addresses which have been printed, by the eminent individuals who during the above-mentioned period have occupied this chair, materials of the highest value. When I passed my eye over the list of my predecessors, I saw at once the difficulty of the task before me; and were it allowable to shrink from the performance of any of the duties which devolve upon your President, I would gladly have broken through the established custom, from the hopelessness of being able to execute the task to the satisfaction of my own mind; but I felt strongly that the custom ought to be maintained, even although the purpose should be imperfectly fulfilled.

The greater number of those who have hitherto delivered these anniversary addresses have belonged to the fortunate few who have been able to devote a great part of the best period of their lives almost exclusively to Geology. Such has not been my lot; I have had other duties to perform, which have left me but little leisure for the active pursuit of science; and all I can now attempt is to bring before you some of those topics that appear to me to possess most general interest, or to be steps in the progress of Geology, which have come under my notice in the limited sphere of reading and observation to which my opportunities have extended. When we consider the vast extent of the domain of Geology as it is now studied, that its fundamental principles are derived from many, indeed from almost all departments of natural history and physical science, it is not possible for any one, although he united the most comprehensive mind and varied attainments with indefatigable industry, to take even a rapid survey of the progress of Geology in a single year, using the term in its most enlarged sense. Even if we confine ourselves to the more important observations that have been made on the mineral structure of the earth, we shall find that to read merely the published accounts of the labours of the cultivators of this branch of science, now actively at work in all parts of the world, is beyond the power of almost any man, even if he had no other occupation. But even if such an herculean task were accomplished, the difficulty would still remain of compressing the general results into that space to which an address of this nature must necessarily be confined.

The Memoirs which were read in this room during the past year, to the conclusion of last session, have already been made known to all through the medium of our Journal; and I will not anticipate the contents of the number which will appear two months hence, and which, in all probability, will include all that have been read, and been ordered by the Council to be printed, up to the end of January; a rapidity of publication hitherto unexampled in the annals of the Society. I have no occasion therefore to do more than allude very briefly to what has been read within these walls, and I shall confine my observations almost entirely to what we have learned from other works published during the last year. Four of these, of pre-eminent interest, are the production of distinguished members of this Society—Sir Roderick Murchison, Mr. Lyell, Professor Owen, Major Cautley and Dr. Falconer. The 'Russia' of Sir R. Murchison and the 'America' of Mr. Lyell are each so rich in observations of the highest value, and embrace so many general views, that even a brief examination of the most interesting subjects they treat of made it impossible for me to refer to several other works of great interest, without exceeding all reasonable bounds. I have been the more inclined to extend my remarks on the work on Russia, because it is less likely, from its magnitude and price, to be in extensive circulation.

It is little more than six years since the publication of 'The Silurian System,' a work containing the results of several years of the most assiduous observation, conducted with the greatest ability. The appearance of this work will ever be held to form an epoch in geological science; and while it has secured to the author an imperishable name, it adds a lustre to this Society, in which he may be said to have been trained. It is so accurate in its details, that a very competent judge, who has trod, hammer in hand, over every part of the region, holds it to be the best piece of topographical geology in our language. Of the correctness of the descriptions I can speak from personal experience during the last summer, in a limited but somewhat complicated part of the country. But it is also a characteristic feature of all Sir R. Murchison's writings, that in the midst of his details, general views are never lost sight of. The principles of classification of the older of the palæozoic rocks laid down, and for the first time, in that work, have been proved by the subsequent researches, both of himself and of others, in distant lands, to be of the most extensive application. They threw a flood of light over many regions that had been explored by the best geologists, but were never before rightly understood; and the key once placed in their hands, geologists in all parts of the world were enabled to interpret and elucidate whole chapters in the earth's history, which revealed the most unexpected and important truths. The almost immediate general adoption of the term chosen by the author for his new classification of the rocks in question, was the most unequivocal proof that he had clearly established his case. It was only in 1836 that he announced his adoption of the term "Silurian System" for that group of distinct formations into which, after five years of the most patient observation, he had separated the transition rocks, the fossiliferous grauwacke, of the western parts of Herefordshire and Shropshire and the adjoining parts of Wales; and it is remarkable that so early as 1837, we find the "*Terrain Silurien*" recognised by the most experienced and distinguished of the French geologists. Indeed nothing can prove more strongly the accuracy of the principles upon which English geologists have separated the several groups of the stratified rocks in the British Isles, than the adoption by our brother-geologists of France not only of these divisions as normal types of formations, but of the English names by which they were originally distinguished. Thus, in the prospectus of the forthcoming '*Palæontologie Universelle*' of M. Alcide d'Orbigny, we find the *Etages Silurien*, *Devonien*, *Liassique*, *Bathonien*, *Oxfordien*, *Kimmeridgien* and *Portlandien*; and even the provincial term of *gault* is there canonized.

Having finished his work on Siluria, Sir R. Murchison did not claim any respite from the labours of the field, as our Proceedings and Transactions testify by several valuable communications; and in 1840, in conjunction with one of our most eminent foreign members, M. de Verneuil, and a young enterprising Russian geologist, Count Keyserling, he undertook the herculean task of exploring Russia in Europe, the Ural Mountains, and a considerable part of Sweden; mainly, as he tells us, "to test whether the British palæozoic classifications would be found equally true over a vast area, in which, since few or no igneous rocks were known, the history of succession might, he hoped, be read off in a very perfect and unbroken manner." The results of their joint labours have just been given to the public in two great and admirably illustrated volumes, which, from the variety and amount of the new and valuable information they contain, may justly be considered as the most important geological work that has appeared in this country, not only in the past year, but for a long period. The authors ask modestly, but very unnecessarily in my opinion, indulgence for inaccuracies of detail "in a first outline of regions which they traversed rapidly and partially examined." The local surveyor or engineer may perhaps discover inaccuracies of detail; but these, even if they exist, do not interfere with the broad general views, the great questions of geological interest, based on a most extensive series of observations, and described with clearness and perspicuity, which we find throughout these volumes.

Following the example of my predecessors, I propose to notice, in the first place, in the order of formations, such particulars relating to the sedimentary rocks as have most arrested my attention during the last year, contained in the works I have had an opportunity of examining with care. But before proceeding to that systematic review, it may be useful, for the reason I have already assigned, to give an outline of the great features in the geology of Russia in Europe and the eastern boundary of the Ural Mountains, described by Sir R. Murchison. And although he nowhere speaks in these volumes in the first person, but associates his fellow-travellers with him in all he tells us, if for the sake of brevity I more generally name him when I have occasion to refer to the authors, I hope I shall not be considered as detracting in the least degree from the merits of M. de Verneuil and Count Keyserling.

Geology of Russia.

Russia in Europe is "one huge depositary basin," encircled on the west and north by the granites of Sweden and Finland, and on the north-east, east and south-east by the chain of the Ural Mountains, which are mainly composed of plutonic and metamorphic rocks. It consists, to a very great extent, of a series of undulations, composed of incoherent clays and sands; but although in that unindurated state, not consisting of modern detritus, but being very ancient deposits that have undergone no consolidating process; for the whole of European Russia appears to have been exempted from igneous agency; no eruptions have tilted up the beds, but the elevatory forces, to which however it has been indubitably and repeatedly subjected, have raised the vast undulating plains *en masse*, without a break. The oscillations of the land having left the strike more or less horizontal, scarcely any traces of unconformability of strata of different ages are to be met with, and beds separated in time by vast intervals are in the same parallelism of juxtaposition as if they were the members of one group. Thus at the mouth of the Vaga, a tributary of the Dwina, about 150 miles south of Archangel, post-pliocene beds are seen resting conformably on limestones with Producti and Corals of the Permian rocks; and an observer unacquainted with fossils might view the two as parts of an unbroken series.

We have some most instructive examples of similarity of lithological characters between deposits of the most different ages, consequent perhaps in some degree upon that absence of consolidating processes to which I have alluded. A grit occurs in Sweden, described as a recomposed granite or granitic gneiss, which constitutes the base of the Silurian system in that country, that can scarcely be distinguished in mineral character from a tertiary grit in central France. Lower Silurian deposits charged with fossils common to the crystalline slaty rocks of other regions often occur as greensands and half-consolidated mud-like limestones. We have Silurian bituminous schists that resemble the hard beds of the Kimmeridge Clay. In one region a carboniferous limestone has all the characters of a soft tertiary deposit; in others, Devonian, Carboniferous and Permian rocks are not distinguishable from the younger secondary or even tertiary deposits of Western Europe; and even an oolitic rock of Miocene age cannot be distinguished from the Great Oolite of the Jurassic period.

These facts are most valuable, as showing that at all periods sedimentary rocks were formed, as they must now be forming, at the bottom of the sea, from the detritus of adjoining land, by the same agencies of disintegration as are now at work; and that then, as now, gravel, sand and mud were the forms which such detritus must have taken, to be afterwards compressed together, and consolidated by a variety of causes acting more or less intensely in different situations.

But Sir R. Murchison also observes, that the connexion between the character of the fossils and the nature of the matrix in which they are imbedded is more pointedly brought before the observer who ranges over the boundless tracts of Russia, than in any other country which he has examined. Notwithstanding the absence of violent dislocations, the various Russian formations, though horizontal, or so nearly so that they may be all considered conformable to each other, are as distinctly separable by their included remains, as in those typical and dislocated tracts where geologists first worked out their order. And these observations hold good in the newer as well as in the older deposits; thus, in the regions of the Volga, greensand, ironsand, chalk, and chalk marl occur, in which the same groups of fossils prevail as in the rocks of Britain and France, which hold the same relative place in geological succession; and pure white chalk, containing some characteristic organic remains, extends from the British Isles to the confines of Asia.

That so vast a tract of country, unlike most other parts of Europe, has been so little broken up locally by igneous eruptive rocks, may perhaps with great probability be ascribed to this, that a safety-valve was opened, an enormous crack or cleft was made on the east, by a subsidence of the country on the west, through which the pent-up elastic force and the molten matter escaped, and thus the high pressure was taken off from under the broad expanse. The Ural Mountains, bounding Russia in Europe on the east, are a comparatively narrow ridge, made up of igneous rocks and sedimentary palæozoic deposits; and through fractures in the latter the igneous rocks were erupted, after having produced in them those changes of structure which we call metamorphic, that is, having caused them to change their original characters, and assume a crystalline aspect; the force acting with such intensity as in many places to overturn the strata, and so invert the order of superposition on the flanks. But it has not been by one great fissure only that the igneous rocks have been erupted; "other parallel outbursts and upheavals have taken place along the same line at subsequent epochs;" and the authors show grounds for belief that the present form of these mountains was the result of more than one elevatory process, and that there was a period when, as a low ridge, they formed the western shore of a great continent to the east, that now called Siberia, and even at so recent a period as when that continent was inhabited by large quadrupeds closely allied to existing species. The Urals extend from Nova Zemlia to the Caspian, through nearly thirty degrees of latitude, in a direction nearly north and south, but sending off branches to the east and west at both extremities, one of which on the north-west, the Timan range, was first explored geologically by Count Keyserling in 1843; and in no part of this long line are they divided by any great transverse valleys, nor does their general altitude exceed from 2000 to 2500 feet. No parts of the authors' descriptions are of higher geological interest than those in which they speak of the Urals; and to some of the more striking features of that chain of mountains I shall afterwards more particularly refer.

The immediate substructure of the whole area of Russia in Europe is composed of the palæozoic rocks, which on the northern division are covered by sand, clay and blocks. A narrow band of Silurian deposits, the older members of that group, stretches along a great part of the shores of the Baltic, succeeded eastward by Devonian and Carboniferous formations, each occupying a vast extent of country, and lastly that highest member of the palæozoic order of strata to which the authors have applied the term "*Permian System*," the most widely-spread of all, occupying a region more than twice the size of the whole kingdom of France. Of the whole range of the secondary deposits between the Permian and the tertiary, two only have been met with, viz. that division of the oolitic series which includes the Oxford clay and its associated rocks, and in South Russia cretaceous rocks, including a white chalk very similar in mineral characters and zoological contents to that of England. The oolitic rocks overlie the Permian, but in detached masses, and with a surprising uniformity of character from the Icy Sea to the southern extremity of the Urals. There are besides, but in Southern Russia only, some limited tertiary districts, and of all ages, from Eocene to Pleistocene.

The most remarkable feature in the physical geography of the country described, and which may justly be said to be, in the words of the author, " one of the most singular features in the ancient condition of the surface of the globe which modern researches have brought to light," is that exhibited by the region around the Caspian; affording the most unequivocal proofs of great changes in the relative levels of the land and water, at a period geologically recent. Over a vast region a calcareo-argillaceous deposit exists in nearly horizontal stratification, abounding in freshwater shells and others analogous to, and to a great extent identical with species now living in the Caspian, attaining in some places a thickness of 300 feet; which appears to prove, that at the time it was deposited, there existed an inland sea, of brackish water, exceeding in size the present Mediterranean, and of which the present Caspian is the diminished relic. Of this remarkable deposit, designated " Steppe " and "Aralo-Caspian limestone " by the authors, I shall speak more particularly when I refer to the Tertiary formations.

This inland sea, although called by Sir R. Murchison a Mediterranean, he does not the less consider to have been entirely separated from the Western Ocean of that period, by a barrier, produced by the elevation of the marine tertiary beds of Miocene age, on which this Steppe limestone, in many places, is seen to repose. To affirm with certainty that the surface of this inland sea once stood at a higher level than that of the Caspian at the present day, and which, according to very careful measurements recently made by order of the Russian Government, is now proved to be 83.6 feet below the Black Sea, would require a most extensive series of local observations and levellings around the region occupied by the Steppe limestone, attended with very great difficulties. It is the opinion of some travellers who have carefully examined parts of this region, that during the historic period, and within modern times, the surface of the Caspian has been diminishing, from the disproportion between the evaporation from so large a surface in that climate, and the sources of supply of water. Whatever portion of the land occupied by the Steppe limestone is now on a level with, and below the level of the Black Sea, may have been laid bare by this gradual lowering of the water of the Caspian; but whatever portion is above that level, and the greatest proportion of it is so, must, it is evident, have been upraised; and there is abundant proof of volcanic forces being in activity in that region to the present time. To endeavour to trace the direction of the vast body of water that must have been displaced by the upheaved land, as there could be no direct outlet to the ocean, would be an inquiry of great interest; for it can hardly be doubted that there must be evidence of a deluge or deluges having swept over a large portion of that part of Asia, and more especially if the elevatory forces acted suddenly.

As the leading features of the physical structure and the great geological divisions of the continent of North America are well known, I do not think it necessary to give any general outline of the country described by Mr. Lyell in his lately-published 'Travels'; but I shall have frequent occasion to refer to the information contained in that work on several points of great importance, in speaking of some of the additions in the past year to our knowledge of the great groups of rocks, and to our better acquaintance with questions of mineral structure, changes in the form of the land, and distribution of organic remains.

I shall now offer some remarks on the several great groups of formations, and shall begin with the lowest fossiliferous deposits.

Silurian Rocks.

It is certainly remarkable, considering the short time that has elapsed since Sir R. Murchison first proposed the separation of the lower beds of the palæozoic strata into one great series, that rocks which appear to be clearly made out to belong to the Silurian system should have been already recognised in so many regions remotely distant from each other. That they constitute a great part of Europe has been shown by many writers. The geologists of the United States and Mr. Lyell have told us how widely they are spread over the northern States of North America; and we learn from Captain Bayfield that they occur extensively all round Lake Huron; northward towards Hudson's Bay; along the northern side of the valley of the St. Lawrence, eastward to the strait of Belle Isle, and on the western coast of Newfoundland from that strait to its southern extremity. M. Alcide d'Orbigny has described them as extensively developed in South America; and from Mr. Darwin we learn that they probably exist in the Falkland Islands, adjoining the farthest extremity of that continent. It is also more than probable, from the information we already possess, that they exist in Australia. The rocks were known, and had been partially described, but they were not understood; they were known mineralogically, and deposits separated by great intervals of time were classified together under the vague, uncertain, general term of grauwacke, or grauwacke slate, or clay-slate. The clear development of the system, and lucid descriptions of the normal types in the Silurian region of Britain, dispelled the obscurity that hung over the history of these ancient beds; and now geologists are at work in all countries, making out the great features of resemblance, and registering those variations in mineral and fossil contents, dependent on geographical position and other local causes, which are found to prevail more or less in all formations.

It appears to be now the opinion of those geologists who have most carefully and extensively studied the sedimentary rocks which contain the oldest forms and first traces of organic life, that from the highest beds of the Lower Silurian rocks to the lowest deposits in which organic remains have been found, there had been no great variation in the circumstances under which these beds were deposited, although there is evidence of a long duration of time, in which gradual changes in animal life took place, some species diminishing in numbers, others becoming extinct, others continuing to exist throughout the whole range, and a few appearing in the lower portion of these beds, which, from a marked general change of forms, are classified as the Upper Silurian rocks. This view you will see developed in the address delivered by Sir R. Murchison from this chair four years ago*, where he states, that the conventional line that had been drawn between the Lower Silurian and the Cambrian rocks beneath them had no longer any reference to strata identified by distinguishing organic remains, for the same fossils are found in strata on each side of that demarcation. He also stated on the same occasion, that "the zone of fossiliferous strata characterized by the Lower Silurian Orthidæ are the oldest beds in which organic life has been detected," and his belief that "many of the subjacent rocks, sometimes even when in the form of gneiss, mica schist, talc schist, chlorite slate, &c., are nothing but metamorphic rocks, in less altered parts of which the same typical fossils are observable." In his recent work on Russia he asks the questions, "Can we lay open the earliest vestiges of animal life, and amid palæozoic forms trace backwards primæval history to a protozoic type? Can we separate such protozoic strata from those which went before them, and were deposited *ere life had been breathed into the waters*†?" To the latter question I am disposed to answer, that the mere negative fact that we have not yet discovered traces of organized bodies in the lowest strata, certainly does not warrant the inference that no living thing had yet existed, or our saying, that *any strata* were deposited "ere life had been breathed into the waters." If these strata contain a particle of undoubted detrital matter, a grain of

* Proceedings of the Geol. Soc. vol. iii. p. 642.
† Russia and the Ural Mountains, &c. vol. i. p. 1.

rolled sand, they afford positive proof of the pre-existence of land and water, and atmospheric destructive agency to supply the materials of these strata, and the bed of a sea to receive them. Is it not highly improbable that this sea was untenanted? There must doubtless be a lowest sedimentary stratum, the materials of which must have been derived from land composed of non-sedimentary rocks. By "non-sedimentary" I mean a rock the formation of which may with the greatest probability be ascribed to igneous action. Whether it was granite, or any other form of igneous rock with which we are acquainted, we cannot tell; because of the great uncertainty as to how far the lowest sedimentary deposits have undergone changes by metamorphic action; but that silica and clay and very little lime entered into its composition is evident from the predominance of the two former earths in all the oldest strata, and the comparative rarity of lime.

But animal and vegetable life may have existed while the land that afforded the materials for the first sedimentary deposits was wholly composed of unstratified rocks. Nor is it necessary to have recourse to the obliteration by metamorphic action in all cases where there are no traces of organic remains. We have learned from the valuable report by Professor Edward Forbes of his researches in the Ægean Sea, that there are profound depths in which no animals and no vegetables seem capable of living; and thus, as there may be now, and probably are, deposits of vast thickness produced without organic bodies having ever lived in or upon them, in the profound depths of the Atlantic and Pacific Oceans, so is the absence of such remains in any stratum no proof, that when it was deposited there might not have existed above it a sea teeming with life. I cannot support this view better than by quoting what Professor Forbes says on the subject: "As in the sea there is a zero of vegetable life, so, we may fairly infer, is there one of animal life. All deposits formed below that zero will be void, or almost void, of organic contents. The greater part of the sea is far deeper than the point zero; consequently the greater part of deposits forming will be void of organic remains. Hence we have no right to infer that any sedimentary formation, in which we find few or no traces of animal life, was formed either before animals were created, or at a time when the sea was less prolific in life than it now is: it might have been formed in a very deep sea*."

The muddy waters of the Amazon stretch 300 miles into the Atlantic Ocean, and their sediment must be deposited in depths far below the zero of animal and vegetable life. Unless therefore portions of dead organisms be transported down steep slopes by submarine currents, from a shallower sea to those depths, and be mingled with the sediment, rocks must now be forming over the bottom of the Atlantic Ocean, which, when upraised in future ages, will exhibit as few traces of living bodies having existed when their component

* On the light thrown on Geology by submarine researches. Edin. Phil. Journ. April 1844.

parts were deposited as we can discover in the slates of Wales and of Westmoreland.

We have received as yet only a part of the results of the labours of Professor Forbes, and wait with impatience for his greater work; but what he has already made known to us of the changes that take place in organized bodies in different zones of depth, and in different states of sea-bottom, have so extensive a bearing upon many of the inferences hitherto drawn as to the ages of deposits, and to changes of climate from fossil contents, that some of our most established doctrines ought to be revised, and their soundness tested by their accordance or otherwise with these conditions. Others hypothetically anticipated that rocks might have been formed in depths unsuited to animal and vegetable life; but Professor Forbes was the first, I believe, to establish by actual observation that such is the fact as to depth, and also the first to show, as an element of geological reasoning, the connection that subsists between *the nature of the sea-bottom* (often changing on the same spot) and the living bodies it supports, and thus to demonstrate the existence of laws of the highest geological importance, and which must have prevailed throughout the whole range of formations.

Among the communications read before the Society since the last Anniversary, we have had two by Professor Sedgwick on the comparative classification of the fossiliferous strata of North Wales with the corresponding deposits of Cumberland, Westmoreland and Lancashire, both of them in continuation of his memoir read in November 1843. I will not attempt to give any abstract of the contents of these papers, because I could not do so, to any useful purpose, without extending my observations to an inconvenient length; but I recommend all who are desirous of acquiring an accurate knowledge of the geological topography of those parts of our island, and of becoming acquainted with many facts that throw light on that obscure and difficult part of geology, to study the memoirs themselves: those of 1843 and of March 1845 are published in the first volume of our Journal, and the last of them will appear in the number of next May*.

It is to Professor Sedgwick we are mainly indebted for the knowledge we possess of the geological structure of those parts of our island; it was he who first grappled with their very complicated and difficult conformation; for nearly twenty years he has been labouring to decipher their obscure and complex characters; and since the discovery of the Silurian key, he has been enabled to make out a clear and intelligible outline of the history of these regions, which, for a long time, geologists seemed to shrink from all attempts to understand. Let us hope that the learned author will soon gather together his scattered materials, and bring out a new edition of his work, with all the corrections and illustrations which his latest observations enable him to supply. When we have that volume, and can study it with the commentaries and the additional illustrations of accurate sections which we in part have, and may soon

* See *ante*, p. 106.

look forward to receive from Sir H. de la Beche and his fellow-labourers in the Geological Survey of Great Britain, we shall possess a very full and correct knowledge of these older sedimentary deposits, and the igneous rocks with which they are associated, and therefore of the most remote periods of geological history; and we may perhaps then indulge in a little excusable national vanity of possessing another standard with which the structure of extensive and distant regions of the earth will be compared, in addition to what we already have of many of the palæozoic and secondary formations.

A paper by Captain Bayfield read before us last April, and published in November in our Journal, gives us much important information on the Silurian rocks that prevail to a great extent in Canada; and we are indebted for a more accurate knowledge of the same class of rocks in the Isle of Man to the Rev. J. Cumming, in the first part of a description of that island, read last June.

We learn from the 'Geology of Russia,' that both in that country and in Scandinavia, a series of ancient deposits cover a great tract of country, which, in all their great features, and often in their minute characters, are identical with the Silurian series of the British Isles, and that they are equally divisible into two distinct groups, and are also overlaid by a true Devonian formation. In the central and southern parts of the continent of Sweden the Lower Silurian rocks only occur, but the adjoining islands of Oesel, Dago and Gothland are mainly composed of Upper Silurian rocks, affording even better types than Wenlock or Dudley. Describing the rocks near Katchkanar, on the eastern flank of the Urals, Sir R. Murchison says, "The banks of the river Is are composed for a considerable distance of white limestone, thickly tenanted by large Pentameri, some Trilobites, and shells which we hailed as true Silurians, and worthy of the very region of Caractacus. We were enchanted when we discovered myriads of them undistinguishable from the *Pentamerus Knightii*; so that seated on the grassy banks of the Is, we might for a moment have fancied ourselves in the meadows of the Lug at Aymestry." Of the Lower Silurian fossils of Russia a few only are absolutely identical with forms of the same age in the British Isles; but the mass of them is essentially the same as that of the main land of Scandinavia; which region being intermediate between England and Russia, is found to contain a considerable number of forms common to deposits occupying the same position in both the other countries. In the lowest part of the Lower Silurian rocks that skirt the southern shores of the Baltic, a grit occurs so abounding in a minute shell, the Ungulite or *Obolus* (which has a great affinity to the *Lingula*), as to form entire beds. Here we have a parallel to those beds in the Silurian series of the British Isles, abounding so copiously in the *Lingula attenuata*. It is also a parallel to beds occurring at a far more distant point, on the opposite side of the Atlantic. Mr. Lyell, in describing the Potsdam sandstone, the lowest member of the Silurian series in North America, as it occurs on Lake Champlain, says, "In many places this most ancient of the fossiliferous rocks of New York is divided into laminæ by the remains of innumerable shells of the genus *Lingula*. They are in such profusion as to form black seams like mica, for which they were at first mistaken. It is highly interesting, that in this lowest fossiliferous bed, one of its commonest organic remains should belong to a living genus, and that its form should come very near to species now existing. Throughout so vast a series of ages has Nature worked upon the same model in the organic world!"

The Silurian system of the northern countries of Europe is, as a whole, closely analogous to that of Great Britain; and it proves that wherever the sediments of the same age in the two regions resemble each other in lithological texture, such similarity is accompanied by a close approximation and frequent identity in the associated organic remains. When the fossils from the Silurian beds of Northern Europe were compared, Mr. Lyell informs us, by M. de Verneuil with those brought by him from America, there was a great distinctness; but the representation of generic forms, whether in the organic remains of the Upper or Lower Silurian strata, was most clear and satisfactory. The geologists of New York make three distinct groups in the Lower Silurian, and four distinct groups in the Upper Silurian series of that country, and Mr. Lyell is of opinion that these divisions are based on sound principles; that is, on mixed geographical, lithological and palæontological considerations; the analogy of European geology teaching us that minor subdivisions, however useful and important within certain limits, are never applicable to countries extremely remote from each other or to areas of indefinite extent. The Silurian rocks are developed in North America on a great scale, and like those of Russia are little disturbed from their original horizontality, making the order of their relative positions clear and unequivocal in both countries. In lithological characters there is a considerable resemblance on both sides of the Atlantic—mudstones, sandstones and limestones prevailing. In America however there is an intercalated group in the Upper Silurian system, to which nothing analogous has yet been observed in Europe, as far as I am aware. It consists of red, green and bluish marls, with beds of gypsum and occasional salt-springs, the whole being from 800 to 1000 feet thick, and undistinguishable from parts of the Upper New Red Sandstone or Trias of Europe. A similar intercalated group of red and green argillaceous marls with gypsum and salt-springs is met with in the middle of the Devonian group in Russia. This occurrence of gypsum and muriate of soda associated together in the older strata as they are in the Pliocene, as well as in many intermediate periods, is a remarkable circumstance; and it would be an investigation well-deserving the joint labours of the chemist and the geologist, to endeavour to account for the origin of these chemical formations.

With regard to the fossil contents of the Silurian beds of North America, it appears that "while some of the species agree, the majority of them are not identical with those found in strata which are their equivalents in age and position on the other side of the Atlantic. Some fossils which are identical, such as *Atrypa affinis*, *Leptæna depressa* and *Leptæna euglypha*, are precisely those shells which have a great vertical and horizontal range in Europe—species which were capable of surviving many successive changes in the earth's surface, and for the same reason enjoyed, at certain periods, a wide geographical range. It has been usually affirmed that in the rocks older than the carboniferous, the fossil fauna in different parts of the globe was almost everywhere the same ; but Mr. Lyell adds, "that however close the general analogy of forms may be, there is evidence in the Silurian rocks of North America of the same law of variation in space as now prevails in the living creation :" and in another place he states, that with regard to the proportion of species common to the Silurian beds of Europe and America, whether of the upper or lower division, he can confidently affirm that it is not greater than a naturalist would have anticipated, from the analogy of the laws governing the distribution of living invertebrate animals.

While the remains of fucoid plants are met with abundantly in the Silurian rocks of Europe and in the lowest members of the series, I am not aware that any vestiges of land plants have yet been discovered in them. Sir R. Murchison says, that in the older palæozoic rocks of Russia he met with no signs of terrestrial fossil vegetables. Fucoids are plentifully distributed through every part of the series in North America; and Mr. Lyell also states, that in the Hamilton group, which corresponds in many of its fossils with the Ludlow rocks, and which, singularly enough, is met with in the neighbourhood of Ludlowville, remains of plants allied to Lepidodendron have been found associated with fossils agreeing perfectly with European Upper Silurian types ; and that other plants allied to these, and ferns, have been met with in the lowest Devonian strata of New York, associated with fossil shells closely allied to the Silurian. Thus we have additional proof, if any were wanting, of the existence of dry land at the time of the deposition of these Silurian beds.

Devonian Rocks.

The Silurian rocks of Russia in Europe are covered conformably by deposits, the identity of which with the Devonian or Old Red Sandstone series of the British Isles, Sir R. Murchison and his companions clearly made out. They extend over an area of not less than 150,000 square miles, a superficies greater by nearly one-third than that of Great Britain and Ireland together. This monotony of feature over so vast a space is even greatly surpassed by the Permian rocks ; and when it is considered that this uniformity is combined with a stratification rarely deviating from the horizontal, never thrown up into natural sections, and that the investigation of them can only be carried on where the beds are exposed in the banks of rivers, geologists can appreciate the tedium and labour of exploring such a country, and cannot too highly praise the patience and perseverance of Sir R. Murchison and his fellow-travellers.

Although recognized by a remarkable degree of identity in fossil contents, and especially in regard to ichthyolites, as a deposit of the same age as the old red sandstone in our own country, it is lithologically very different in most places. Sometimes it is made up of numerous alternations of flat-bedded, light yellowish limestones, often so impregnated with magnesia as to be scarcely distinguishable from some of the magnesian limestones of England, or the Zechstein of Thuringia; at other times it is composed of red and green flags and marls; and, on the flanks of the Urals, this series is represented by black and calcareous slaty masses. Moreover, it is comparatively rare as a red sandstone. But the fishes and shells the beds contain soon rectify the mistake as to the true position of these rocks, into which their mineral aspect alone might lead the most experienced geologist, should he not have an opportunity of seeing them reposing on true Silurian rocks and covered by carboniferous strata. In regard to the evidence from fossil contents, it is so complete in these Russian deposits as not only to establish their own position, but to corroborate the soundness of the reasoning which unites the old red sandstone of Scotland with the slaty limestones and schists of Devonshire and the Continent; for they contain the characteristic fishes of the former and the mollusks of the latter. The examination of Russia, Sir R. Murchison further observes, has afforded numberless proofs that the ichthyolites and mollusks which in Western Europe are separately peculiar to smaller detached basins, were there inhabitants of many parts of the same great sea. Of the known Russian ichthyolites, two-thirds are specifically the same as those of the same epoch in Great Britain.

The neighbourhood of Dörpat in Lithuania is a very remarkable locality for the ichthyolites of this age; they are there met with of so gigantic a size, that they were supposed to belong to Saurians, until the closer examinations of Professor Asmus of Dörpat, M. Agassiz and Professor Owen disclosed their true nature. A note by Professor Owen in the Appendix to the 'Geology of Russia' is highly instructive, as showing the great importance of an examination of the internal structure of the substance of fossil teeth by the microscope, in determining the classes of animals to which they have belonged. He points out, by a striking illustration, how the microscopic labours of the philosopher in his closet may have the most important effect on questions that appear to be far remote from the subject of his inquiry. Had the teeth under consideration continued to be held to belong to Saurians, the matrix in which they are imbedded having a close resemblance in mineral character to magnesian limestone, or to members of the new red sandstone series, borings for coal might have been carried on in many parts of Russia, involving vast losses; but the teeth having been proved to belong to a class of fishes that are characteristic of the old red sandstone, all expectations of finding profitable seams of coal are known to be vain.

If we now cross the Atlantic with Mr. Lyell, and visit the Silurian region of North America, we find that series of rocks covered by others having characters corresponding with those of the Devonian group in Europe. The rocks of the Appalachian chain consist of deposits of the Silurian, Devonian and Carboniferous periods. A deposit called by the American geologists the Waverley sandstone, which Mr. Lyell is of opinion corresponds with the old red sandstone of Europe, intervenes in the state of New York between the coal-beds and the Upper Silurian groups, in strata of considerable thickness. On the western side of the Alleghanies, at Portsmouth on the Ohio, the same formation also occurs, but greatly diminished in thickness, some of the subordinate beds being reduced to a very thin slate, others entirely lost, conformably with what is observed in other sandstones and associated slates and shales in that country, viz. by a gradual thinning of the beds as they extend westward, and as they become more distant from that great eastern continent, now sunk beneath the waters of the Atlantic, from which the materials composing them must have been derived.

Our knowledge of the old red sandstone or Devonian group has been much advanced by the Monograph of the fishes of that series of deposits by M. Agassiz, which has just been completed; a work of the highest merit, in which the skill with which the anatomy of the singular forms of that earliest creation of fishes is worked out is quite admirable, and which also contains many highly important general views. This work was undertaken at the request, and has been carried out by the assistance, of the British Association, and is one of the many valuable gifts for which science is indebted to that body.

The history of the old red sandstone supplies a useful lesson to geologists, by showing them the danger of coming to hasty conclusions, and founding generalizations, on negative evidence. The formation itself was long supposed to be confined to a limited portion of England; it is now known to extend over large districts in the British Isles and on the continent of Europe. It is most extensively developed in the northern and western parts of the United States, as may be seen by inspecting Mr. Lyell's Map; and we learn from Captain Bayfield that a sandstone which prevails greatly in Upper Canada, and which may be traced all round Lake Superior, resting on granite, appears to be of the same age as the old red sandstone, or Upper Silurian; and he also observed in the district of Gaspé, at the south entrance of the river St. Lawrence, a calcareous sandstone with Devonian characters. It appears too from the work of Mr. Strzelecki on New South Wales and Van Diemen's Land, published last year, that the greater part of the palæozoic rocks he examined in Australia and Tasmania are the equivalents of the Devonian series. In like manner this bed was long held to be barren of organic remains; Sir Henry de la Beche, in the third edition of his 'Manual of Geology' published in 1833, which was no doubt brought up close to all that was known at that time, says, "Few organic remains have been discovered in that rock." When M. Agassiz, in 1833, began the publication of his 'History of Fossil Fishes,' he knew of none older than the coal-measures, and only a small number in them; and he tells us that when he first learned that fishes had been discovered in the old red sandstone, during his visit to Scotland in 1834, not more than four species were known. Five years afterwards, when Sir R. Murchison published his 'Silurian System,' ten genera and seventeen species of fishes, and fifteen genera and twenty-three species of mollusca are enumerated by him as belonging to the middle and lower Devonian beds. In the recent work on Russia, M. de Verneuil enumerates forty-six species of fishes and sixty-six species of mollusca, which he and his fellow-travellers found in the same group in that country. M. Agassiz, in his 'Monograph of the Fishes of the Devonian System,' raises the number of genera to forty-three, and of species to 105, belonging to six or seven families; and he tells us that Monte Bolca itself, hitherto reported to be the locality of all others most rich in species of fossil fishes, does not contain a greater number; adding, that as only a comparatively small portion of the rocks of this system has been examined, many additions may be expected. M. Agassiz is shortly going, it is said, to North America, where he will very likely discover many new forms. It is gratifying to find him ascribing the main success of his researches in this field "aux recherches persévérantes et au zèle infatigable des géologues Anglais."

But not only is there this great variety of genera and species, but the number of individuals found in some localities is immense. Thus in some parts of Russia there are breccias almost wholly composed of the scales and plates of the Asterolepis, and the remains of the Pterichthys are so abundant in the geodes of Lethen Bar in Nairnshire as to have been collected in cart-loads. But our wonder is not alone excited by the great variety and number of vertebrate animals of a high organization in strata so very low in the order of formations; there are many most remarkable features in the history of this early part of the animal creation which the researches of M. Agassiz have brought to light; for these however I must refer you to the work itself.

M. Agassiz, in speaking of the lowest beds in which the remains of fishes have been found, makes the following important observations on the probability of their existing in still lower beds:—"If we have not yet been able to recognize remains of fishes below the Lower Ludlow rocks, I do not think that we ought from that to conclude that fishes do not exist even in the oldest of the fossiliferous beds; for their extraordinary abundance in the Devonian series, and the distinct recognition of them in certain Silurian beds, where, it is true, they are but imperfectly preserved, sufficiently indicates that on its first appearance that class of animals was contemporary with the development of the types of all the classes of invertebrate animals."

Mr. Lyell states that the lowest rock in which ichthyolites have been traced in America is the Clinton group, which may be considered the bottom of the Upper, or top of the Lower Silurian series. Ichthyolites have recently been found in the Wenlock shale; another step in descending order, and so far in support of M. Agassiz's views.

The Carboniferous Series.

Although rocks of this age cover a great extent of country in European Russia, extending over a tract equally vast in horizontal extension with that occupied by the Devonian series, there are few places, except in the coal-field of the Donetz in the south, where the coal-seams are more than a few inches in thickness; and where they are thicker, they are so poor in quality as to be rarely worth working. The great coal-fields of England, France, Belgium and America have no well-marked equivalents there, nearly the whole of the coal-beds in the empire being, like those of Ireland and the coal-field on the banks of the Tweed, included in the lower members of the system; which, with the sandstones, shales and marls, are the equivalents of our mountain limestone, as is proved by the identity of a large series of fossils. From a section of the works at Lissitchia-Balka on the river Donetz, we learn that in a depth of 900 feet there are twelve seams of coal, the united thickness of which amounts to thirty feet; they are associated with sandstones, grits and shales; and eight beds of limestone are intercalated (containing, from the uppermost to the lowest, marine shells), the united thickness of which is fifty feet, three of the beds of limestone resting directly on the coal. Many of the forms of Equisetacea, Calamites, Sigillariæ and Ferns are of the same species as those of the west of Europe; and the carboniferous fauna of Russia contains numerous forms identical with those in the same class of rocks in the British Isles.

A glance at the Geological Map which accompanies Mr. Lyell's 'Travels,' shows the enormous development of the coal series in the territory of the United States, and that it occupies no inconsiderable space in Nova Scotia and New Brunswick. We learn from the report of Mr. Logan, on the Geology of Canada, which I shall presently refer to, that a great coal-field covers nearly the whole of New Brunswick, a considerable part of Nova Scotia, Cape Breton Island and the south-west corner of Newfoundland. The greater part of the carboniferous series in North America belongs to the upper portion, and not only abounds with numerous and thick beds of coal, but, on the western side of the Alleghanies especially, they are so little disturbed, and lie so nearly horizontal, that the coal is quite easy of access; and where the strata are intersected by rivers, it can be obtained with little trouble or expense. The great coal-field of Pennsylvania, Virginia and Ohio extends continuously from north-east to south-west for a distance of 720 miles, its breadth being in some places 180 miles*. That extending over parts of Il-

* On the 17th of March I received a letter from Mr. Lyell, dated the 16th of February at Tuscaloosa in Alabama, containing a notice on the Alabama coal-field, and which was read at the Geological Society on the 25th of March. He states that he had been examining three coal-fields, the existence of which was unknown to him when he compiled his Map in 1844. They occur near Tuscaloosa, in the centre of Alabama, more than 100 miles farther south in a direct line than the southern limit which he had assigned to the Appalachian coal-field, and are situated on the Tombecbee, Great Warrior, and Cahawba rivers. That on the Great Warrior river has been found by Professor Brumby of the University of Tusca-

linois, Indiana and Kentucky is not much inferior in dimensions to the whole of England, and consists of horizontal strata, with numerous rich seams of bituminous coal. Another carboniferous deposit, 170 miles by 100, lies farther to the north, between Lakes Michigan and Huron. I may give the following as an example of the almost boundless resources of fuel which this country affords. At Brownsville, on the Ohio, there is a seam ten feet thick of good bituminous coal, commonly called the Pittsburg seam, which may be followed the whole way to Pittsburg, fifty miles distant. "The boundaries of this seam have been determined with considerable accuracy by the Professors Rogers in Pennsylvania, Virginia and Ohio, and they have found the elliptical area which it occupies to be 225 miles in its longest diameter, while its maximum breadth is about 100 miles, giving a superficial extent of about 14,000 square miles."

Mr. Lyell states that at Blossberg in Pennsylvania he was much struck with the surprising analogy of the coal-measures to those of Europe in mineral and fossil characters. The same grits or sandstones are found as those used for building near Edinburgh and Newcastle; similar black shales occur, often bituminous, with the leaves of ferns spread out as in a herbarium, the species being for the most part identical with British fossil plants; there are seams of good bituminous coal, some a few inches, others several yards in thickness associated with beds and nodules of clay ironstone; and the whole series rests on a coarse grit and conglomerate containing quartz pebbles, very like our millstone grit. The same similarity of mineral and fossil characters to European coal-measures is found to prevail throughout North America. That remarkable circumstance of the very general occurrence of a sandy clay abounding in Stigmariæ beneath the seams of coal, observed in the Welsh and other coal-fields of Britain, is also found to prevail in those of North America. Mr. Lyell saw numerous instances of this; thus, at Pottsville in Pennsylvania, there are thirteen seams of anthracitic coal (true bituminous coal supposed to be altered by metamorphic action, a subject to which I shall allude hereafter), several of them from eight to ten feet thick, and in a vertical position: on the side which had been the roof of the coal, consisting of shales, he observed numerous ferns with stems of Sigillaria, Lepidodendron and Calamites; on the other side, that which had once been the floor, he found an underclay with numerous Stigmariæ, often several yards, and even in some cases as much as thirty feet long, with their leaves or rootlets attached.

Theories of the Formation of Coal.

It is scarcely possible to visit a coal-field, or to read the description of one, without being led to theorize on its mode of formation. The origin of coal has long been a subject of great difficulty, nor

loosa, to be no less than ninety miles long from north-east to south-west, with a breadth of from thirty to forty miles. These coal-fields are portions of the great Appalachian coal-field, with the same mineral and palæontological characters. Mr. Lyell promises a more detailed account of his observations.—*April* 3, 1846.

has any theory been yet advanced with which it has been possible to reconcile all the appearances which the coal-measures exhibit, all the variety of forms in which coal is found. Indeed the more closely we examine the phænomena, the more do we feel the distance we are from a satisfactory explanation of them. According to some geologists, coal-seams and their accompanying strata are accumulations of land plants and stony detritus carried down by rivers into estuaries, and deposited in the sea, where the vegetable matter undergoes changes that convert it into coal. Others are of opinion that coal is the altered residuum of trees and smaller plants that have grown on the spot where we now find them; that the forests were submerged and covered by detrital matter, which was upraised to form a foundation and a soil for another forest, to be in its turn submerged and converted into coal, and that thus the alternations which the vertical section of a coal-field exhibits are to be accounted for.

In the works of the last year to which I have chiefly referred, we find the former theory maintained by Sir R. Murchison as most generally applicable; Mr. Lyell is more inclined to adopt the latter. Sir R. Murchison dwells upon the facts of the alternations of coal with limestones containing marine remains, which are so frequently met with in most countries where coal-fields prevail; and as a striking instance of this, he refers to the Donetz coal-field which I have already alluded to. A remarkable example of a similar kind, occurring in Maryland, is mentioned by Mr. Lyell. At Frostburg a black shale ten or twelve feet thick, full of marine shells, rests on a seam of coal about three feet thick, and 300 feet below the principal seam of coal in that place. The shells are referable to no less than seventeen species, and some of them are identical with, and almost all the rest have a near affinity to species found in the Glasgow and other coal-measures.

The theory which refers the coal to trees and plants which have grown on the spot where it now rests is illustrated by Mr. Lyell by observations he made in Nova Scotia, on the south shore of the Bay of Fundy, at a place called "The Joggins." He states that there is a range of perpendicular cliffs composed of regular coal-measures, inclined at an angle between 24 and 30 degrees, whose united thickness is between four and five miles. About nineteen seams of coal occur in the series, and they vary from two inches to four feet in thickness. The beds are quite undisturbed, save that they have been bodily moved from the horizontal position in which they must have been deposited to that inclination they now have. In these coal-beds, at more than ten distinct levels, are stems of trees, in positions at right angles to the planes of stratification, that is, which must have stood upright when the coal-measures were horizontal. No part of the original plant is preserved, except the bark, which forms a coating of bituminous coal, the interior being a solid cylinder of sand and clay, without traces of organic structure, as is usually the case with Sigillaria, and like the upright trees in the coal-measures cut through by the Bolton Railway. The trees, or rather the remains of stems of trees broken off at different heights above the root, vary in height from six to twenty-five feet, and in diameter from fourteen inches to four feet. There are no appearances of roots, but some of the trees enlarge at the bottom. They rest upon, and appear to have grown in, the mass which now constitutes the coal-seams and underlying shale, never intersecting a superior layer of coal, and never terminating downwards out of the coal or shale from which the stem rises. The underclay or shale often contains Stigmariæ. Here then, he states, are the remains of more than ten forests, which grew the one over the other, but at distant intervals, during which each, from the lowest upwards, was successively covered by layers of great thickness of clays and solid stone, the materials of which must have been arranged and consolidated under the surface of water, and the vegetation of every layer in which the upright trees are fixed must have grown on land.

The formation of coal-measures like the above, and of all others where there is evidence that the vegetable matter was not drifted to the place it now occupies, but must have grown on the spot, is then accounted for by supposing, that the land sank below the level of adjoining water; that gravel, sand and mud were washed down from the land that did not sink, and formed layers of clay and sandstone over the submerged forest, either in sufficient quantity to rise to the surface of the water and form land for the next forest, which was submerged in its turn, or that a contrary internal movement took place, which again raised the submerged land; and that for every seam of coal, one above the other, a similar series of changes must have taken place. It is to this oscillatory movement that Mr. Lyell ascribes the formation of the above remarkable phænomena in the Bay of Fundy, and others of a like nature.

At first sight, both theories seem well-founded, when applied to the particular coal-fields described; and it is possible that these eminent and experienced geologists may be of opinion that both are true, as applied to different situations. But I see great difficulties to the full acceptance of either, in many of the phænomena which, on a close examination, we find coal-fields generally present. As examples, I will call your attention to two sections that have very recently been published; the one a section of the western part of the South Welsh Coal-field, included in the valuable series lately issued from the Office of the Geological Survey of Great Britain, the work of W. E. Logan, Esq., a Fellow of this Society, so well known to us as an excellent observer, and as intimately acquainted with coal-fields, and who was formerly attached to that Survey; the other is entitled a "Section of the Nova Scotia Coal-Measures, as developed at The Joggins, on the Bay of Fundy, in descending order, from the neighbourhood of West Rugged Reef to Minudie, reduced to vertical thickness." It is also the work of Mr. Logan, who is now employed by the Government of Canada to make a Geological Survey of that country, and is contained in his Report to the late Governor Sir Charles Metcalfe, and transmitted by the Governor to the Legislative Assembly. And here I may remark, in passing, that while we, as geologists, have to thank that provincial Government for commencing so useful an undertaking, we have also the satisfaction of feeling convinced that it will be prosecuted with vigour by the present Governor, Earl Cathcart, one of our own body, and, as we know, an able and active geologist. This is a section of the same series of coal-measures so carefully examined and described by Mr. Lyell*, though with less minuteness of detail as to the lithological characters and dimensions of the several beds. The phænomena exhibited in the above sections are not peculiar to them; they are to a great extent common to all coal-fields, particularly in the higher parts of the carboniferous series.

Before giving the analyses I have made of these sections, I wish to call to your recollection that in both theories it is assumed, that the deposition of the coal-measures took place *in the sea.* Mr. Lyell speaks of the accumulations having taken place in a sea: he says, "It by no means follows that a sea four or five miles deep was filled up with sand and sediment; on the contrary, repeated subsidences may have enabled this enormous accumulation of strata to have taken place in a sea of moderate depth."

The example from South Wales is a vertical section†, representing the beds as they are known to succeed each other in descending order, the dimensions being the thickness of each bed at right angles to the plane of stratification. The coal-measures rest upon carboniferous limestone, in an inclined and somewhat waved stratification; and although these measurements would vary in different places, from the swellings and thinnings-out which all strata exhibit more or less when traced to a distance, they are probably not far from the average amount over a large area.

1. From the top of the highest bed to the limestone, the sum of the measurements amounts to nearly 7000 feet; that is, the beds must have been originally deposited over each other in horizontal or nearly horizontal stratification to that thickness.

2. Reckoning only the greater divisions, when a difference of mineral character takes place, there are, besides the coal-seams, 340 beds, from a few inches to 190 feet thick, without alteration of mineral composition; involving, in the latter cases, long periods without any change in the nature of the detritus washed into the water where the deposition was going on.

3. These beds consist of sandstones, arenaceous and argilliferous slates, and clays, alternating without any apparent order of succession; sometimes one sometimes another lying upon the coal; and occasionally, but not frequently, the shale upon the coal is said to be carbonaceous.

4. Interstratified with these beds are *eighty-four* seams of coal, from one inch to nine feet thick; the highest being covered by a series of beds of sandstone, &c. 200 feet thick; the lowest seam separated from the carboniferous limestone by 1340 feet of similar sandstones and shales, making the *coal-bearing* strata 5460 feet in thickness.

5. The seams of coal occur at very unequal distances; some are separated by a few inches only of shale or sandstone, others by as much as 360 feet.

* 'Travels in America,' vol. ii. p. 178.

† No. 1 in the series, illustrating the horizontal section No. 7.

6. There are twenty-three seams, occurring in succession, most of which are not distinguished by any term indicating quality; in two instances, one a three-feet seam, they are said to be *bituminous*, and several seams are said to be *binding*, which means the same as *caking*, a quality which only richly-bituminous coals possess; the rest are merely called "Coal." These twenty-three seams with their interstratified sandstones and shales occupy 1840 feet.

7. Then succeed thirteen seams, in a space of 1000 feet, and nine of these are described as "*not bituminous*."

8. The thirty-seventh seam, in descending order, is said to be *anthracitic*, and fourteen seams below it are so designated: then come four seams merely called "Coal," and all very thin. Beneath the lowest of these, and separated by sixty feet of arenaceous shales and sandstones, comes a bed of coal, four feet six inches thick, called *Anthracite*, with five feet of underclay; beneath this are seven seams called *Anthracite*, and three more are intercalated called *anthracitic*.

9. Between the thirty-seventh seam, called Anthracitic, and the lowest of all, which is called Anthracite, there are twenty-two seams intercalated, without having any distinctive term affixed to them, most of them very thin; but about midway, three occur near together, without intermediate sandstones and shales, but separated by clay containing Stigmariæ, in the following manner:—

	ft.	in.
Coal	1	0
Underclay	0	4
Coal	4	0
Underclay	8	0
Coal	1	4
Underclay	8	0

10. The seams of coal, whether termed merely "Coal," or bituminous, or anthracitic, or anthracite, have, with very few exceptions, underclays, and these, generally, but not uniformly, contain Stigmariæ. The two lowest beds of anthracite have underclays of five feet each, the third from the bottom has seven feet of underclay, each with Stigmariæ. The underclay is of variable thickness; in no part more than fourteen feet, and except in a few instances, is always said to contain the *Stigmaria ficoides*.

11. There appears to be no relation between the thickness of the underclay with Stigmariæ, and that of the coal resting upon it. The thickest seam of coal, which is nine feet, rests on three feet of underclay, and there are instances of a seam of coal only an inch thick, with five feet of underclay stated to be *filled with Stigmariæ*.

12. A bed of clay, eight feet thick, with Stigmariæ, has no coal upon it, but a foot of carbonaceous shale; and above that forty feet of arenaceous shale, then four feet of clay with Stigmariæ, covered by three inches of coal, and that overlaid by twenty-five feet of argillaceous shale and sandstone.

13. In no case is any difference stated in the mineral character of the sandstones or shales either *over or under* the Anthracite seams, or of any other coal-seam.

The example from Nova Scotia is a vertical section on the same plan as that in South Wales; and the coal-measures there also rest upon limestone, containing organic remains, "among which there is, in some abundance, a bivalve shell which Mr. Logan recognised as identical with *Producta Lyelli* of Windsor in Nova Scotia." This limestone at Windsor Mr. Lyell describes as "a lower carboniferous limestone." The total vertical thickness of the coal-measures is more than double that of the South Wales section, being 14,570 feet.

a. The number of distinct beds in the section, of which separate measurements are given, is 1114, from six inches to 138 feet thick, without change in mineral composition.

b. These beds consist of quartzose sandstones, grits and conglomerates, and of arenaceous and argillaceous shales, all of various shades of red, grey, and green, without any apparent order of succession, sometimes one sometimes another lying upon the coal, and occasionally a carbonaceous shale is associated and intermixed with the coal-seams.

c. Interstratified with these beds are *seventy-six* seams of coal, from an inch to two feet thick, the far greater proportion very thin. The aggregate thickness of the seventy-six seams is only forty-four feet, and there is about the same aggregate thickness of carbonaceous shale. The highest seam is covered by a series of beds of sandstones, conglomerates and shales, 2274 feet thick. Beneath the lowest seam of coal there are 2800 feet of sandstones and shales of the same nature as those above, but having numerous beds of grey concretionary limestone intercalated. Thus the *coal-bearing* strata have a thickness of about 9500 feet.

d. There are no terms attached to the word "Coal" indicating any change of quality throughout the section. Some of the seams are called "Coaly clay," others "Carbonaceous shale" mixed with the coal. The seams occur at very unequal distances; from a few inches apart to more than 1200 feet.

e. As in the South Wales section, the coal-seams usually rest on beds containing *Stigmariæ*, but, in a great proportion of instances, these occur not in clay but in sandstone and arenaceous shale. This under bed is from a foot to twenty-seven feet in thickness; in one place an understone with *Stigmariæ* ten feet thick has a seam of coal over it only an inch thick.

f. Between the sixty-seventh and sixty-eighth coal-seams, the former with associated carbonaceous shale only fourteen inches thick, there are 170 beds of sandstone and argillaceous shale, from six inches to 132 feet thick, their aggregate thickness being 2620 feet, and the sixty-eighth coal-seam is only called coaly clay, two inches thick, with an underclay containing *Stigmaria* leaves of six feet.

g. In the 2274 feet of sandstones, &c. lying above the highest seam of coal, fragments of plants are seen in several of the beds; they first occur in a bed of sandstone 218 feet from the top, and the plants are converted into coal; they are often called "drift plants," and stated to be "coated with coal." In one bed there are "carbonized drift plants of large diameter," say one foot, the stems lying prostrate; and 1520 feet below this, there is a sandstone "fit for grindstones, with a few *Calamites* nearly at right angles to the plane of the beds, as if *in situ*, but forced over at the top;" this sandstone rests on a black carbonaceous shale two feet thick, but it is not stated whether the Calamites are fixed in this carbonaceous stratum. Between this last and the first seam of coal, which is only one inch thick, there are three feet of a "greenish-grey sandstone with *Stigmaria ficoides*," succeeded by two feet of "grey argillaceous shale with impressions of *ferns* and other plants."

Between the seventy-fifth seam, half an inch, and the seventy-sixth, two inches thick, are eighty-four beds of sandstone from a foot to 117 feet thick, together 1223 feet; and twenty of these beds, all called greenish-grey sandstone, are said to contain carbonized drift plants; and in one of these beds there is said to be "a vast confused collection of carbonized drift plants; one lying prostrate measured twenty-five feet in length, and about one foot in diameter at the small end." So likewise in the 2800 feet of sandstones, &c. which are beneath the seventy-sixth or lowest seam of coal, ten of the beds are said to contain carbonized drift plants.

h. At a distance of 4400 feet from the surface there occurs a "bituminous limestone with shells and fish-scales," four feet thick, and lower down, in the succeeding 2000 feet, there are eighteen beds of similar bituminous limestone, one of them only half an inch thick, eleven of them under six inches, and the thickest two feet. Neither the shells nor the nature of the fish-scales are described, but that these are freshwater limestones may be inferred from this, that several of them are mixed with Stigmariæ and other plants: thus, associated with the twenty-eighth seam of coal is a "bituminous limestone and carbonaceous shale in alternate layers of one to three inches, with *plants*, shells and fish-scales;" under the thirty-first, "with Stigmariæ, shells and fish-scales;" along with the thirty-sixth, "black bituminous limestone with branches and leaves of *Stigmariæ* well-marked, and very minute shells;" under the forty-fourth, "with *Stigmariæ* branches and leaves, fragments of other plants, and minute shells." Mr. Lyell states that he observed "not far above the uppermost coal-seams with vertical trees, two strata, *perhaps of freshwater or estuary origin*, composed of black calcareo-bituminous shale, chiefly made up of compressed shells, of two species of *Modiola*, and two kinds of *Cypris*." It is possible, therefore, that the "minute shells" of Mr. Logan are *Cypris*. Beneath the lowest seam of coal are intercalated fourteen beds of what is called a "Concretionary limestone," and "Limestone in concretionary nodules," from one to three feet thick, one of them as much as eight feet, and in one instance the limestone is said to contain carbonized drift plants.

i. Several instances are given of stems of plants standing perpendicular to the plane of stratification; the first is 2160 feet from the top of the uppermost bed.

α. Calamites "as if *in situ*."

β. Lower down, 570 feet below *a*, two upright stems of Calamites, two inches in diameter, coated with coal, start from the top of a dark grey argillaceous shale, and penetrate into a grey shale with sandstone above. The length of the stems is not given.

γ. Forty feet below is a foot of sandstone and then a foot of shale, and "in this shale, and running into the sandstone above, is a Calamite at an angle of 45°: it appears to start from a coal-seam below, an inch thick."

δ. Beneath this, 640 feet, a seam of coal three inches thick occurs, and from it "there springs up an erect *Sigillaria* eighteen inches in diameter, and it penetrates the shale and sandstone above it, five feet of the plant being visible." Underneath the coal is "a grey sandstone with *Stigmaria ficoides* (*underclay*)."

ε. The next instance given is 1038 feet lower down, where, from a grey argillaceous shale, rises an upright *Sigillaria*, one foot in diameter, penetrating to a height of two feet into argillaceous shale above. There are sixteen feet of sandstone and shale below this *Sigillaria*, and *without Stigmariæ*.

ζ. The next is 270 feet lower, where, from an argillaceous shale, "springs an upright *Sigillaria* of one foot in diameter; the lower part commences to spread." There are seven feet of argillaceous shales, with ironstone balls, beneath this *Sigillaria*, *without Stigmariæ*.

η. The next is 228 feet lower, where from a "gray, crumbly, argillaceous shale, like underclay, but no *Stigmariæ* visible, spring several upright Calamites, three of them in the distance of two feet, and eight more, the whole eleven in the distance of twenty feet."

θ. The next, 137 feet lower, in sandstone, are upright Calamites, three in the space of a foot.

ι. From a carbonaceous shale, a foot thick, sixty-two feet lower, "spring up erect Calamites, penetrating an arenaceous shale above two feet; and there are seven in the space of eight feet."

κ. The next is 254 feet lower, where, from an argillaceous shale, springs an upright *Sigillaria*, four inches in diameter; five feet of it are seen in a sandstone above. Argillaceous and carbonaceous shale beneath, six feet thick, does *not* contain *Stigmariæ*.

λ. From a grey argillaceous shale, twenty-two feet lower down, springs an upright *Sigillaria*. Its roots spread out into the shale, which is ten feet thick, and does *not* contain *Stigmariæ*; but *over* it lies a grey, crumbly, argillo-arenaceous shale or sandstone *with Stigmariæ*, in which six feet of the stem are visible. From the root of the plant proceeds a *Stigmaria* branch, which at first sight had much the appearance of being a root of the Sigillaria, but close inspection showed that the two, although touching, were distinct.

μ. The next is 108 feet lower, where, from a grey argillaceous shale, "springs an upright *Sigillaria*, eighteen inches in diameter, penetrating an incumbent sandstone." Fourteen feet of argillaceous shale and sandstone beneath do *not* contain *Stigmariæ*.

ν. The next is 133 feet lower, where, from a thin seam of coal with carbonaceous shale beneath, "rises an upright *Sigillaria*; the roots spread on the top of the coal; the plant is a foot in diameter, and only one foot of the length is visible."

ξ. The next is 160 feet lower, where, from a red argillaceous shale, springs an upright *Sigillaria*. Two feet of the length is seen, but it is cut clean off at the top and at the bottom by the measures which pass both without disturbance. No *Stigmariæ* occur for many yards below.

ο. The next is 101 feet lower, where, from grey argillaceous shale, six feet thick, without *Stigmariæ*, starts an upright *Sigillaria*, four inches in diameter; it is planted two feet in the shale, and penetrates the sandstone above, being four feet in length altogether.

π. The next is 362 feet lower, where, from a red and dark grey variegated shale, twenty-eight feet thick, with small balls of ironstone *and Stigmariæ*, arise two upright *Sigillariæ*. The roots of these spread out just on the top of the bed, and two feet of the plant are visible. The roots of the other spread out likewise, but they sink deeper into the shale by two feet, and the plant penetrates farther into the superincumbent sandstone."

ρ. The next distinct instance is 490 feet lower, where, from a grey argillaceous shale, several upright *Calamites* from half an inch to four inches in diameter penetrate an incumbent grey arenaceous and argillaceous shale containing prostrate carbonized plants. The roots of a Calamite three inches in diameter, spread on the top of the shale underneath; and twenty-one more Calamites are visible along the bank in the space of twenty yards.

This is the last instance stated of stems of plants found in the strata perpendicular to the plane of stratification; the seventeen instances thus occurring in a vertical thickness of 4515 feet.

Throughout the whole 7000 feet in the South Wales section, and, if the limestones are, as is most probable, of freshwater origin, also throughout the 14,570 feet in the Nova Scotia section, there appears to be no trace of any substance of a *marine* character; and from anything exhibited in the composition of the beds, all might have been deposited in fresh water. It seems infinitely improbable, had the deposition taken place in a sea, that a series of accumulations of this description, implying, be it observed, a vast duration of time, with different depths and different qualities of sea-bottoms, should have taken place without a trace being discoverable, either upon the surface of the submerged layers of vegetable matter, or in any part of the clays and sandstones that lie upon them, of a marine animal or plant. It seems no less improbable, that, in a sea skirting a shore, there should be such an absence of agitation throughout so vast a space of time, as to allow a tranquil deposit of layers of fine detritus over a wide area, a spreading out of the leaves of delicate plants in layers of clay and sand like the specimens in a herbarium, and a gradual and insensible passage, in many instances, from one bed into another. Great as the North American lakes are, I am not prepared to say that grave objections may not be urged against the probable existence of such vast bodies of fresh water as would be of sufficient extent and depth to receive the beds of many coal-fields; but the absence of marine remains throughout vast depths of strata in coal-fields is a remarkable fact well deserving of the most careful investigation.

That the terrestrial vegetable matter from which coal has been formed has in very many instances been deposited in the sea is unquestionable, from their alternations with limestones containing marine remains. Such deposits and alternations in an estuary at the mouth of a great river are conceivable, but whether such enormous beds of limestone, with the corals and mollusks which they contain, could be formed in an estuary may admit of doubt. But it is not so easy to conceive the very distinct separation of the coal and the stony matter, if formed of drifted materials brought into the bay by a river. It has been said that the vegetable matter is brought down at intervals, in freshets, in masses matted together, like the rafts in the Mississippi. But there could not be masses of matted vegetable matter of uniform thickness 14,000 square miles in extent, like the Brownsville bed on the Ohio (the Pittsburg seam mentioned in page 170); and freshets bring down gravel, and sand, and mud, as well as plants and trees. They must occur several times a-year in every river; but many years must have elapsed during the gradual deposit of the sandstones and shales that separate the seams of coal. Humboldt tells us (Kosmos, p. 295) that in the forest lands of the temperate zone, the carbon contained in the trees on a given surface would not on an average of a hundred years form a layer over that surface more than seven lines in thickness. If this be a well-ascertained fact, what an enormous accumulation of vegetable matter must be required to form a coal-seam of even moderate dimensions! It is extremely improbable that the vegetable matter brought down by rivers could fall to the bottom of the sea in clear unmixed layers; it would form a confused mass with stones, sand and mud. Again, how difficult to conceive, how extremely improbable in such circumstances, is the preservation of delicate plants, spread out with the most perfect arrangement of their parts, uninjured by the rude action of rapid streams and currents carrying gravel and sand, and branches and trunks of trees.

In the theory which accounts for the formation of beds of coal by supposing that they are the remains of trees and other plants that grew on the spot where the coal now exists, that the land was submerged to admit of the covering of sandstones or shale being deposited, and again elevated so that the sandstone or shale might become the subsoil of a new growth, to be again submerged, and this process repeated as often as there are seams of coal in the series —these are demands on our assent of a most startling kind. In the sections above examined, we have eighty-four seams of coal in the one, and seventy-six in the other. In the Saarbrück coal-field there are 120 seams, without taking into account the thinner seams, those less than a foot thick*. The materials of each of these seams, however thin (and there are some not an inch thick, lying upon and covered by great depths of sandstones and shales), must, according to this theory, have grown on land, and the covering of each must have been deposited under water. There must thus have been an equal number of successive upward and downward movements, and these so gentle, such soft heavings, as not to break the continuity or disturb the parallelism of horizontal lines spread over hundreds of square miles; and the movements must, moreover, have been so nicely adjusted, that they should always be downward when a layer of vegetable matter was to be covered up; and in the upward movements, the motion must always have ceased so soon as the last layers of sand or shale had reached the surface, to be immediately covered by the fresh vegetable growth; for otherwise we should have found evidence, in the series of successive deposits, of some being furrowed, broken up, or covered with pebbles or other detrital matter of land, long exposed to the waves breaking on a shore, and to meteoric agencies. These conditions, which seem to be inseparable from the theory in question, it would be difficult to find anything analogous to in any other case of changes in the relative level of sea and land with which we are acquainted.

That some seams of coal were formed of vegetable matter that grew on the spot where the coal now exists, seems to be proved in several cases (such, for instance, as that of the Bolton railway section) beyond dispute; and that some seams afford proofs of having been formed by drifted vegetable matter may be true. The coal-seams and the beds associated with them could be formed in no other way than under water; and the accumulation of the vegetable matter near the surface of it, and a very gradual submergence of the land, arrested at unequal intervals, appear to be the conditions most reconcileable with the phænomena. This implies, however, a deposition of the alternating sandstones and shales in very shallow

* Humboldt's Kosmos, p. 295.

water; and as we often find these rocks in regular thin stratification, forming the immediate bottom of coal-seams, the question arises, could such a laminated arrangement of detrital matter take place in water so shallow as is here supposed?

It is held by some geologists, that *Stigmariæ* are the roots of *Sigillariæ*, and that the stems of the latter contributed largely to the formation of coal. We should therefore expect to find, that where there is the greatest accumulation of *Stigmariæ* there should be the thickest seams of coal: this is not only not the case in the above sections, but sometimes there is no coal at all (11, 12, *e*, *f*, *g*). In a bed of sandstone 190 feet thick, in the South Wales section, and at a depth within it of sixty feet, there is a seam of coal four inches thick, without underclay and without *Stigmariæ*. Then again, in the Nova Scotia section, we find stems of *Sigillaria*, standing at right angles to the plane of stratification, resting on shales that do not contain any *Stigmariæ* (i, ζ, κ, λ, μ). Is this a proof that the stems are here, though apparently, really not in the place where they grew; or is it a proof that *Stigmariæ* are not the roots of *Sigillariæ*?

Several of the instances of upright stems given in the Nova Scotia section by Mr. Logan, can hardly be considered as occupying the spot were they grew, certainly not that (ξ) where it is cut clean off at the bottom. It is remarkable, that in the instances of upright stems described by Mr. Lyell and Mr. Logan, if occupying the spot where they grew, roots should so seldom be connected with them. Of all parts of the tree, none, we should expect, would be more likely to be preserved; being protected by their covering of soil from causes of destruction to which the stems were evidently exposed, as we find them so generally cut off at a short distance above their bases.

The whole subject of the theory of coal, whether we consider its mode of deposition, the plants out of which it has been formed, or the various changes which the vegetable matter has undergone to convert it into lignite, jet, common coal, cannel coal, blind coal and anthracite, two or more of these varieties often occurring in the same coal-field, is extremely obscure, and presents a wide and interesting field for future investigation. Before concluding this part of my subject, into which I shall probably be thought to have entered at disproportionate length, I would call your attention to some difficulties which the South Welch section offers to the commonly-received and, I believe, well-founded opinion, that anthracite is bituminous coal, the volatile parts of which have been driven off by heat acting gradually from below; for we see (8 and 9) that thin seams of common coal are interstratified with anthracitic seams and with anthracite. Neither do we find any signs of metamorphic action in the underclay in immediate contact with the coal, nor in the strata that lie between two seams of anthracite. We must look to the chemist to explain all this, as well as for enlightenment on the formation of the different qualities of coal; but we must be contented to receive from him only indications and resemblances; for we must never forget, that in our experiments we can never have the volume of materials, the amount of pressure, and above all, the duration of time with which nature has worked; and each of these, singly and combined, must have had important influence in modifying the results.

Permian System.

The soundness of the principles on which Sir R. Murchison and M. de Verneuil first proposed to establish this great division, has been confirmed by subsequent observations both by themselves and by others, and appears to be recognised by the geologists of all countries. The name of Permian, too, has been as willingly adopted as that of Silurian was, being at once convenient and appropriate, and recalling the locality where a true type of the series can be referred to. In their first journey to Russia, only a part of the region where these rocks predominate was examined; but they saw enough then to satisfy them that some new classification was called for, and Sir R. Murchison developed his views and those of his associates at the Meeting of the British Association at Glasgow in 1840, and in a paper read before this Society in the following spring. In his Address as President at our Anniversary in 1842, he referred to his second journey in the summer of 1841, and announced the discovery, that these newer red sand deposits, covering an enormous portion of European Russia, constitute a separate zoological system, distinct in age from the Trias, and comprehending in ascending order our Lower New Red Sandstone (the *rothe-todte-liegende* of Germany), our Magnesian Limestone (the Zechstein of Germany), and the sandstones and conglomerates that constitute the lower member of the *bunter*, or variegated sandstone of the Germans (represented by the Grès des Vosges of France); and leaving the Trias, composed of the Upper Bunter-sandstein, Muschelkalk and Keuper, as the lowest of the secondary rocks, and the commencement of new orders in various forms of life. Sir R. Murchison maintained the same views in his Address of 1843; and in the spring of 1844, in a paper which he read to this Society, he gave a full confirmation of the correctness of his original conclusions, after a more careful examination of the fossils collected from the Permian series in Russia, and comparison of them with those collected in different parts of Germany and Poland, which countries he visited for the special purpose of examining *in situ* the characters of the lower members of the New Red Sandstone series in their long-established typical forms. The Permian system therefore consists of a series of conglomerates, sandstones, clays, marls, common limestones and magnesian limestones, all under a great variety of forms, and intermediate between the Carboniferous and Triassic groups. It contains a peculiar fauna and flora, mingled however with a proportion of the animal and vegetable remains of the Carboniferous series, on which its beds repose, and thus connected with the palæozoic class of deposits; whereas the Triassic series, which succeeds in ascending order, has not yet been found, it is said, to contain any palæozoic forms, whether animal or vegetable. The Permian system, the authors of the 'Geology of Russia' observe, constitutes the remnant of the earlier creation of animals, and exhibits the last of the partial and successive alterations which those creatures underwent before their final disappearance. The dwindling away and extinction of many of the types, produced and multiplied in such profusion during the anterior epochs, and the creation of a new class of large animals, the Saurians, clearly announce the end of the long palæozoic period, and the beginning of a new order of zoological conditions.

It is remarkable however that palæozoic vegetable forms reappear, as I shall afterwards more particularly show, in beds much newer than the Trias; for in the Alps, in many parts of a series of beds which two such experienced geologists as M. Elie de Beaumont and M. Sismonda unhesitatingly declare to belong to the Liassic period, plants have been found which so skilful a fossil botanist as M. Adolphe Brongniart has not been able to distinguish from species found in the Carboniferous series. There is besides this peculiarity, that while the base of the Permian rocks frequently occurs in unconformable stratification with the Carboniferous, there is no example, it is said, in any part of Europe, of the Trias being found in stratification unconformable with the upper members of the Permian system. Too much stress however, Sir R. Murchison observes, ought not to be laid on this last circumstance, as evidence of a gradual passage in time from the Permian to the Triassic series, because sedimentary matter may be thrown down on the edges of older strata immediately after their dislocation, and that dislocation may have taken place without any great period having elapsed since the strata were deposited. On the other hand, if the sea-bottom were undisturbed, there might have been, so far as mineral structure is concerned, an immense interval of time between the deposition of two beds that are perfectly conformable, and even have a similarity in lithological character. And such in fact is the case. "Throughout whole regions of Russia the older deposits are clearly separable from each other by means of their respective fossils, although they are all apparently conformable."

The different memoirs which Sir R. Murchison had read before this Society made us acquainted with the leading features of the Permian system; but his great work on Russia has not only given us the evidence, at full length, of his opinions, but brings conviction to our minds by a more graphic and more impressive form of testimony than it was possible to produce in his abridged sketches. This system is developed on an enormous scale in European Russia, reposing upon carboniferous strata, throughout more than two-thirds of a basin which has a circumference of not less than 4000 English miles; that is, it occupies a space greater than twice the area of France.

The palæozoic series in North America ends with the carboniferous rocks; for although that and the inferior groups are developed on so great a scale, a narrow zone of red sandstone on the Atlantic slope, celebrated for containing the footmarks of giant birds, which in the opinion of Professor Rogers belongs to the Trias, is almost the only sedimentary deposit between the Carboniferous and the Cretaceous rocks.

The Secondary Rocks.

The Trias, so largely developed in other parts of Europe, is unknown in European Russia.

It is remarkable that, except one member of the oolitic series, the whole of the secondary formations between the Permian and Cretaceous groups should be wanting in Russia, and that with the exception of a very limited and even doubtful oolitic deposit in Virginia, not a trace of them should have been found from the Atlantic to the Mississippi, and even as far west from that river as any geologist has yet penetrated. Professor Rogers rests his determination of this deposit in Virginia as belonging to the lower part of the oolitic series, solely on the striking resemblance *as a group* of certain plants, accompanying a bed of coal which it contains, to those which are found associated with the oolite coal of Brora, Whitby, and other European localities. He says that, "judging by lithological indications alone, perhaps no more probable conclusion would have been reached on the subject than that of the able geologists Mr. Maclure and Mr. R. C. Taylor, the former of whom assigned this deposit, consisting of slates and of coarse grits composed of the materials of granite so little worn as to have the aspect of that rock in a decomposing state, and resting upon gneiss, and without any calcareous bed, to the period of the Old Red Sandstone; the latter to the "transition carboniferous deposits." If it be true, that in the Alps species of plants identical with those of the Carboniferous period have been found in undoubted Jurassic beds, it becomes doubtful whether the mere "resemblance as a group" of the plants in the Virginian beds is conclusive evidence, opposed as it is by the lithological character of the deposit, and the most remarkable circumstance of the entire absence of the oolitic series in any other part of the American continent. In a letter I had from Mr. Lyell, who last December passed through Virginia, he informs me that he had seen some specimens of coal plants and of ichthyolites from this deposit, which throw some doubt on its being of the oolitic age, especially when he compares the list with those from Connecticut, and that he intends to return to the spot in April next, in the hope of being able to determine their true age more precisely.

The only member of the oolitic series found in Russia is a representative of our Oxford clay and the beds immediately associated with it,—that which the French geologists call the *Terrain Oxfordien*. Nor, where these Jurassic beds occur, do they occupy any great extent of surface, but are in detached spots, at remote intervals, in isolated basins, patches or stripes. They are composed of slightly coherent dark-coloured pyritous shales, sands and calcareous concretions, sandstones and marlstones, very seldom solid calcareous beds, and throughout with a surprising uniformity of character. They are besides of little vertical thickness compared to the same series in other countries of Europe, the most considerable not exceeding 400 feet. They form low masses, which no doubt were at one time more connected, and have been subjected to powerful denuding causes.

They extend from the plains of Prussia to the frontiers of Asia on the east, and to the Frozen Ocean on the north. They are moreover seen to underlie the cretaceous and tertiary deposits of Southern Russia, and appear in the steppes which lead from Europe into Asia; but in these southern regions they undergo a change in lithological characters, becoming siliceous and calcareous grits, and resembling the conglomerates and grits found at the base of the oolitic series in some parts of England; their fossil contents however continue the same.

Cretaceous Rocks.

These occupy a great part of Southern Russia, but are unknown to the north of 55° of latitude. In regard to mineral arrangement, there exists that sort of general parallelism between the beds in Russia and those in Western Europe, particularly with those of Eastern Germany, which we might expect to find in strata of the same epoch separated from each other by great distances. Greensand, ironsand, chalk and chalk marl occur, in which the same groups of fossils prevail as in rocks of Britain and France which occupy the same relative age in geological succession; and pure white chalk, containing some characteristic organic remains, occurs at intervals to the confines of Asia. In the southern steppes of the Don Cossacks, on the banks of the river Donetz, chalk possessing all the characters of the English and French chalk, and containing some of its characteristic fossils, occurs of great thickness, Artesian wells having been sunk in it to a depth of 630 feet without any indications of a change of rock. It contains layers of flint, and the banks of the same river exhibit a section of a greensand group seventy feet thick, resting upon an equivalent of our coral rag, and surmounted by white chalk. A zone of true chalk, 120 miles in width, stretches through a great region about 100 miles south-west of Orenburg.

The cretaceous rocks occupy a very limited zone on the eastern side of the Alleghanies, extending about sixty miles, but having rarely a breadth of half a mile. They sweep round the southern extremity of these mountains, occupying a vast tract which stretches far westward of the Mississippi; and Mr. Lyell saw a collection of chalk fossils brought by M. Nicollet from the higher parts of the Missouri river. It appears further, from the recent report of Captain Fremont, that cretaceous rocks occur on the eastern flanks of the Rocky Mountains. The series examined by Mr. Lyell in the State of New Jersey consist of a lower portion of greensand and green marl, and above these a pale yellow limestone with corals, both however belonging, in the opinion of Mr. Lyell, who has carefully examined a large series of fossils, to the age of the white chalk, including the period from the gault to the Maestricht beds. As a detailed account of these beds and their fossil contents is given in the first volume of the Society's Journal, I need not dwell further upon them, except to give a statement of the general results. There is a remarkable generic accordance between the fossil mollusca, corals, echinoderms, fish and saurians, and those of the same series in Europe; out of sixty shells collected by Mr. Lyell, five seem to be quite identical with European species, while several others approach very near to and may be the same as European; fifteen may be regarded as good geographical representatives of well-known cretaceous fossils, belonging for the most part to beds above the gault. This amount of correspondence is not small, when it is considered that the part of the United States where these cretaceous beds occur is from 3000 to 4000 miles distant from the chalk of Central and Northern Europe, and that there is a difference of 10° in the latitude of the places compared on the opposite sides of the Atlantic. "Some of the species common to the opposite sides of the Atlantic are those which in Europe have the greatest vertical range, and which might therefore be expected to recur in distant parts of the globe." He concludes with the following remarks:—"We learn from the facts mentioned that the marine fauna, whether vertebrate or invertebrate, testaceous or zoophytic, was divided at the remote period under consideration, as it is now, into distinct geographical provinces, although the geologist may everywhere recognise the cretaceous type, whether in Europe or America, and I might add India. This peculiar type exhibits the preponderating influence of a vast combination of circumstances prevailing at one period throughout the globe—circumstances dependent on the state of the physical geography, climate, and the organic world in the period immediately preceding, together with a variety of other conditions."

Tertiary Deposits.

The tertiary deposits of Russia, exclusive of a few patches of very recent age, are most expanded in the southern parts of the empire, those of Eocene and of Miocene ages both occurring. The former has in many parts the very same structure and contents as the London clay. Sections are seen of beds equivalent to the calcaire grossier and London clay in connexion with strata referred to the upper part of the cretaceous system. In the neighbourhood of Saratof, on the Lower Volga, there occurs a sandy calcareous grit, subordinate to clay and sand, of a concretionary structure, undistinguishable from the Bognor rocks in Sussex, and containing the same shells. The authors appear inclined to believe that an insensible gradation may be traced from the upper cretaceous into the tertiary beds.

The Miocene deposits are of far greater extent than the Eocene. They are the extension of the great basins of Vienna and Hungary, and are spread over Volhynia, Podolia and Bessarabia, stretching to the Black Sea and the country north of Odessa, where they are covered by deposits of a more modern age. They have a close affinity to the deposits of the sub-Apennines and of Bordeaux, and like beds of the same age in Styria and Hungary, contain extensive oolitic beds, undistinguishable, lithologically, from many English and French varieties of the Jurassic group.

Marine Pliocene deposits are wanting, but the Miocene are covered by the vast deposit of argillaceous limestone already referred to as occupying the region around the Caspian, called by Sir R. Murchison the Aralo-Caspian or Steppe limestone, in which the univalves are of freshwater origin, associated with forms of Cardiaceæ and Mytili which are common to partially saline or brackish water. It abounds in many places with freshwater shells, and indeed presents the true and persistent characters of a deposit in an inland sea, and contains no vestiges of corals or other marine bodies. It was observed to be in some places between 200 and 300 feet thick, and at elevations of 700 feet above the present level of the Caspian. It possesses an uniformity of character which separates it from any tertiary deposit of Western Europe.

You are aware that Mr. Lyell read before this Society four papers on the tertiary deposits of the United States, which have been published in our 'Proceedings'; it is unnecessary therefore for me to give even a brief summary of them, and I shall content myself with stating some of the general results. On the Atlantic side of the Alleghanies, an area about 400 miles long from north to south, and varying in breadth from ten to seventy miles (with some detached patches further south), is occupied at intervals by tertiary deposits, which in the intermediate spaces are probably concealed by the more modern deposits and alluvium which form the surface. There are extensive tracts of Eocene formations, particularly in the south. Out of 125 species of shells which Mr. Lyell obtained from these deposits, he was not able to identify more than seven with species of the same epoch in Europe. But there are a considerable number of representative species, and an equal number of forms peculiar to the older tertiary strata of America. The *Ostrea sellæformis* may be considered as representing the *Ostrea flabellula* of the Paris and London basins, and appears to be one of the most characteristic and widely disseminated Eocene shells in this North American deposit.

The Miocene deposits are of far greater extent than the Eocene; and there is in them a close affinity of many of the most abundant species with mollusca now inhabiting the American coast, the proportion being about one-sixth of the whole, or about seventeen per cent., in those examined by Mr. Lyell, who was able to identify twenty-three out of 147 with living shells. The corals also agree generically with those of the Miocene beds of Europe, the cetacea also agree generically, and the fish in many cases specifically.

Metamorphic Rocks.

The theory of metamorphism in its more extended application, in recent times, to the explanation of the peculiar structure of certain stratified rocks, has thrown a clear light upon some of the most obscure and difficult parts of Geology. No geologist will now I presume hesitate to admit, that there is evidence amounting to demonstration that a permanent source of heat exists in the interior of the earth, widely spread beneath the stony envelopment, and that it has existed at all times. Whether it is local or widely spread under the surface—whether it is constantly maintained or is excited at intervals by certain combinations, are questions for the solution of which we have as yet no data to lead us beyond probable inferences. It was long ago observed that when dykes of basalt passed through sedimentary rocks, earthy limestones were frequently changed into crystalline marble, shales into flinty slate, argillaceous sandstone into jasper, and bituminous coal into graphite or cinder. Similar changes were also often observed at the junctions of granite with sedimentary rocks. An attentive observation of these phænomena led Hutton to infer that the strata derived from the detritus of pre-existing rocks had been consolidated into stone by the agency of subterranean heat; and although he extended his theory to all the strata, to many which subsequent observations have shown it to be inapplicable, still the germ of the modern theory of metamorphism is clearly seen in one of the fundamental positions of the Huttonian theory of the earth. But sound as were the views of that philosopher in his leading doctrines, they were adopted by a very small number of geologists, so strongly had the theories and system of Werner got possession of men's minds, especially in Germany and France. About twenty years ago however some startling facts were brought to light; we heard that Belemnites had been found in micaceous schists in the Alps, and that an insensible passage could be traced from a secondary oolite full of organic remains, to the highly crystalline marble of Carrara, the old type of primary limestone, and under circumstances which afforded the strongest presumptive evidence that the oolite had been changed into the marble by the action of adjacent igneous rocks. Then there came facts on a grand scale analogous to those that had been observed at the junctions of trap dykes and granite veins with sedimentary rocks, and not only extending to great distances from the igneous rocks, but the secondary shales were changed into rocks that could not be distinguished from the so-called primitive gneiss and mica-schists, and like them included crystallized garnets.

Mr. Lyell, in 1833, brought forward a more extended and complete development of the Huttonian hypothesis of consolidation, and first proposed the adoption of the term "metamorphic" to this peculiar altered structure of sedimentary rocks,—a term which has been since universally adopted; and every year has disclosed new facts from all parts of the world, in confirmation of the theory that the older crystalline and indurated schists, limestones, dolomites and quartzites, and many similar beds of more modern date, were not deposited with a structure such as they now present, but were accumulations of detrital matter, *transformed* into their present condition mainly by the action of heat, accompanied by other chemical action, and the powerful agency of steam and elastic forces under enormous pressure. A very ingenious process, invented by Mr. Brockedon, described in a short paper read before us last year, by which he converts, under very powerful pressure, the powder of graphite into a solid mass having a conchoidal fracture, and undistinguishable from the most compact native black-lead, shows that pressure alone may convert fine detrital matter into solid stone.

It is not very long ago, far within our own time, since geologists spoke and wrote of chaotic fluids holding mineral matter in solution, and of precipitations of crystalline rocks from that menstruum. But these hypotheses, not only unsupported by, but at variance with all known chemical laws, are now laid aside, and we reason more soberly, interpreting past changes in the mineral structure of the earth by our experience of the laws by which the operations in the material world are governed. Every accession to our knowledge of the older sedimentary, highly consolidated, and semi-crystalline rocks, renders the probability greater that they were formed in the same manner as those now in progress of formation in existing seas; in short, that they originated from the waste of pre-existing lands. As Astronomy leads us to contemplations of immensity of distance in space, thus does Geology lead us to contemplate distances in past time almost as boundless; equally difficult for us to form a conception of, but, although not capable of measurement, not less certain. We are thus brought to admit the truth of another of the fundamental doctrines of the Huttonian theory, laid down by its author more than half a century ago, and some years afterwards so eloquently illustrated by his disciple and friend Playfair, whom I am proud to call my first master in Geology, "that in all the strata we discover proofs of the materials having existed as elements of bodies, which must have been destroyed before the formation of those of which these materials now actually make a part*." We learn from Professor Sedgwick, that in the north of England there are chloritic slates alternating with countless contemporaneous ribs of porphyry, as well as with trappean conglomerates and slaty beds, *derived mechanically from materials of igneous origin*. M. Abich of Dörpat considers that certain dark green grains disseminated through the lowest beds of the Lower Silurian "Pleta," or Orthoceratite limestone of Russia, are the detritus of the ancient augitic rocks of the Finnish frontier†. The least fragment of an organic body in the lowest deposits, it is evident, must have been encased in silt or mud, and that silt or mud must have been derived from pre-existing rocks, and most probably rocks exposed on land to the destructive power of meteoric agents. We are told by Mr. Lyell that the Potsdam sandstone, the lowest of the Silurian strata of North America, at the Falls of Montmorency near Quebec, is remarkable for containing *boulders* of enormous size—the largest he ever remembers to have seen, he says, in any ancient stratified rock. He measured some of them, which were eight feet long. They consist of the same gneiss as that on which the sandstone rests. He also observed in the same sandstone, on the borders of Lake Champlain, ripple-marks on the surface of its flags.

Several of the works of geologists which have been published during the last year have supplied much additional evidence of metamorphic action; none more important, I may say more conclusive, than is contained in the work of Sir R. Murchison on Russia,

* Illustrations of the Huttonian Theory, p. 5. † Murchison's Russia, i. 28.

and of Mr. Lyell on America, and in a very valuable memoir by M. Virlet. As far as my limits will allow, I will bring forward some of that evidence.

With limited exceptions, true granites are rarely found in the higher portions of the Urals, but they are of frequent occurrence in the lower regions, particularly on the Siberian side. The igneous rocks that enter into their composition are different forms of syenite, porphyry, greenstone, and felspar rocks, often graduating into each other, and associated with serpentine. These have evidently been erupted at different periods; and there are wide tracts occupied by granitoid rocks, which appear to have been erupted after the age of the carboniferous series, and posterior to the greater proportion of the greenstones and other eruptive rocks of the Urals.

It was only after Sir R. Murchison and his companions had become thoroughly acquainted with the slightly consolidated and unbroken sedimentary deposits in European Russia, that they were able to decipher the intricate characters of the indurated and crystalline strata which constitute the flanks, enter into the very body, and form lofty serrated ridges of the Ural chain; broken up and cast about in much apparent confusion. But from the presence of organic remains, traceable at intervals along both flanks, and even close to the axis of the chain, they were satisfied that some of the central ridges, although composed of chloritic, talcose, micaceous, and quartzose slates, cannot be of higher antiquity than the unconsolidated Lower Silurian rocks on the shores of the Baltic; and that others, although in a highly crystalline state, are not older than the Devonian and carboniferous series. The same rocks, when they recede from the great lines of eruption, resume their ordinary sedimentary characters. In one place the authors expressly say, that in proportion as they receded from the igneous zone, the sedimentary strata gradually parted with their talcose, chloritic and quartzite characters, and assumed the appearance of ordinary argillaceous schist, with bands of grit and sandstone, all parallel to the crystalline axis of the chain. In another place they describe certain Upper Silurian beds, consisting of alternations of argillaceous slate and black encrinite limestone, passing into talc-schist, and containing great flakes of mica. Between two great parallel lines of eruption they saw pure white saccharoid limestone containing Encrinites, and associated with other crystalline beds, which they were satisfied were once sandstones formed under the sea in the palæozoic period. In like manner the sedimentary rocks on the northern frontier of Russia, where they approach the great granitic and trappean region that stretches southward from Russian Lapland, become so changed, that the shales are converted into Lydian stone, the limestones into marbles, and the sandstones into indurated and sometimes granular quartz. These are not partial local effects, but characterize a long line of country in a broad zone. The authors observe, that "the thorough examination of this great band of Silurian rocks, more or less metamorphic, which lies between the purely crystalline or azoic rocks of the north and the wholly unaltered Devonian and carboniferous deposits on the south, well merit the special attention of the geologist, mineralogist, and chemical philosopher; for the scale on which these operations of change have been conducted is gigantic. Our present acquaintance with the phænomena is however sufficient to convince us, that here, as in other countries, the consolidation, rupture, and alteration of large portions of the earth's crust have been effected by the agency and eruption of igneous and gaseous matter." A limestone—ascertained, both by lithological characters and fossiliferous proofs, to belong to the Devonian age, in which copper veins occur at a point where it is intersected in a complicated manner by greenstone porphyry—is converted, for a space 350 fathoms long and twenty wide, into a crystalline rock, in some places becoming a pure white crystalline saccharoid marble, and associated with it is a garnet rock, loaded with very beautiful and large crystals; a case somewhat analogous to that observed by Professor Henslow in Anglesea twenty-five years ago*, and to that in the neighbourhood of Christiania described by Mr. Lyell†. On the east flank of the Urals, south of Ekaterinburg, there is a succession of low ridges parallel to the main crest of the chain, composed of metamorphic rocks, some of them so micaceous that they might pass, the authors say, for primary mica-schist; others resembling gneiss, which a few years ago any geologist would have termed primary, but which are in fact only altered palæozoic sedimentary strata.

If we cross the Atlantic to North America, we obtain equally clear proofs of the alteration of the sand and mud of the lands of remote antiquity into crystalline schists, and of the forests that grew upon them into anthracitic coal, by this same powerful agency.

The Appalachian or Alleghany Mountains, which run from north-north-east to south-south-west for 1000 miles, varying in breadth from 50 to 150, and in height from 2000 to 6000 feet, have not, like the Ural chain, the features of a great rent in the earth's crust formed by elastic forces from beneath, and into which molten rocks were injected; they are composed of Silurian, Devonian and carboniferous rocks, in a series of nearly equal and parallel ridges formed by flexures of these rocks. The bending and fracture of the beds is greatest on the north-eastern or Atlantic side of the chain, and the strata become less and less disturbed as they extend westward, until at length they regain their original or horizontal position; thus offering between the Alleghanies and the western boundary of the basin of the Mississippi a country very similar in conformation to that between the Urals and the Baltic, and composed to a great extent of similar rocks. The internal movements which caused these flexures took place, as in Russia, subsequent to the carboniferous period; and on the eastern side the igneous rocks have invaded the strata, forming dykes, some of which run for miles parallel to the main direction of the mountains. These igneous rocks are largely developed to the north-east in the States of New Hampshire, Vermont and Maine.

Near Worcester in Massachusetts, Mr. Lyell observed mica-schist

* Cambr. Phil. Trans. vol. i. † Elem. of Geol. ii. 403.

containing beds of anthracite, the mica-schist including garnets and asbestus; and he states that he is strongly inclined to believe, that however crystalline they may be, they are no other than carboniferous rocks in a metamorphic state. There are many other places in Rhode Island and Massachusetts of similar transformations, especially in the neighbourhood of masses of granite and syenite*. The coal which, westward of the Alleghanies, is highly bituminous, as it approaches the igneous rocks to the east gradually loses its bitumen and gaseous contents, and is finally converted into anthracite.

The concluding part of the first volume of the second series of the 'Bulletin de la Société Géologique de France,' published last year, contains an interesting, and, in many respects, highly instructive account of the proceedings of the Society at their meeting at Chambery in August 1844. During the sixteen days it continued several valuable papers were read, and interesting discussions thereon are reported. Among others, the subject of metamorphism was frequently brought forward, and it appears to be the settled opinion of the most eminent French, Swiss and Italian geologists, who have thoroughly examined the Alpine regions, that a great proportion of the mica-schists, talc-schists and clay slates of the Alps, long held as types of primitive rocks, are unquestionably deposits of secondary age metamorphosed by igneous action. The neighbourhood of the place of meeting is described by the Archbishop of Chambery,—who took an active part in the proceedings, and who, from the communications he read, seems to be a zealous geologist,—as one of the countries of Europe the most interesting in this respect, and one in which the modifications of metamorphic action may be traced from its commencement to its extreme intensity with the greatest facility. At the conclusion of the meeting, M. Virlet read a paper on the participation which veins have had in metamorphic action, and brought forward some new views on the theory of metamorphism. He states that it has generally been held to be the result only of the action of plutonic rocks on the sedimentary deposits with which they come in contact, but that it is a far more complex operation, and is probably the result of several causes acting either simultaneously, separately or successively; among these he is disposed to ascribe much to the addition of new materials, insinuating themselves in the shape of gaseous emanations from the interior of the earth. He also dwells much on the matter injected into fissures, forming veins, as having had great effect, maintaining that in all metalliferous regions, the greater the number of veins by which they are traversed, so is the degree of metamorphism increased. He insists much on the metamorphic action of quartz veins, which he holds to be of eruptive nature, refers to the growing conviction among geologists, that in many cases there have been eruptions of veins of calcareous spar, and even ascribes the veins and slender ramifications of gypsum in the argillaceous beds of the lias of Burgundy and the other eastern provinces of France to eruptions of sulphate of lime.

* Lyell's America, i. 248.

Metallic Products.

The protrusions of igneous rocks along the line of the Urals were accompanied throughout a great part of the chain by the formation of numerous and extensive metallic veins, particularly on the eastern flanks, the chief seat of the metallic riches of Russia, especially in copper and iron. The geological details connected with these metalliferous rocks constitute a large and interesting part of Sir R. Murchison's work. One of the most important geological features connected with them, and it is one which appears to be well established, is the comparatively recent date of the eruptions which brought these metallic products of nature's crucibles within the reach of man. The accounts of the rich gold deposits are curious, and the ejection of the rock in which that metal is contained appears to have been very modern—little, if at all, anterior to the destruction of the mammoths, whose remains are entombed in the gravel which is found everywhere in the depressions of the Ural chain, and which covers vast regions of Siberia. The matrix appears to be quartz in the form of veins, but to find the gold in that state is extremely rare. It is found in lumps and grains that have been rolled, mixed with other detrital matter. A lump weighing about seventy-eight pounds English, found in 1843, is now in the Museum of the Imperial School of Mines at St. Petersburg.

Several curious facts are adduced to show that some of the ores of copper, particularly the green carbonate or malachite, are aqueous productions, derived from pre-existing ores, as calcareous stalagmites are derived from limestone rocks. In the copper mine of Nijny Tagilsk, at a depth of 280 feet from the surface, an immense irregularly-shaped botryoidal mass of solid pure malachite was found, of a bulk estimated at upwards of half a million of pounds weight, presenting in its interior the wavy radiations and silky structure of that beautiful mineral; almost identical in structure with many calcareous semi-crystalline minerals, of whose aqueous origin no doubt exists.

All the best iron of Russia is brought from the Ural chain and its flanks. It is found in veins in greenstones, and intermixed with the mass of erupted rocks of that class, often in great abundance at the junction of the igneous and stratified rocks, these last being in a metamorphic state. Magnetic iron ore is the chief form in which the metal is found, and it constitutes vast masses, sometimes worked in an open quarry.

Changes in the Relative Level of Sea and Land.

You are well aware that proofs of changes in the relative level of the sea and land along certain shores, particularly in the Baltic and Mediterranean, since our continents and adjacent islands were bounded by their present lines of coast, had attracted the attention of some of the earlier geologists; but it is only within a comparatively recent period that the discovery, in numerous instances, of the action of the sea at elevations far above its present level, in what have been termed *raised beaches*, has excited due attention to this most important class of geological phænomena; changes which may almost be said to come within the range of our experience, and which appear to afford a key to the right solution of many analogous changes during periods long antecedent. We have for some time known that eroded rocks, and long lines of level beds or terraces of shingle, sand and clay, mixed with broken shells like what we now find at the sea-shore, are met with along the coasts of Sweden, and in Norway and the islands adjacent, from the Naze to the North Cape, and even to Spitzbergen. These beds of detritus, which have been found at elevations of 600 feet, and are sometimes above 160 feet in thickness, usually rest on the solid rock, and frequently contain shells in a perfect state of preservation as to freshness and colour, the bivalves, which are identical with species now living near the shore of the adjoining sea, retaining their uniting ligament; indicating that the changes have occurred, either during the latter part of the tertiary period, or at the commencement of the existing geological period. These facts are described in the writings of Playfair, Von Buch, Keilhau, Sefström, Lyell and others, and some very remarkable cases have recently been given in a memoir by M. Bravais*, who resided a year in Finmark, between the seventieth and seventy-first degrees of latitude, and who has measured with great care a series of terraces or raised beaches in the Alten Fiord, which extend over a line of coast from fifty to sixty miles.

The western coast of our own island has also, as you know, afforded some most remarkable instances of these changes of relative level of sea and land, from the north of Scotland to Cornwall, and in some cases at a much greater elevation than in Norway, as at Moel Tryfane in Caernarvonshire, more than 1000 feet above the sea. That they have not been found in as continuous extent in Britain as in Norway is perhaps owing to this, that the shores of our island being cultivated, these banks of loose materials would gradually become obliterated.

But it is not the shores of Europe alone that have afforded proofs of these changes; the continents of North and South America exhibit them on a far grander scale, both on the Atlantic and Pacific coasts. We are indebted to Mr. Darwin for descriptions of many remarkable instances; and some of these which have recently come again under our notice, in the second edition of his 'Journal,' published within the last few months, I will draw your attention to: I know no geologist whose observations, and the inferences he draws from them, are more to be relied upon; for he examined the country he describes evidently uninfluenced by any preconceived opinions. They have besides a bearing upon some fresh accessions to our knowledge of facts of this description, both in Europe and North America, during the past year.

At Coquimbo, in northern Chile, five narrow, gently sloping, fringe-like terraces rise one behind the other, and, where best developed, are formed of shingle. At Guasco, farther north, the terraces

* A translation of this valuable memoir is given in the fourth number of the Quarterly Journal of the Geological Society.

are much broader, and may be called plains, and they run up the valley for thirty-seven miles from the coast. Shells of many existing species not only lie on the surface of the terraces, to a height of 250 feet, but are imbedded in a friable calcareous rock, which is in some places as much as from twenty to thirty feet in thickness; and these modern beds rest on an ancient tertiary formation, containing shells apparently all extinct. "The explanation of the formation of these terraces must be sought for, no doubt, in the fact, that the whole southern part of the continent has been for a long time slowly rising, and therefore that all matter deposited along shore in shallow water must have been soon brought up and slowly exposed to the wearing action of the sea-beach *." He describes a great valley near Copiapo, reaching far inland, the bottom of which, consisting of shingle, is smooth and level; and states that he has little doubt that this valley was left, in the state in which it is now seen, by the waves of the sea, as the land slowly rose †. He then goes on to state, "I have convincing proofs that this part of the continent of South America has been elevated near the coast at least from 400 to 500, and in some parts from 1000 to 1300 feet, since the epoch of existing shells ‡." Speaking of the neighbourhood of Valparaiso he says, "The proofs of the elevation of this whole line of coast are unequivocal: at the height of a few hundred feet old-looking shells are numerous, and I found some at 1300 feet. These shells either lie loose on the surface, or are imbedded in a reddish-black vegetable mould. I was much surprised to find, under the microscope, that this vegetable mould is really marine mud, full of minute particles of organic bodies §."

So far for instances of changes in the relative level of sea and land on the western shores of the continent; they are no less conspicuous on the Atlantic side. "The land from the Rio Plata to Tierra del Fuego, a distance of 1200 miles, has been raised in mass (and in Patagonia to a height of between 300 and 400 feet) within the period of now existing sea-shells. The old and weathered shells left on the surface of the upraised plain still partially retain their colours. The uprising movement has been interrupted by at least eight long periods of rest, during which the sea ate deeply back into the land, forming at successive levels the long lines of cliffs or escarpments which separate the different plains, as they rise like steps one behind the other ||."

Now it is important to observe, that in some of the above instances, and also in others which Mr. Darwin gives, the proofs of change are not in terraces or raised beaches only, but that there are broad expanses of land far from the coast, where marine shells of existing species lie near the surface and upon it; in other words, that we have that which recently was a sea-bottom now forming an elevated part of the continent.

The authors of the 'Geology of Russia' have described a sea-bottom, extending nearly 200 miles inland from the shores of the

* Journal of a Voyage round the World, 2nd edit. p. 344. † Ibid. 355.
‡ Ibid. 357. § Ibid. 254. || Ibid. 171.

Arctic Ocean, which they were the first to discover. In ascending the Dwina, which flows into a bay of the Icy Sea at Archangel, they discovered at about 150 miles from that city, near where the Vaga, a tributary, falls into the Dwina, a profusion of shells having a very modern aspect, regularly imbedded in clay and sand of about ten feet in thickness, which, covered by about twenty feet of the coarse gravel and detritus of the country, reposed on red and white gypsum, subordinate to red marls of the Permian system of rocks. They traced these shelly beds to a distance of about eight miles. Some of the shells preserved in the blue clay or marine sand, and thereby excluded from atmospheric influence, have retained all the freshness of their original colour, with their valves often united; and the whole, even when blanched, are generally in a good state of preservation. What they collected were carefully examined by skilful conchologists. Dr. Beck of Copenhagen considered all he examined to be identical with those now existing in northern seas which range from 42° to 84° north latitude. Mr. Smith of Jordan-hill was of opinion, that though many of these species are recent, some are of peculiar varieties, now found in desiccated and elevated sea-beaches only. Mr. Lyell recognised the group as identical with that which he had described from Uddevalla in Sweden, a distance of a thousand miles from the Dwina; and Mr. G. Sowerby stated, that the shells, though on the whole an association of existing species, have yet among them forms seldom, if ever, found except in raised sea-bottoms of a subfossil character. The authors estimate the place where these shelly beds occur to be about 150 feet above the sea at Archangel, and consider them to afford undoubted evidence that the land, from the Vaga to Archangel, was a sea-bottom during the period of existing species. A similar estuary appears to have existed about 300 miles eastward, in the valley of the Petchora; for Count Keyserling found fragments of sea-shells, apparently of existing arctic forms, at a distance of 180 miles from the present embouchure of that river, strewed upon argillaceous slopes in the depression of the valley. He further observed, that they do not occur in the adjoining plateaux; and that these higher grounds are occupied by sand, gravel and clay, containing here and there bones of the mammoth, from which he infers, that the shelly deposits were formed in a bay of the sea that extended far into low lands, which were then inhabited by great extinct mammalia.

In the sketch given by the same authors of the structure of Siberia, they adduce a body of very satisfactory evidence to justify the inference they draw, that the vast region in which the bones of Mammoth, Rhinoceros and *Bos Urus* are so abundantly dispersed, and especially the wide and low tract of northern Siberia, and all the low promontories between the Obe, the Yenessei and the Lena, were elevated at a period long subsequent to the time when large herds of these animals for many successive generations inhabited that region. Following up the views first propounded by Mr. Lyell, to whom they do full justice, they infer that the change of climate, the diminished temperature, occasioned by the increase of land when the sea-bottoms of these estuaries and shores were upraised, caused the extinction of these great quadrupeds.

Although the great tract of country from the Baltic to the elevated region westward of the Ural Mountains has not been locally broken up by eruptive rocks, there is ample evidence to prove that it has been subjected to the action of subterranean forces, which elevated the whole region, after the deposition of Miocene tertiary beds, and after the land, while submarine, had assumed its present form. "From the German Ocean and Hamburgh on the west to the White Sea on the east, a vast zone of country, having a length of near 2000 miles, and a width varying from 400 to 800 miles, is more or less covered with loose detritus, including erratic crystalline blocks of colossal size, the whole of which blocks have been derived from the Scandinavian chain." The eastern and south-eastern boundary of these erratic blocks mark the line of coast westward of which all the land as far as the shores of the Baltic was then submerged. Between that line of coast and the Urals is the region that constitutes the Governments of Perm, Viatka and Orenburg; and for a considerable space to the west of the Ural there is not a vestige of any superficial deposit which can be referred to the influence of the sea. "We believe, therefore," say the authors, "that the region so characterized was really above the waters, and inhabited by mammoths, when the erratic blocks were transported over the adjacent north-western sea." The amount of this elevation, subsequent to the covering of the sea-bottom by the northern drift, must have been at least from 800 to 1000 feet; for the tops of the Valdai hills, a range on the eastern borders of Lithuania, and to the south of the Government of St. Petersburg, which rise in some places to that height, are covered with these blocks on their southern slopes.

Mr. Lyell, speaking of the country near Savannah in North America, says, "It is evident that at a comparatively recent period, since the Atlantic was inhabited by the existing species of marine testacea, there was an upheaval and laying dry of the bed of the ocean in this region. The flat country of marshes was bounded on its inland side by a steep bank or ancient cliff, cut in the sandy tertiary strata; and there are other inland cliffs of the same kind, at different heights, implying the successive elevation above the sea of the whole tertiary region." In a letter which I received from him a few days ago, dated from Savannah, Mr. Lyell tells me "that he had seen on the coast of Georgia quite a counterpart of the terraces, or successive cliffs of Patagonia, cut out of the tertiary deposits." But there are also evidences on that coast of a downward movement at the present time. Mr. Lyell says, "There have also been subsidences on the coast, and perhaps far inland; for in many places near the sea there are signs of a forest having become submerged, the remains of erect trees being seen enveloped in stratified sand and mud. I even suspect that this coast is now sinking down at a slow and insensible rate, for the sea is encroaching and gaining at many parts on the freshwater marshes. . . .Everywhere there are proofs of the coast having sunk, and the subsidence seems to have gone on in very modern times." Speaking of some phænomena connected with a boulder formation at Brooklyn near New York, he says that he had come to the conclusion "that the drift was deposited during the successive submergence of a region which had previously been elevated and denuded, and which had already acquired its present leading geographical features and superficial configuration." In the region near the Falls of Niagara, on Lake Ontario, and in the valley of the St. Lawrence, he enumerates many unequivocal proofs of emergence and submergence during the modern period now under consideration. He states that in the valley of the St. Lawrence he seemed to have got back to Norway and Sweden, passing over enormous spaces covered by deposits so modern as to contain exclusively shells of recent species, resting on the oldest palæozoic and older non-fossiliferous rocks. Wide areas are covered with marine shells of *recent* species, at the height of 500 feet above the sea, and where all the rocks can be shown both to have sunk and to have been again uplifted bodily, for a height and depth of many hundred feet, since the deposition of these shells. At the village of Beauport, three miles below Quebec, he made a collection of shells from a cliff consisting of a series of beds of clay, sand, gravel and boulders; and he states that when they arrived in London, Dr. Beck of Copenhagen happened to be with him, and "great was our surprise," he adds, "on opening the box to find that nearly all the shells agreed specifically with fossils which, in the summer of the preceding year, I had obtained at Uddevalla in Sweden, and figured in my paper "On the Rise of Land," &c., in the 'Philosophical Transactions' for 1835. Among the species most abundant in these remote regions (Scandinavia and Canada) were *Saxicava rugosa*, *Mya truncata*, *M. arenaria*, *Tellina calcarea*, *T. Grœnlandica*, *Natica clausa*, and *Balanus Uddevallensis*. All of them are species now living in the northern seas; and whereas I had found them fossil in latitudes 58° and 60° N. in Sweden, Captain Bayfield sent them to me from a part of Canada situated in latitude 47° N."

Ascending the St. Lawrence, he found near Montreal, at a height of about sixty feet above the river, great numbers of the *Mytilus edulis*, retaining both valves and their purple colour, associated with *Tellina Grœnlandica* and *Saxicava rugosa*, in horizontal beds of loam and marly clay. He found the same shells at ninety feet associated with boulders of gneiss and syenite three feet in diameter, characteristic of the Canadian drift; and he was afterwards conducted to a hollow between the two eminences which form the Montreal mountain, where he found a bed of gravel six feet thick, containing numerous valves of *Saxicava rugosa* and *Tellina Grœnlandica*. This bed he estimates at 540 feet above the sea, 306 feet above Lake Ontario, and only twenty-five feet below the level of Lake Erie.

Such comparatively modern changes in the relative level of the land and sea, were ascribed by the earlier geologists, and are by some still ascribed, to a rising or sinking *of the sea*. Playfair, nearly half a century ago, combating this opinion maintained by the Swedish naturalist Celsius, demonstrated the untenable nature of such a hypothesis; it was he who first showed that these changes of relative level are alone explicable by the movements *of the land*, and that a permanent change of level of the sea, in detached regions of the earth's surface, is physically impossible. "The imagination," he says, "naturally feels less difficulty in conceiving that an unstable fluid like the sea, which changes its level twice every day, has undergone a permanent depression in its surface, than that the land, the *terra firma* itself, has admitted of an equal elevation. In all this, however, we are guided much more by fancy than by reason; for, in order to depress or elevate the absolute level of the sea, by a given quantity, in any one place, we must depress or elevate it by the same quantity over the whole surface of the earth; whereas no such necessity exists with respect to the elevation or depression of the land. To make the sea subside thirty feet all around the coast of Great Britain, it is necessary to displace a body of water thirty feet deep over the whole surface of the ocean. It is evident that the simplest hypothesis for explaining those changes of level, is, that they proceed from the motion, upwards or downwards, of the land itself, and not from that of the sea. As no elevation or depression of the sea can take place but over the whole, its level cannot be affected by local causes, and is probably as little subject to variation as anything to be met with on the surface of the globe*".

Notwithstanding that this unanswerable doctrine was thus clearly laid down so far back as 1802, we still find geologists of authority speaking *of the sea* having risen or fallen, in their endeavours to explain certain phænomena. I have within the last year heard this said repeatedly in this room; and in a recent excellent paper of my friend Mr. Maclaren of Edinburgh, on Boulders and grooved and striated Rocks observed by him on the shores of the Gare Loch in Dumbartonshire, an excellent observer, and in general a sound reasoner, I find such expressions as the following:—"The anomalous presence of granite boulders at Gare Loch seems best explained by assuming that they were floated on icebergs from Ben Cruachan, Ben Nevis, or some other of the lofty granite mountains of the north .... *The sea must then have stood perhaps* 1500 *feet above its present level*, to permit the rafts of ice to pass over the lowest part of the barrier.... An iceberg starting from the West or North Highlands, *and floating in a sea* 1500 *or* 2000 *feet above the present level of the Atlantic*, is an agent perfectly capable of effecting the transportation of the stone, and offers, I think, the only conceivable solution of the difficulty .... *When the sea stood, as it certainly once did stand*, 1000 *feet or more above its present level*, a current would set eastward through the gulf then occupying the low lands, of which the estuaries of the Forth and Clyde form the extremities." Speaking of an ancient beach thirty-two feet above the present high water line on the shore of Gare Loch, he says, "We may infer that when the glacier occupied the valley of Gare Loch, *the sea stood higher than it does now by at* least thirty feet, and probably a great

* Illustrations of the Huttonian Theory, p. 446.

deal more*". It is possible that these may be mere inaccuracies of expression in describing changes of relative level of sea and land, but if they are so they ought to be guarded against, for they may be very easily misapprehended; and they tend to perpetuate an error that leads to the most false reasoning on many changes on the earth's surface.

If the land of Norway had been immovable, if the sea had fallen from a higher level, the lines of its former shores, as it sank at intervals, would have been continuous and parallel; but the raised beaches are, within short distances, at different elevations; other observers had remarked this, but it is to M. Bravais that we are indebted for the first exact measurements of the relative positions of the successive terraces, and these have demonstrated that their parallelism is only apparent. During his residence on the Alten Fiord, near North Cape, he extended his levelings over a space of from nine to ten myriametres, that is, from about fifty-five to sixty-two English miles; and he ascertained that the two great lines of ancient level there, which are on a slope rising from the sea, come nearer and nearer to each other as they approach the present shore; their greatest elevation is in the upper part of the Fiord, and they are there widest apart. It is evident therefore that the movement of the land has been different in different parts of the fiord. It seems as if the continental mass had been elevated with an inclination seaward, the axis of motion corresponding nearly to that of the great chain of the mountains of Norway. It is most desirable that measurements similar to those of M. Bravais should be made in all places where there are terraces or raised beaches one above another along our coasts. Mr. Darwin's explanation of the parallel roads of Glen Roy, that they are ancient sea-beaches, appears to be now generally accepted; and it would be most interesting if it were ascertained by exact levelings, such as those of M. Bravais in the Alten Fiord, whether they are really parallel; because, as M. Bravais well remarks, they may seem so to the eye, which can take in only a small part of the space they occupy, while exact measurements might prove that the appearances are deceptive.

That land in various parts of the earth has undergone movements of elevation and depression, and that it has been subject to such oscillations at all times, up to the present day, admits I think of no doubt; without therefore going quite so far as my friend Mr. Darwin, who tells us that "daily it is forced home on the mind of the geologist, that nothing, not even the wind that blows, is so unstable as the level of the crust of this earth," still I believe it may be safely affirmed, that the stability of the sea and the mobility of the land must be acknowledged to be demonstrated truths in Geology.

Boulder Formations and Erratic Blocks.

The geologically modern changes in the relative level of sea and land are intimately connected with the history of the vast accumu-

* Edin. Phil. Journal, January 1846.

lations over Northern Europe and North America of detrital matter, in the form of sand, clay, gravel, boulders, and huge erratic blocks, and of the grooved, striated and polished surfaces of hard rocks which usually accompany them. This great problem, complicated in its nature and full of difficulties, has of late years more particularly arrested the attention of geologists; and it must long continue to do so before a sufficient mass of observations can be collected on which a satisfactory solution of it can be founded. Although, as regards Europe, many important local facts, exhibited in limited districts, have been well described by several geologists, both of this country and of the continent, we are indebted for the most extended observations and the most comprehensive views of the subject to the labours of Keilhau, Sefström, Durocher, Murchison, De Verneuil, and Forchhammer. The geologists of the United States, and Lyell, have brought together a great body of evidence respecting the same phænomena in North America. There is reason to infer, from the limited observations that have been made along the shores of Siberia, that the boulder formation extends also over Northern Asia.

Many new observations have been made known to us during the last year, by the authors of the 'Geology of Russia,' by Mr. Lyell in his 'Travels in the United States, Canada, and Nova Scotia,' and by M. Durocher in an additional memoir which he read last December before the Geological Society of France, describing observations made by him in Norway during the preceding summer.

You are aware that Agassiz and Charpentier have attempted to explain the phænomena by supposing, that at a very recent geological period, since the time when the land had assumed its present form, Northern Europe was covered with a vast mantle of ice, and that the detritus and erratic blocks have been formed and transported by the agency of sub-aërial glaciers, in the same manner as moraines have been accumulated, blocks transported, and rocks furrowed, striated, rounded and polished by the glaciers descending from the Alps. Abundant evidence has been brought forward to demonstrate, that by no such action can the phænomena be explained; and all the geologists mentioned above, who have carefully investigated them, reject the theory as inapplicable to Northern Europe and America, except in a very limited sense.

The Boulder Formation, or Northern Drift, and The Erratic Blocks, are shown, by the authors of the 'Geology of Russia,' to be two distinct classes of phænomena; the latter being usually angular, the materials of the former being rounded and worn by attrition. It appears to me to have been clearly proved that the boulder formation is not the work of a sudden transient action of short duration, but the result of operations that were going on during the middle tertiary deposits, and in Europe extended at least to the Pleistocene period; that the greater part of the accumulations took place since existing species of testacea inhabited the adjoining seas; and that the transport of erratic blocks took place at a later period. It seems to be no less clearly established, that the boulder and drift accumulations and the erratic blocks now covering the dry land were deposited upon a sea-bottom which has been since upraised. Where the smaller detritus and rounded boulders came from, and how they were drifted into their present situations, are branches of the subject involved in great obscurity. That fragments of hard rock were the tools which graved the furrows and striæ, and polished the surfaces of hard rocks they passed over, is pretty evident; but what held and guided the tool, what force applied it, to what extent ice, and to what extent water was the agent, is not so clear; that both have acted there can be no doubt. It is, I think, very satisfactorily shown, that the erratic blocks must have been brought down from lofty mountains, to the open sea that washed their bases, by glaciers; that they were floated to great distances by masses of ice breaking off from these glaciers, to form icebergs, in different directions from central points, and stranded on elevated parts of the sea-bottom, without having been subject to much attrition; and, moreover, that these erratic blocks can, in a great number of instances, be traced to their parent rock, though now separated some hundred miles. Some of the evidence in support of these positions, supplied during the last year, I will now bring forward. I regret that my limits will not allow me to do greater justice to the authors to whom we are indebted for it, either as regards their facts, or their deductions from these facts.

The boulder formation and erratic blocks cover an enormous area, from the Arctic Sea over a great part of Northern Europe; not continuously, but often uninterruptedly over vast regions. The masses of clay, sand and gravel are sometimes of so great thickness that it is impossible to detect a trace of the subjacent solid rock, over very wide tracts, even in the beds of the Volga and the deepest cutting rivers. M. Durocher, in his first memoir*, did not trace the erratic blocks farther east than the forty-second degree of longitude, nor farther south than the fifty-fifth degree of north latitude; but the authors of the 'Geology of Russia' have described them as extending 500 miles farther east, and above 200 miles farther south. As the parent rocks of most of these huge fragments are in Scandinavia and Finland, they have been in some instances transported to a distance of 800 miles in a direct line†. It is possible that the *boulder formation* may extend somewhat farther, but probably not much; for there is reason to believe that land on the east and south was above the level of the sea, as has been already stated, at the time the country to the west and north was submerged, which would stop the advance of the boulder formation and erratic blocks, but in an irregular line. No erratic blocks of northern origin have been seen for a considerable distance westward of the Ural Mountains.

There is a feature in the character of this superficial covering of detritus which is very important to attend to in tracing its history, viz. that the materials are not always the same; that the principal mass in each district is of local origin, and very clearly bespeaks its derivation to be in the subjacent rocks; and that the great northern

* Comptes Rendus, Janvier 1842. † Map accompanying 'Geology of Russia.'

drift is distributed in the form of long sand-banks, "*trainées*," or "*osar*," as they are called in Sweden, often of great length and breadth, and rising sometimes more than 100 feet above the depressions between them, which last are occasionally of great width. These trainées are often composed of finely laminated sand and clay, containing shells identical in species with those now living in the Baltic or in the northern seas; they traverse, from the shores of the Baltic, the Silurian, Devonian, and carboniferous regions in succession, deriving new materials from each zone of rocks crossed, but always indicating a southerly direction of the drift, the Devonian detritus never being found in the Silurian zone, nor the carboniferous in the Devonian zone.

Mr. Forchhammer describes the boulder formation of Denmark as being of different ages. The oldest which affords any distinct evidence to mark its age consists of a congeries of clays, marls, and sands, which have been traced to a depth of several hundred feet, and contain boulders throughout the entire mass, extending to the deepest part of the series. The boulders, sometimes several hundred cubic feet in size, are of granite, gneiss, porphyry, greenstone, and quartz rock, and also of transition (Silurian) sedimentary rocks; none of these occurring nearer than Norway and Sweden. Besides these travelled blocks, there are many parts of the formation composed of chalk, identical with rocks upon or near to which the boulder formation occurs. In the duchy of Schleswig, this boulder formation *alternates* with beds of Brown Coal, a deposit which extends over the greater part of Denmark, and which, besides brown coal, consists of clays, limestones and sandstones, containing fossils that in the opinion of Mr. Forchhammer mark it to be identical with the sub-Apennine group. The causes which produced this boulder formation, in part at least, were therefore in operation as early as the Miocene tertiary period (if, as some maintain, the sub-Apennines are of that age), during which the sea, overspread at its bottom by this detritus, was inhabited by Mediterranean species. There is clear evidence in the works of the authors I have quoted, of the operation of the same causes long after the northern seas were inhabited by existing species; and throughout the whole of this period, how long we have no means of determining, all the land in Northern Europe overspread by the boulder formation must have been under the sea. Thus the authors of the 'Geology of Russia' describe the deposit of recent shells in the valley of the Dwina, 150 miles inland from Archangel, as covered by sand and gravel, which, they say, they would have great difficulty in separating from the superficial northern drift; and they add, that "a recent excursion through Sweden has convinced them that in the neighbourhood of Upsala, marine post-pliocene deposits, containing the *Tellina Baltica*, are there covered by coarse gravel and large erratic blocks, as stated by Mr. Lyell."

The ingenious and ardent naturalists of Switzerland, who have held that the boulder formations of Northern Europe were produced by sub-aërial glaciers, never could have advanced so extravagant a theory had they visited that region and been even moderately acquainted with the facts above stated, and others which as indisputably prove a submarine origin. But there is every reason to conclude that glaciers in high lands in Scandinavia, Finland and Lapland, in very remote times, had much to do with the origin of *the erratic blocks*, in separating them from their parent rocks and transporting them to the coast. Sir R. Murchison informs us that he was assured by Dr. Wörth, a distinguished mineralogist of St. Petersburg, that after a careful examination of the numerous blocks scattered around that capital, there was not among them a single example which could not be paralleled with its parent rock in Finland. Speaking of the observations of himself and his companions, he states that near Jurievitz on the Volga, they found erratic blocks of a quartz rock associated with others of a trap breccia peculiar to the north-western side of Lake Onega, affording clear evidence that they had been transported in a south-eastern direction, 500 miles from their parent rocks.

If the blocks were encased in and transported by icebergs, they would be accumulated chiefly on the ridges and higher parts of the sea-bottom, by which the progress of the icebergs would be arrested, and where the icebergs would be fixed until they gradually melted, leaving their stony cargo on the spot. Such we find to be the fact. The great accumulations of the blocks are not in the valleys, but on the high grounds. The summits of the cliffs on the south shores of the Gulf of Finland, at an elevation of 150 feet above the sea, are covered with angular blocks of the granite, gneiss and porphyry of Finland; they are found on the hills adjoining Lake Onega, at elevations from 400 to 600 feet above the lake; the Valdai Hills, which are in some places 1000 feet above the level of the Baltic, have arrested large quantities of blocks from Finland, which are profusely spread over their southern slopes. In the sandy plains east of Posen, not a block is to be seen for several miles, until the elevations towards the Polish frontier are reached, and they again become numerous. In the sandy plain the blocks are usually small, but on the hills between Konin and Kolo, vast numbers of large blocks are buried in and mixed with sand at heights of 300 or 400 feet above the sea.

A very important circumstance in the history of these erratic blocks is pointed out by the authors of the 'Geology of Russia,' viz. that they have not travelled from north to south only, but in all directions from certain centres in Scandinavia and Lapland. In Denmark they have come from north by east; in most parts of Prussia almost direct from north; opposite the coasts of Finnish Lapland, where the granitic and other crystalline boundary sweeps round to the north-east, the direction of the blocks changes accordingly. Near Nijni Novgorod they must have travelled from north-west to south-east; and in the Government of Vologda they have nearly an eastern course. By the observations of Böhtlingk we learn that the erratic blocks of Scandinavia have been shed off from the coast of Kemi into the bay of Onega, and from Russian Lapland into the

Icy Sea, in north-eastern, northern, and north-western directions; and Norwegian detritus has been transported westward to the coasts of Norfolk and Yorkshire.

Russia in Europe, from the nature of its surface, cannot be supposed to afford many proofs of furrows grooves, and striæ on hard rocks; but on Lake Onega a hard greenstone and siliceous breccia are rounded off, grooved and striated on the northern face of a small promontory, the direction of the grooves and striæ being north and south, and the striæ are to be seen, through the transparency of the water, eight feet below its surface; they are also to be traced near the summit of a low hill. On the south side of that hill, however, no such traces of wearing or friction can be seen, "and thus," the authors say, "we had before us, on the edges of Russian Lapland, the very phænomenon so extensively observed by Sefström over Sweden, viz. a rounded, worn, and striated surface of the northern sides of promontories, whose southern faces are natural and unaffected by any mechanical agency."

M. Durocher visited the coasts of Sweden and Norway, in the neighbourhood of Christiania, last year, and discovered there many most remarkable instances of these furrows and striæ, detailed accounts of which he has given in the paper read before the Geological Society of France, in December, which I have already alluded to. He indeed describes effects of erosion on a much greater scale than I remember to have read of before; furrows so deep, that channels are a more appropriate term; as he himself has thought, for he calls them *canaux*. Both on the east and west coasts of the bay at the head of which Christiania is situated, from Gothenborg on the Swedish shore, and from Arendal, on the Norwegian, to Christiania, distances of 160 and 170 miles respectively, and especially among the islands that skirt the Norwegian coast, he observed the rocks worn into deep channels and furrows, or striated, in directions from north-west to south-east, and having their surfaces rounded and polished. These channels or furrows are of various dimensions; some from twenty-five to fifty centimetres (ten to twenty inches) in width, with a depth of from one and a half to two and three metres (five to ten feet). In a great number of instances the sides of the interior of these channels are grooved and striated in the direction of their longer axis. Sometimes they divide into two or more branches, which afterwards reunite into one. Many are rectilinear, but many are undulating, and bent in short waves. The axes of the channels and the striæ in their interior have the same general direction as the depressions of the neighbouring country. The north-western extremity of these channels, that is, the openings made where the eroding instrument entered, are somewhat wider than the rest of the channel, and are rounded off, polished, and striated.

Another very curious, and, as far as I know, a new class of facts has been described by M. Durocher. These furrows, he states, are frequently met with in horizontal lines *on the under side of overhanging rocks*, and he has met with instances of this description along the Norwegian coast to beyond Drontheim, a distance from Gothenborg of more than 500 miles. One remarkable case he gives, that occurs to the north of Drontheim, where the furrows are cut horizontally in a pudding-stone rock of pebbles of granite and quartz, the hardest of which are cut through as clean as the softer argillaceous cement. The eroding tool has acted to the length of forty-five metres (about fifty yards), on a surface inclined from 45° to 50°, and with a breadth of from four to five metres (thirteen to sixteen feet). But my limits oblige me to refer you to the memoir itself, and to the report of the discussion to which it gave rise, for many most interesting facts, and some important views as to the causes of these remarkable phænomena*. For the same reason I can only very briefly allude to the descriptions contained in several parts of Mr. Lyell's 'Travels,' of the boulder formation, the erratic blocks, and the furrowed surfaces that are met with over a great part of the northern regions of North America, presenting many features identical with those of Northern Europe.

In Europe the boulder formation has not been traced farther south than 52° north latitude, but a similar kind of detritus, sand, clay, gravel, and rounded blocks of great size, cover a considerable extent of country in the neighbourhood of Boston, which is ten degrees farther south, or about the latitude of Valencia in Spain. It is not found within the range of the Alleghany Mountains; but blocks again appear on their western side, near the Ohio river, in latitude 40°, and some scattered blocks have reached Kentucky, the northern boundary of that state, in latitude $38\frac{1}{2}$°. How far a boulder formation, erratic blocks and furrowed rocks extend beyond the valley of the St. Lawrence, we have yet to learn; but the scanty information we do possess leads us to infer that they exist on the shore of the Arctic Sea.

Near Boston the boulder formation has been pierced to a depth of more than 200 feet without the solid rock having been reached; and although mainly composed of the materials of neighbouring rocks, huge rounded blocks brought from a great distance rest upon them or are buried in them. Here, as in Russia and Denmark, we have a boulder formation composed of materials that have not been far-travelled, intermixed, in some degree, with, but more frequently covered by that of northern origin. An instance of this last occurs at Brooklyn, near New York.

In the United States, Canada, and Nova Scotia, where the gravel or drift has been removed, the rock immediately subjacent is very frequently furrowed and striated, and here and there flattened domes of smoothed rock (*roches moutonnées*) are met with. The furrows have been found in the New England Hills at all heights, even to as much as 2000 feet. In one place, on the summit of a high hill of sandstone, Mr. Lyell saw an erratic block of greenstone 100 feet in circumference. The erratic blocks and boulder formation have been transported southwards along the same lines as are marked out

* Bulletin de la Soc. Géol. de France, tome iii. p. 65.

by the direction of the furrows: in New England from N.N.W. to S.S.E.; in the valley of the St. Lawrence from north-east to south-west.

With regard to evidence of the age of the boulder formation of North America, I am not aware of any having been met with that connects it with a period so early as in Denmark; it contains in many places shells identical in species with those now living in the adjoining seas. The detritus in which the bones of Mastodon are buried at Big-Bone-Lick, in Kentucky, Mr. Lyell is inclined to believe to be more modern than the northern drift.

In the last number of the 'Edinburgh Philosophical Journal' are two valuable papers relating to erratic blocks, grooved surfaces, and the action of glaciers; the one by Mr. Maclaren, to which I have already referred, the other by Professor James D. Forbes. The paper of Mr. Maclaren describes grooves and striæ which he observed last summer on the rocks on each side of the Gare Loch, in Dumbartonshire, and these, together with blocks and an accumulation of loose materials resembling a terminal moraine, appear to indicate very clearly the former existence of a glacier in the space inclosed between the hills that bound the loch. He also observed numerous rounded blocks in the same locality, which could not have been produced by the same glacier, for they consist of granite, some of great size, as much as five feet in diameter, at various heights on the hills—one on the top of a hillock, 320 feet above the loch; and no granite, no parent-rock to which they can be traced is nearer than forty miles to the north. But between the localities where they now exist and that parent-rock there are ridges, over which they must have travelled, that are 1500 feet above the present sea-level. This then is a case analogous to that of the Valdai Hills in Russia, on the southern flanks of which blocks of Scandinavian granite are scattered, indicating that these hills, and in like manner the summits of the barrier north of Gare Loch, were a sea-bottom, upon which the blocks were dropped from floating icebergs; that sea-bottom being subsequently raised, to form the existing land.

The principal object of Professor Forbes's paper is to describe the topography and geological structure of the Cuchullin Hills in Skye. He gives us much new and interesting information respecting the igneous rocks, of which they are composed, particularly that comparatively rare variety, hypersthene rock: but he also describes these same rocks as being furrowed and polished in several of the valleys, but especially in the valley of Coruisk, the furrows there radiating from a centre to the sea-shore, and, in his opinion, they demonstrate in as clear a manner as the subject admits of, the former existence of a glacier in that locality. All will admit that the opinion of Professor Forbes on this subject is one in which we may place entire confidence. The hypersthene rocks "are smoothed and shaven in a direction parallel to the length of the valley wherever their prominent parts are presented towards the head of the valley; but towards the sea, they are often abruptly terminated by craggy surfaces, showing the usual ruggedness of the natural fracture of the rock, and exhibiting the phænomenon of *Stoss Seite* and *Lee Seite*, so often described in the Scandinavian rocks."

"When the same rock is traversed by claystone veins, or by veins of crystallized hypersthene and magnetic iron, these various parts of such different hardness are all uniformly shaven over, in conformity with the general form of the mass to which they belong. This presents a striking analogy to the phænomena of polished rocks in the Alps, where the quartz veins are cut off parallel to the surface of the bounding felspar. . . . . The furrows are not confined to the entrance of the valley, but extend to the upper part of it, and to a great height above its level, particularly on the west side, where the faces of these almost vertical cliffs of adamantine hardness are scored horizontally, as potter's clay might be by the pressure of the fingers, or like the moulding of a cornice by the plasterer's tool."

The question naturally arises, at what period were these valleys in Dumbartonshire and in Skye occupied by glaciers? That they were so after the land had been formed into the present mountains and valleys is obvious; but that defines no particular period. We have in the Gare Loch two distinct classes of phænomena, which could not have been produced either by the same agents or at the same time. We have proof of the action of sub-aërial glaciers; we have also proof that there are erratic blocks that could not have been brought into their present position unless the ground on which they rest had been submerged: they were dropped, it is most reasonable to suppose, from icebergs floating in a sea, and arrested by elevations in the sea-bottom. During such submergence there could be no glaciers in the valleys of Gare Loch or Coruisk. Are we to suppose that after these valleys had been occupied by a glacier, and the erosions had been made, the land sank down, continued for a long interval as a sea-bottom, during which time the glaciers melted away, and that the land again emerged, bearing the erratic blocks upon it? The subject is one of vast difficulty; but the phænomena evidently involve great changes in the condition of the land, and consequently, perhaps, in the climate of that region.

It is an important feature in the history of the boulder formation, that the mode of its accumulation, and the direction of the channels, furrows and striæ worn in the rocks, indicate a force coming from the north between N.W. and N.E. The worn and polished surfaces of so many rocks facing the north, while their rugged unworn surfaces point to the opposite direction, are farther proofs of the same movement. The travelled rounded boulders and detritus from the middle of Sweden and Norway southward must therefore have been derived from land existing north of that latitude.

Submarine currents are by many geologists supposed to have been the moving power; and it is also said, that the detrital matter they hurried along smoothed and polished the rocks they met with in their progress, and graved the furrows and striæ. We as yet know little of the existence, at great depths, of submarine currents, or of their power of transporting heavy materials. Sir R. Murchison, referring to the generation and power of what Mr. Scott Russell calls a wave of the first order, or "the wave of translation," and to the application of Mr. Russell's researches and theory by Mr. Hopkins, in his paper "On the Elevation and Denudation of the district of the Lakes of Cumberland and Westmoreland*," considers that all the phænomena of the boulder formation and drift of Northern Europe (not including the erratic blocks) may be accounted for by the action of such waves. But a sudden paroxysmal movement of the bed of the sea is a necessary condition for the production of a wave of translation. Mr. Hopkins says, "If the elevation were sufficiently gradual, no sensible wave would result from it; but if it were *sudden*, the surface of the water above the uplifted area would be elevated very nearly as much as the area itself, and a *diverging* wave would be the consequence;" and that "there is no difficulty in accounting for a current of twenty-five or thirty miles an hour, if we allow of *paroxysmal elevations* of from 100 to 200 feet;" and he adds, that "if the extent of country be considerable, the elevation might occupy *several minutes*, and still produce the great wave above described." It is to be observed that the wave would be *diverging*, and therefore the currents would not be limited to one direction. But however great the power of transport of the sudden wave might be, its action would be transient, and we must therefore suppose, either that the whole phænomena were produced by one sudden elevation, or that there was a succession of paroxysms. Whether such sudden violent transport, such tumultuous hurrying-along of the blocks, gravel and sand, be consistent with the forms and arrangements of the detrital matter, the long "trainées," "the widely spread and finely laminated sands," and the included fragile shells, can only be determined by special observations directed to such an inquiry. It does not appear at all consistent with the formation of the detritus of local origin, that which constitutes so great a part of the boulder formation over the whole northern region, and which seems to indicate a long-continued action over the same ground. We ought, besides, to have some independent evidence of paroxysmal action in the same region; whereas there is the strongest proof of gradual upheavals: take, for example, the whole continent of European Russia, which exhibits scarcely any disruption, and which, Sir R. Murchison is of opinion, was elevated *en masse*.

But we must go further back in our inquiry; before the wave of translation was generated. Whence the detrital matter which the wave transported? Are we to suppose that the same paroxysmal movement broke up and shattered to fragments the bottom of the sea, and that it was these fragments which the transient wave transported and rounded into boulders? Or is it more reasonable to suppose, that the materials of the detritus must have been derived from pre-existent land, the rocks of which were broken by glacial and atmospheric action, as rocks now are, to be afterwards rolled, rounded and polished by currents of water; as they unquestionably must have been, however the currents may have been produced?

* Proc. Geol. Soc. vol. iii. p. 757.

Then as to the power of such currents, transporting hard bodies, to produce the furrows and striæ, I should be disposed to refer to the *physicien*, to him conversant with the laws of mechanical philosophy, the questions whether rounded blocks and gravel, *moving in water*, passing over rocks, would be capable of producing on them these deep furrows and striæ; or whether it is not more probable that they were worn by angular fragments of rock held fast in ice, and pressed, as the current floated the iceberg, against the opposing rock, with a vast force derived from the weight of the mass?

We learn from the 'Magazine of Natural History' of last September, that letters had been received the preceding month from Mr. Harry Goodsir, attached, as Naturalist, to the Arctic Expedition under the command of Sir John Franklin, dated from Disco in Baffin's Bay the 7th of July last; and it is stated that "Mr. Goodsir is making minute observations upon the ice of the bergs, and as he purposes continuing them throughout the voyage, there can be little doubt of his arriving at valuable conclusions." It is added, "We also find some observations upon the action of floating ice upon the *granitic* shores of the islands. *All the rocks below high-water mark, and some considerably above it, are rounded off into long irregular ridges with intervening hollows by the half-floating masses of ice.*"

Palæontology.

This great department of Geology is now cultivated with so much industry by so many naturalists in Europe and America, that scarcely a month elapses without some valuable additions to our knowledge. It is not possible for me to do more than briefly refer to some of the more important of those which I have had an opportunity of becoming acquainted with.

At the last Meeting of the British Association at Cambridge, Professor Edward Forbes made an interesting and important communication to the Natural History Section, in which he pointed out a connexion of the present distribution of plants with geological changes which took place during the later tertiary periods. He maintains, for example, that the existing flora of Britain belongs, not to the present epoch only, but is composed in part of the remains of the floras of the pliocene and post-pliocene periods. He considers that certain peculiarities of the vegetation of the west of Ireland depend on an ancient geological connexion with the Asturias; those of the Scottish and Welsh mountains on the migration of plants from Scandinavia during the glacial period, and the subsequent upheaval of the land, and consequent change of climate; whilst the great mass of the British flora migrated across the upheaved bed of the Pleistocene sea. He further holds, that the determination of the date of the migrations of terrestrial plants and animals will eventually aid in fixing the periods of many geological events.

In the year 1828, M. Elie de Beaumont published in the 'Annales des Sciences Naturelles' an account of some observations he had recently made at Petit-Cœur, a village in the Tarentaise, east of Chambery; where he had seen resting on talcose gneiss and hornblende schist, a series of sedimentary beds, which prevail over a great extent of that country, the lowest of which, a micaceous sandstone alternating with a black slaty rock, is surmounted by a bed of fissile argillaceous limestone containing Belemnites, and this last passes insensibly into a black slaty clay containing impressions of plants identical in species with some of those belonging to the true coal formation. M. de Beaumont concludes his detailed description in these words:—" Il me parait donc incontestable que le système de couches qui, à Petit-Cœur, contient les Belemnites et les impressions végétales, et qui s'enfonce sous toutes les autres couches non-primitives de cette partie des Alpes, *appartient à la formation du lias.*" The plants were carefully examined by M. Adolphe Brongniart, and in an accompanying memoir descriptive of them he states, " que l'identité la plus parfaite existe entre ces plantes et celles du terrain houiller, tandis qu'il n'y a aucun rapport entre elles et celles qui se trouvent habituellement dans le lias, ou dans les terrains oolitiques." He enumerates among others of Petit-Cœur, *Neuropteris tenuifolia,* found at Liege and Newcastle; and *Pecopteris polymorpha,* one of the most common in the coal-fields of France.

At the meeting of the Geological Society of France at Chambery in autumn 1844, an account of which we have received since our last Anniversary*, the attention of the members was directed to this most remarkable fact, in a memoir by M. Rozet; and afterwards, several who attended the meeting visited Petit-Cœur. The observations of M. Elie de Beaumont and M. Adolphe Brongniart were confirmed in every particular; they found abundance of the vegetable remains, and of Belemnites below them. The report farther states:—" Il a été évident aussi, pour tous les membres de la Société, que l'on ne peut aucunement admettre l'explication d'un plissement qui aurait rapproché les fossiles de deux formations et produit une alternance apparente entre les couches à Belemnites et les couches à empreintes. Ce sont les mêmes schistes et la même formation qui renferment ces deux genres de fossiles que l'on avait cru pendant longtemps appartenir à des époques géologiques très éloignées l'une de l'autre." M. Sismonda, who was present, stated, that in another locality he had found Ammonites in a prolongation of the same bed; and in reply to M. Agassiz, also present, affirmed, that he had found this bed containing Belemnites and coal-plants over an extent of from twenty-five to thirty leagues. We have thus the same species of plants continuing to exist throughout the whole Carboniferous, Permian and Triassic periods, and into that of the lower portion of the oolite age. I need not say how important a bearing this remarkable fact has on the theories of climate, and of the prevalence of an atmosphere loaded with carbonic acid gas during the Carboniferous period.

M. Adolphe Brongniart, in his memoir above cited, thus accounts

* Bulletin de la Soc. Géol. de France, vol. i. new ser. p. 601.

for the anomalous position of these coal plants; "À l'époque où la formation du lias se déposait en Europe, notre globe présentait très-probablement deux régions très-diverses par leur climat et par les végétaux qui y croissaient. L'une comprenait l'Europe et peut-être toute la zône tempérée, et était habitée par des végétaux fort différens de ceux qui y croissaient à une époque plus reculée, et qui avaient donné naissance aux couches de houille; l'autre s'étendant sans doute sur les parties plus chaudes du globe, était encore couverte des mêmes végétaux qui, dans des temps plus anciens, avaient habité la région européenne, et formé les dépôts houillers. Les végétaux de cette partie du globe pouvant dans certaines circonstances, être transportés dans les régions plus tempérées, auraient donné lieu à ces anomalies apparentes que présentent les terrains d'anthracite des Alpes qui, d'après les observations géologiques et zoologiques, appartiennent à l'époque de formation du lias, et dont les végétaux sont cependant les mêmes que ceux du terrain houiller." This theory therefore admits that the same species of plants existed through the whole series of ages that passed from the time of the deposition of the carboniferous series to that of the lias; that they and Belemnites were co-existing, but in different regions. It is not very easy to conceive how such delicate vegetable bodies should be drifted the vast distance between a tropical and temperate zone, to form parts of thin continuous strata thousands of square miles in extent, in successive layers of great thickness on the same spot, in the depths of the sea.

It is extremely improbable that this case in the Tarentaise is a solitary one; future researches will probably bring to light other instances of a similar kind. May not these facts be an extension to plants of the recently advanced doctrine regarding animals, that species which have had a wide range in space have also had a long duration in time? or as it is expressed by those who first brought it forward,—"That the species which are found in a greater number of localities and in very distant countries are almost always those which have lived during the formation of several successive systems." The attention of geologists, I believe, was first directed to this highly important observation by Viscount d'Archiac and M. de Verneuil, in their joint paper "On the Fossils of the older Deposits of the Rhenish Provinces," read before this Society in December 1841; and while these distinguished geologists announced the law as applicable to the oldest fossiliferous beds, Professor Forbes has shown the extension of it to existing species. He found "that such of the Mediterranean testacea as occur both in the existing sea and in the neighbouring tertiaries, were such as had the power of living in several of the zones in depth, or else had a wide geographical distribution, frequently both." He adds, "The same holds true of the testacea in the tertiary strata of Great Britain. The cause is obvious: such species as had the widest horizontal and vertical ranges in space, are exactly such as would live longest in time, since they would be much more likely to be independent of catastrophes and destroying influences than such as had a more limited distribution." Now we know

P 2

that the same species of plants are found in the coal-fields belonging to the palæozoic carboniferous rocks of Europe and of North America, and in regions with differences of more than thirty degrees of latitude; and therefore they may have been able to live through the many vicissitudes of condition of the earth's surface that must have occurred between the Carboniferous and Liassic periods.

The plants from the Permian system of Russia, collected by Sir R. Murchison and his fellow-travellers, have been described by Mr. Morris, and further illustrated by the remarks of M. Adolphe Brongniart. The species are few, not exceeding sixteen in number. Three of these—*Neuropteris tenuifolia*, *Lepidodendron elongatum* and *Calamites Suckowii*—are pronounced by M. Brongniart to be identical with plants of the coal formation. The remainder are peculiar (as far as is hitherto known) to the Permian system. All the *genera* are common to this and to the carboniferous series; the genera *Odontopteris*, *Noeggerathia* and *Lepidodendron* had been hitherto supposed peculiar to the coal-measures. Altogether, the Permian flora is evidently much more similar to that of the carboniferous system than to any other: it has no affinity to that of the Grès bigarré, or of the Jurassic system.

Mr. Morris has likewise described the fossil plants brought by Count Strzelecki from the coal-fields of New South Wales and Van Diemen's Land. Unfortunately the materials were very scanty, the number of species being only eight; and it is singular, that of this number four are from the coal-field of New South Wales, and four from that of Van Diemen's Land, no one species having been found common to the two. Both these Australian coal-fields are very remarkably distinguished from those of Europe and North America by the entire absence of *Stigmariæ*, *Sigillariæ*, *Lepidodendra*, and *Calamites*. In this respect they agree with the coal formation of Burdwan in Northern India, to which indeed they have other points of striking similarity in the character of their vegetable remains. The *Glossopteris Browniana* is actually common to the coal formations of New South Wales and of India, and the *Pecopteris australis* of the former country comes very near to the Indian *P. Lindleyana*. The flora of the coal-fields of Australia has likewise a striking similarity to that of our Yorkshire oolites. *Glossopteris Browniana* is nearly allied to *Glos. Phillipsii*, *Pecopteris australis* to *P. Whitbiensis*, and *Pecopteris alata* to *P. Murrayana*. It is possible that the coal of Australia and of Northern India may really belong to the Jurassic system.

In the 'Geology of Russia,' a work I have already so often referred to, there is an immense mass of valuable contributions to palæontology, by different distinguished naturalists. The following are the parts which relate to the Invertebrata:—

1. A very elaborate and important essay by Mr. Lonsdale on the palæozoic Corals of Russia, abounding in minute details of structure, deserving the attention of every one engaged in the study of that class of organic bodies.

2. A full synopsis of the palæozoic Radiata, Articulata and Mollusca, by M. de Verneuil. The species are all admirably described, and full details of great interest are given respecting their affinities, synonyms, and distribution. A great number of new and curious forms are made known for the first time. In that part which treats of the Brachiopoda, M. de Verneuil has given the results of a critical investigation of the genera, accompanied by tables of characters of the greatest value. He has constituted a new genus, *Siphonetreta*, for the reception of certain very curious fossils, which, while presenting much of the form of *Terebratulæ*, are really allied to *Orbiculæ*, and have the same corneous texture of shell. Among the palæozoic *Acephala*, he has described a well-marked species of *Astrea*, a genus hitherto having only doubtful claims to such high antiquity. Among the *Gasteropoda*, *Ianthina* for the first time appears as a palæozoic genus.

In the account of the *Radiata* are interesting descriptions and comments on the Russian species of *Cystideæ*. Among the *Articulata* is the genus *Fusulina*, a foraminiferous animal abounding in certain beds of carboniferous limestone in Russia. Hitherto, traces of such animals in such ancient beds have been few and imperfect.

3. The Jurassic, cretaceous, and tertiary mollusca are described in full detail by M. d'Orbigny, and their synonyms carefully elaborated,—a service for the rendering of which we cannot be too thankful, since duplicate names have accumulated to a most confusing extent. As an instance, it may be mentioned that M. d'Orbigny enumerates as synonyms of the *Ammonites Jason* of Zieten, no less than fourteen distinct names.

The plates throughout are admirable.

The history of fossil radiate animals has received one of the most important additions ever made to it, in the memoir of M. von Buch on the *Cystideæ*; a memoir of the greatest value to the naturalist, since it furnishes him with an elaborate and philosophical exposition of the organization and affinities of a group of fossil animals hitherto misunderstood, and which fill up a blank in the series of Radiata. As these fossils are now known to be by no means unfrequent in the British palæozoic strata, though they have hitherto attracted but little attention, the study of the paper, itself a model of palæontological description, will well repay the attention of geologists. They will find it at full length, translated by Professor Ansted, in the last number of our Journal; and I may adduce it as an instance of the valuable assistance which we afford to the geologists of this country, by devoting a portion of our Quarterly publication to original foreign memoirs; for how few there are who can have an opportunity of seeing the 'Transactions of the Berlin Academy,' to say nothing of those who do not read German!

M. Agassiz, that most indefatigable of living naturalists, besides his important contributions during the last year in that department in which he is universally acknowledged to occupy the highest rank, has commenced a new series of essays under the title of '*Iconographie des Coquilles Tertiaires reputés identiques avec les espèces vivantes, ou dans différens terrains de l'époque tertiaire.*' In the preface to the first part he announces his views and object. He says that he has been long convinced that the greater number of identifications of tertiary shells with those of other tertiary epochs, or with recent species, are incorrect. From his investigations he is led to maintain, 1st, that notable differences exist between living and tertiary species; and 2ndly, that in the tertiary formations the different stages present distinct faunæ. He opposes classification founded on *per-centages* as purely artificial, and attributes the errors to the mistaking analogues for true identifications. He holds that each geological epoch is characterized by a distinct system of created beings (the results of a new intervention of creative power), including not only different species from those of the preceding system, but also new types. At the same time he admits that the "reiterated intervention of the creative power" does not necessarily and absolutely imply a specific difference between the beings of different deposits. He holds however the probability of such a difference existing, and his object in this 'Iconographie' is to prove that such difference has been overlooked. He goes the length of saying, that, even when species are, so far as the eye can judge, identical, they may not be so. "Perhaps," he says, "there may exist species so nearly allied, as to render it impossible to distinguish them; yet even that would not be to my eyes a proof of their identity; it would only prove the insufficiency of our means of observation:" and further, "the animals might differ though the shells are like."

In the special part of his essay, M. Agassiz proceeds on the position that the law of variation is not the same in all classes, families and genera; and selects his examples from certain genera of Acephalous Mollusca in which the characters are very constant, viz. *Artemis*, *Venus*, *Cytherea*, *Cyprina* and *Lucina*, on thirty-one forms of which genera, considered by him as distinct species, he gives full comments and valuable details. One species only among them, the *Cyprina islandica*, he admits to be at the same time recent and fossil.

M. Agassiz introduces the same doctrine in his Monograph of the Fishes of the Old Red Sandstone. Thus he says, at page xi, that the characteristic fossils of each well-marked geological epoch are the representatives of so many distinct creations, and affirms that he has demonstrated "*pour un nombre assez considérable d'espèces*," that the presumed identifications are exaggerated approximations of species resembling one another, but nevertheless specifically distinct.

Whether species of Mollusca hitherto deemed common to two or more of the tertiary periods be really, as M. Agassiz affirms, distinct, is a doctrine that must await the concurrence of experienced conchologists before it can be made the means of overthrowing present generalizations, and the basis of new ones. With regard to the Mammalia, certain eocene forms have been repeatedly recognised in miocene strata, and the continental miocene Mastodon has been satisfactorily determined as a fossil of our older pliocene (Norwich Crag). But M. Agassiz is peculiarly unfortunate in citing Dr. Falconer and Major Cautley (p. xi) as supporting, by their discoveries of fossil animals in the Sub-Himalayan Mountains, his views as to marked distinctions of the tertiary fauna, since they have done more than any other palæontologists to prove the progressive and undistinguishable blending of eocene into miocene, and this into pliocene, by the mammalian fossils, and have shown that some species of reptiles actually exist at the present day which were coeval with the Himalayan Anoplothere, Mastodon and Hippopotamus.

The attention of several distinguished naturalists has lately been directed to the investigation of the structure and classification of Trilobites. A valuable work on these singular extinct crustacea has been lately given to the world by Professor Burmeister, who is now revising an English translation of it, to be published by the Ray Society. In this work there is a systematic arrangement of all the species known to the author, and there are dissertations of great value on their organization. M. Emmerich has also published a very important memoir on the structure of Trilobites, a translation of which has lately appeared in Mr. Taylor's 'Scientific Memoirs.' In Sweden, Professor Löven, a naturalist distinguished for his researches among the invertebrate animals, has commenced the investigation of the Trilobites of that country with great success. His papers may be found in the Proceedings of the Swedish Academy for 1844 and 1845. All the memoirs now enumerated are illustrated by excellent plates. Lastly, in the 'Geology of Russia' will be found an interesting note on the affinities of Trilobites, by Professor Milne Edwards.

In what I have said of the accessions during the last year to our knowledge of the Devonian rocks, I have referred to the Monograph by M. Agassiz of the Fishes of the Old Red Sandstone, which those most capable of appreciating its value consider as one of his most important works; and I have reason to know that he himself views it in that light. I again refer to it in this place on account of some peculiar views there developed which I do not find altogether assented to by those whose judgements on this subject are much looked up to.

M. Agassiz states, p. xxx, "que les poissons de l'Old Red représentent, *par leur structure toute particulière*, l'age embryonique du règne des poissons." A part of the peculiar structure which he especially dwells upon is, "le développement extraordinaire que présente le système cutané;" but he acknowledges that "malheureusement nous n'avons pas encore des termes de comparaison avec les poissons de la création actuelle assez nombreux pour apprécier la valeur de ces caractères." Another feature of the peculiar structure which he points out is the continuity of the vertical fins. This character, however, Sir Philip Egerton and Professor Owen inform me, is only of partial application; the family of *Cephalaspides* he does not cite, but in *Coccosteus*, the sole form of Old Red fishes in which vertical fins have been observed, the distance between them is considerable. In the *Dipterians*, *Dipterus* has these organs very close, but in *Diplopterus* and *Osteolepis* they have considerable intervals between them. *Diplopterus* moreover occurs in the coal-measures. In the *Cœlacanths* the fins of *Glyptolepis* are very near each other, but this family runs into the chalk. In the *Acanthodians* the fins are quite distinct, and *Acanthodes* is found in the coal-measures. There are also recent fishes with their vertical fins quite as little distinct as in the most exaggerated of the Old Red. Neither is the heterocerque tail a character peculiar to the fishes of the Old Red, for all the fishes older than the lias have this form, as have the Sturgeons of the present day; and it is perhaps more important to find, that certain highly characteristic genera of the Old Red, for example, *Pterichthys*, *Pamphractus* and *Coccosteus*, did not possess the heterocercal tail.

Another character, viz. the flattened form of head, is not peculiar to the Old Red, for the *Siluridæ* and other recent fishes have this character equally prominent. Then the non-development of the vertebral column is found in the Sturgeon, Lamprey and other recent fishes. Persons seeking for support to the theory of progressive development might, on a hasty perusal of this work, find sentences in favour of their views; but the above facts are irreconcilable with the theory as ordinarily promulgated, and it would be a perversion of M. Agassiz's undoubted opinions to quote detached sentences from his writings in support of that doctrine. They will find for instance, at p. 23, a rectification of the error committed by the ingenious Hugh Miller, in describing the jaws of the *Coccosteus* as being vertical, like those of crustacea, and thence inferring that "it seems to form a connecting link between two orders of existences;" M. Agassiz having proved that they are horizontal, and move vertically, as in other true fishes. Then there are four species of Sharks of the Cestracion division in the Devonian rocks of Russia, and the squaloid fishes of the present day offer the highest organization of the brain and of the generative organs, and make in these respects the nearest approach to the higher vertebrate classes.

The work of Professor Owen on the fossil remains of Mammalia and Birds found in the British Islands, which has been for some time in course of publication, is now completed, the concluding part having been published within the last few days. This valuable contribution to palæontology, in which it is the purpose of the author "to deduce from these remains, by physiological comparisons, the living habits of the extinct species, to trace out their zoological affinities, and to indicate their geological relations," is another gift in the last year for which geologists are indebted to the British Association. Professor Owen in his preface states, that the special researches which have enabled him to fulfil in any degree the above-mentioned design, were begun by the desire, and have been carried on chiefly by the liberal aid of that body.

The concluding part contains a very interesting and instructive introduction, which will enable the reader to follow with far greater pleasure, and more fully to appreciate the value of the special details which follow. He begins by pointing out that first trace of the creation of mammalian quadrupeds which was discovered in the Stonesfield slate of the oolitic series, and it was certainly a most fortunate accident which brought these minute bones within the sight of a geologist. It is a very remarkable circumstance, that all the researches of geologists, multiplied as they have been since that discovery was made, have not yet brought to light another fragment of the same order of animals, throughout the vast series of deposits, the immense duration of time, that intervened between the Stonesfield slate and the eocene tertiary deposits; notwithstanding that there are indubitable proofs of the existence during that interval of extensive continents, of forests growing on that land, of its being tenanted by other races of animals, and that birds and pterodactyls spread out their wings in the air above it.

The land that supported the mammalia whose remains are found in the eocene deposits of our island must have been submerged, and must to a great extent have remained so during the miocene period, when the adjoining continent was inhabited by the animals whose remains have been disinterred there from the deposits of the miocene age; for it is in pliocene and post-pliocene deposits that the mammalian remains in the British Islands next present themselves. There is the most conclusive proof that the animals lived and died, generation after generation, for a long succession of years, in the land where their remains are now found; evidence which completely "refutes the hypothesis of their having been borne hither by a diluvial current, from regions of the earth where the same genera of quadrupeds are now limited. The very abundance of their fossil remains in our island is incompatible with the notion of their forming its share of one generation of tropical beasts drowned and dispersed by a single catastrophe."

The author ably discusses the question how the various members of that ancient fauna came into this island. Other and independent geological proofs show that the British Islands were united with the continent when it received its pliocene mammalia, and the zoologist finds the known habits and powers of these mammalia to be in accordance with that configuration of the land. He then considers the no less important question, although it is one more difficult of solution—by what processes they became extinct? The subterranean movements which separated our islands from the continent, and submerged other parts of these islands, must have produced such changes in the means of subsistence and powers of migration of these animals as must have been one great cause of their diminution and eventual extinction; the loss of a sufficient supply of vegetable food for the greater herbivorous quadrupeds, and, by their diminished numbers, the want of support for the larger carnivora which preyed upon them. He enumerates other causes which must have operated for a long period before the agency of man aided the work of extinction. He adduces many most curious and interesting particulars in illustration of the laws by which the geographical distribution of the mammalia of the pliocene and post-pliocene periods generally appear to have been determined; showing that, "with extinct as with existing mammalia, particular forms were assigned to particular provinces, and, what is still more interesting and suggestive, that the same forms were restricted to the same provinces at the pliocene period as they are at the present day."

In this work eighty species of British fossil Mammalia are described, of which the following (forty-two in number) were either originally determined by the author as new species, or were first recognised by him as occurring in a fossil state. They were for the most part described in the publications of this Society.

Amphitherium *Broderipii.*
Arvicola *agrestis.*
——— *pratensis.*
Balæna *affinis.*
——— *definita.*
——— *emarginata.*
——— *gibbosa.*
Balænodon *physaloides.*
Bison *minor.*
Bos *longifrons.*
Cervus *Bucklandi.*
——— *Tarandus.*
Chæropotamus *Cuvieri.*
Coryphodon *eocenus.*
Dichobune *cervinum.*
Equus *plicidens.*
Felis *pardoides.*
Hyracotherium *leporinum.*
——— *cuniculus.*
Lagomys *spelæus.*
Lophiodon *magnus.*
Lophiodon *minimus.*
Lutra *vulgaris.*
Macacus *eocenus.*
——— *pliocenus.*
Machairodus *latidens.*
Meles *taxus.*
Palæotherium *magnum.*
——— *crassum.*
——— *minus.*
Palæospalax *magnus.*
Phascolotherium *Bucklandi.*
Phocæna *crassidens.*
Physeter *macrocephalus.*
Rhinolophus *ferrum-equinum.*
Sorex *vulgaris.*
Strongyloceros *spelæus.*
Talpa *vulgaris.*
Trogontherium *Cuvieri.*
Ursus *priscus.*
Vespertilio *vulgaris.*

Of the eighty species described in this work,
Three are of Oolite antiquity;
Twenty from Eocene tertiary strata;
Five from the Miocene Red Crag;
Fifty-two from the older and newer Pliocene freshwater and drift formations.

Of the newer Pliocene species of fossil Mammalia, seventeen became extinct before the historic period, viz.—

Macacus pliocenus.
Palæospalax magnus.
Ursus priscus.
—— spelæus.
Hyæna spelæa.
Felis spelæa.
Machairodus latidens.
Trogontherium Cuvieri.

Lagomys spelæus.
Elephas primigenius.
Rhinoceros tichorhinus.
———— leptorhinus.
Equus plicidens.
Hippopotamus major.
Megaceros Hibernicus.
Strongyloceros spelæus.
Cervus Bucklandi.

Five species came down to the age of tradition or history, and have been extirpated in England, viz.—

Canis lupus, Wolf.
Castor Europæus, Beaver.
Cervus Tarandus, Reindeer.
Bison priscus, Aurochs.
Bos primigenius, or great Urus. This species is also extinct on the continent.

Twenty-six of the Mammalia whose fossil remains testify to their co-antiquity with the Mammoth, still exist in England as well as on the continent of Europe, viz.—

Vespertilio noctula, } Bats.
Rhinolophus ferrum-equinum, } Bats.
Sorex, Shrew, three species.
Meles taxus, Badger.
Putorius vulgaris, Polecat.
——— ermineus, Stoat.
Lutra vulgaris, Otter.
Canis vulpes, Fox.
Felis catus, Wild Cat.
Mus rattus, Black Rat.
—— musculus, Mouse.
Arvicola, Vole, three species.
Lepus timidus, Hare.
Lepus cuniculus, Rabbit.
Equus caballus, Horse.
——— asinus, Ass.
Sus scrofa, Hog.
Cervus elaphus, Red Deer.
——— capreolus, Roe.
Capra hircus, Goat.
Bos longifrons (probable source of the Highland cattle).
Physeter, Sperm Whale.
Balænoptera.
Balæna mysticetus, Whalebone Whale.

You cannot but remember the great interest that was excited when Dr. Royle, in March 1836, communicated to this Society a paper by his friends Captain Cautley and Dr. Falconer, then resident in India, on the remains of Mammalia found in the Tertiary formations of the Sewalik Mountains, at the southern foot of the Himalayas, between the Sutlej and the Ganges; discoveries deemed so important, that the Council, at the following anniversary, awarded a Wollaston Medal to each of these gentlemen. Besides the paper by Captain Cautley, published in the fifth volume of our 'Transactions,' numerous details respecting these discoveries are contained in the 'Asiatic Researches,' and in the 'Journal of the Asiatic Society of Bengal.' A magnificent donation of these remains, contained in more than two hundred chests, was made by Captain Cautley to the British Museum, and a work of immense labour and research has been undertaken by Dr. Falconer, to describe, in conjunction with his friend, now Major Cautley, these very interesting remains. Her Majesty's Government and the Directors of the East India Company have supplied funds in aid of the successful progress of the work. The first part has just appeared; it bears the title of '*Fauna*

Antiqua Sivalensis,' and consists of twelve folio plates, and sixty-four pages of 8vo letter-press. Nothing has ever appeared in lithography in this country at all comparable to these plates; and as regards the representations of minute osseous texture by Mr. Ford, they are perhaps the most perfect that have yet been produced in any country.

The work has commenced with the Elephant group, in which, they say, "is most signally displayed the numerical richness of forms which characterizes the Fossil Fauna of India," and the first chapter relates to the PROBOSCIDEA—Elephant and Mastodon. The authors have not restricted themselves to a description of the Sewalik fossil forms, but they propose to trace the affinities, and institute an arrangement of all the well-determined species in the family. They give a brief historical sketch of the leading opinions which have been entertained by palæontologists respecting the relations of the Mastodon and the Elephant to each other, and of the successive steps in the discovery of new forms which have led to the modifications of these opinions. They state that the results to which they themselves have been conducted, lead them to differ on certain points from the opinions most commonly entertained at the present day respecting the fossil species of Elephant and Mastodon. As they differ in their conclusions from those of Cuvier, De Blainville and Owen as to specific differences, you will readily conclude that the proof they adduce rests upon nice distinctions in anatomical structure; to enter upon which would be quite unsuitable on the present occasion, by even the most competent to judge of questions in which such high authorities disagree.

CONCLUSION.

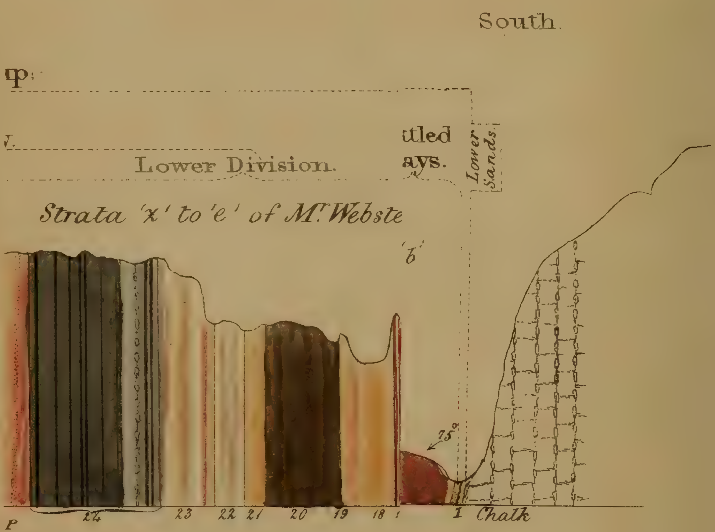
Although this Address has extended to so great a length, those who are actively alive to what is going on in the several departments of Geology will have found many important works of the past year unnoticed, many topics of interest left untouched. This would not have been the case to so great an extent, if I had had more time at my disposal. Even with the opportunities I have had, I might have briefly noticed a greater number of books published in our own and in foreign countries, and memoirs contained in Journals and Transactions; but I confess to yielding to an inclination to dwell upon topics that have more particularly attracted me in my past geological studies.

It is highly gratifying to see so much activity in the cultivation of our science in almost every part of the civilized world; and still more satisfactory to observe, that it has been for some time past pursued in a better spirit, with a disposition to greater accuracy and rigour in investigation, and with a more strict adherence to the rules of philosophical inquiry. When we contrast the state of Geology now with what it was when this Society was established, or compare the then limited extent of our knowledge of Palæontology with the wide range it now takes, and when we think of the crude hypotheses and hasty generalizations, founded on the most scanty and imperfect observations, which were then misnamed science, we may well look back with satisfaction to the work of the last thirty years, to which this Society has contributed no inconsiderable share.

It has hitherto too frequently happened that geologists have dealt with important questions of physics, chemistry, comparative anatomy, zoology, or botany, without an adequate acquaintance with the principles and known laws of the science essentially involved in the question; now, unless our conclusions will bear the test of the most strict examination by those who are acknowledged authorities in the particular science, it is obvious that we cannot make any secure progress. The study of Geology, more perhaps than that of any other branch of natural science, has a tendency to create a disposition to theorize; this disposition, however, if kept within due bounds, is rather to be encouraged than repressed, for it has often proved a stimulus to accurate observation; and to arrive at a knowledge of a true theory of the earth, is, in truth, the great aim of our inquiries. But we must carefully guard against the error which the earlier geologists too frequently fell into, of quitting the sober path of inductive philosophy, and wandering into the regions of imagination. We must indulge in no theory that is not in accordance with laws of nature of which we have had experience, or which may be fairly inferred from that experience, although the operations we seek to explain may have been on a greater scale than any of which we have certain knowledge. The cautious and accurate Playfair was wont to inculcate upon those who studied in the school of Hutton, the warning of the noble aphorism with which Bacon opens his great work, the 'Novum Organum,'—an aphorism which every geologist will do well to bear in mind when he ventures to theorize on causes:—"*Homo, naturæ minister et interpres, tantum facit et intelligit, quantum, de naturæ ordine, re vel mente observaverit; nec amplius scit, aut potest.*"

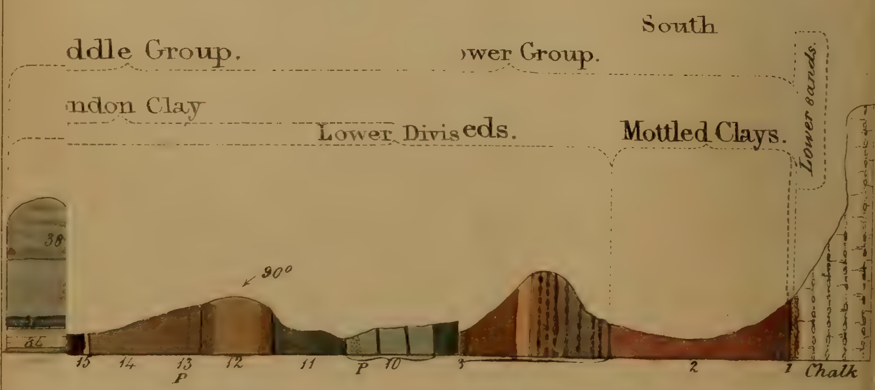
Fig

OF WIGHT.



Fig

Y, ISLE OF WIGHT.



Reeve, E.

J. Prestwich Jun.r del.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

February 25, 1846.

G. E. H. Vernon, Esq., and Julius Jeffreys, Esq., F.R.S., were elected Fellows of the Society.

The following communications were read:—

1. *On the* Tertiary *or* Supracretaceous Formations *of the* Isle of Wight *as exhibited in the Sections at* Alum Bay *and* White Cliff Bay. By Joseph Prestwich, Jun., Esq., F.G.S.

Plate IX.

In the London tertiary district there are but few good sections of the middle and upper Eocene strata; and there is no part of it in which the order of superposition is so well shown, or can be so conveniently studied, as in the coast sections of Hampshire and of the Isle of Wight. Owing to this better and more permanent stratigraphical evidence, it may be desirable, before treating of the London tertiaries, to fix the subdivisions of the contemporaneous Hampshire series, in order that they may serve as types and points of reference. I therefore beg to submit to the Society the following observations made in the autumn of 1839, which I should have brought forward at an earlier period, had I not hoped to have rendered them more complete by a further examination of the district, which however I have not had leisure since to resume.

Fig. 1

SECTION OF ALUM BAY, ISLE OF WIGHT.

Eocene Series

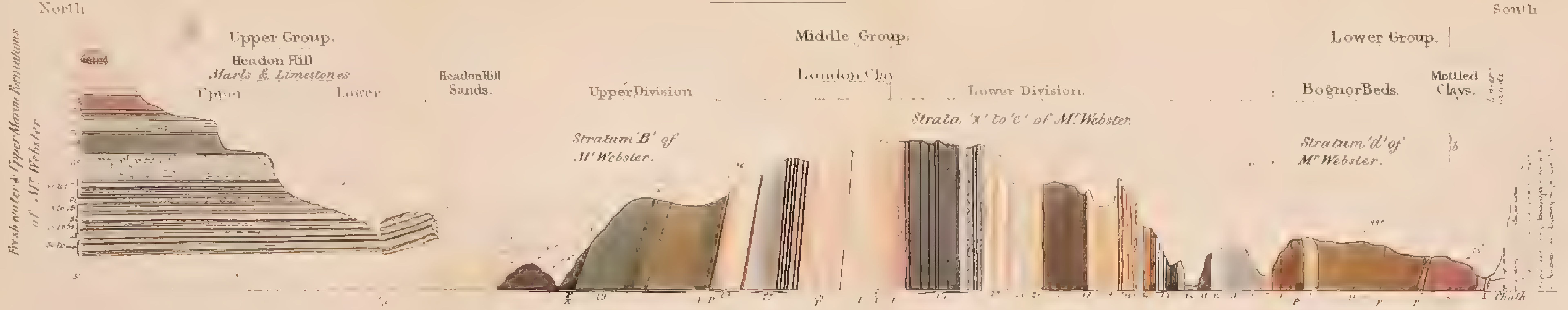
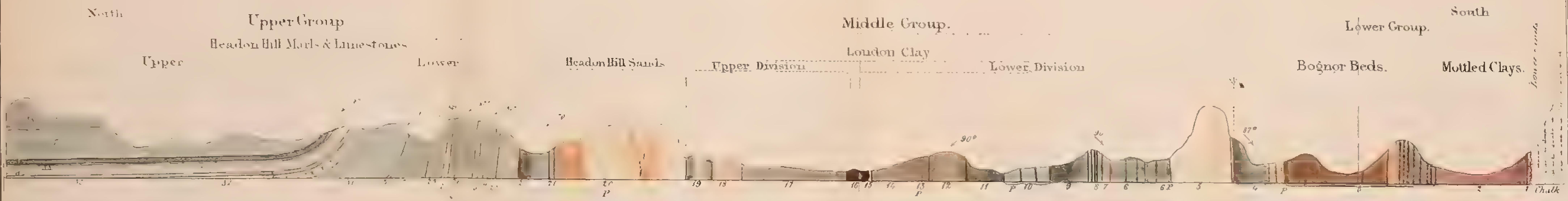


Fig. 2

SECTION OF WHITE-CLIFF BAY, ISLE OF WIGHT.

Eocene Series.



Scale, 1 Inch = 150 feet.

Ruse Brothers Lithographers King William Street, Strand

The general details of this subject are well known. I will briefly note the results obtained by former observers, and then examine in succession the development and nature of the organic remains, conjointly with the changes of lithological characters and of dip, and I hope these may tend to remove some of the uncertainty and doubt which seem still to exist, particularly on the continent, on the subject of the fauna of these strata, and on the period of the disturbance by which they have been affected. Their age and synchronism with the Paris groups also require, I think, some material revision.

In 1766 Brander* published his descriptions and beautiful drawings of the London clay fossils of Barton and Hordwell Cliffs.

In 1802 Sir Henry Englefield† noticed the disturbance affecting the chalk and adjacent strata of the Isle of Wight.

In 1803 Lamarck‡ inferred, from a comparison of the fossils of the calcaire grossier of Grignon and Courtagnon with those figured by Brander, that these beds were of the same geological epoch.

In 1811 Dr. Berger§ gave several good mineralogical details and barometrical heights of parts of Hampshire and Dorsetshire, but his geological descriptions are defective.

In 1813 Mr. Webster|| detected the analogy of the geological structure of the tertiary rocks of the Isle of Wight with those described by Cuvier and Brongniart in the neighbourhood of Paris, and, following their classification, he grouped them into the formations of—1, sands and plastic clay; 2, London clay; 3, lower freshwater; 4, upper marine, and 5, upper freshwater.

In 1816 Dr. Buckland¶ noticed the strong resemblance between the London and Hampshire basins, inferred their former continuity, and traced the range of the plastic clay in the Hampshire basin.

In 1816 Sir Henry Englefield** published some excellent coast sections of the Isle of Wight and Dorsetshire, after drawings by Mr. Webster, who in the text gave a further geological description of the island. He states that in the lower dark brown clay (stratum *d*) of Alum Bay he found fossil shells, but he considered them as rather resembling those of the Woolwich beds than of the London clay. He did not consider the evidence that the elevation of the London clay took place prior to the deposition of the freshwater formation quite conclusive, but expressed his willingness to admit of any modification in his views which subsequent discoveries might render necessary.

In 1821 Mr. Webster†† gave an account of Hordwell Cliff and its freshwater beds.

In 1821 Mr. G. Sowerby‡‡ pointed out the occurrence of London clay fossils and Septaria in stratum "*d*" of Mr. Webster's section of

* Fossilia Hantonensia.
† Trans. Linnean Soc. vol. vi.
‡ Annales du Muséum, tom. i.
§ Trans. Geol. Soc. vol. i. p. 249.
|| Trans. Geol. Soc. vol. ii. p. 161.
¶ Ibid. vol. iv. p. 276 to 304, and 2nd Series, vol. ii. part i. p. 119.
** Sir H. Englefield's Isle of Wight.
†† Trans. Geol. Soc.
‡‡ Annals of Philosophy, vol. xviii. p. 216.

Alum Bay, and of the mixture of freshwater and marine shells in the so-called upper marine formation, which he considered to be of estuary origin. The sands, plastic clay, and London clay, he groups in one formation.

In 1822 Professor Sedgwick* confirmed the general correctness of the divisions introduced by Mr. Webster, and noticed that in stratum "*d*" the fossils rather resembled those of the Bognor rocks than those of Barton Cliff; he also found marine shells in the most northern vertical strata of White Cliff Bay agreeing in character with those of the sandy and overlying beds, which repose upon the London clay at Hordwell Cliff. In this notice Professor Sedgwick gave a detailed account of the nature and range of the freshwater beds over the north of the Isle of Wight, and showed the mixture and passage of the marine and freshwater exuvia, and the passage of indurated calcareous marls into clays and argillaceous marls.

In 1822 Dr. Mantell† noticed the great extent of the Bognor rocks, described their organic remains, and gave full details of the Newhaven plastic clay beds.

In 1824 Dr. Buckland‡ announced the discovery by Mr. Allan of the remains of the "*Anoplotherium commune*" in the lower freshwater limestone of Binstead.

In 1826 Mr. Lyell§ gave a detailed account of the beds underlying the London clay between Muddiford and the chalk at Stutland, and also of the beds above the London clay at Hordwell Cliff. He showed the paucity of organic remains in the former, and their great abundance in the latter, which he considered to belong exclusively to the lower freshwater formation.

In 1829 Mr. P. J. Martin || contributed some interesting observations on the anticlinal line of the London and Hampshire basins.

In 1830 Mr. Pratt¶ discovered in the quarries of Binstead remains of the *Palæotherium* and of a new species of ruminant allied to *Moschus*.

In 1831 Professor Sedgwick** stated that he considered the anticlinal axis of the Isle of Wight to have been formed subsequently to the deposition of the lower beds of the freshwater formations, a portion of which he had discovered to be in vertical position in the cliffs of White Cliff Bay. He considered Mr. Webster's minor divisions not tenable, but the main ones he thought held good.

In 1832-33 Mr. Lyell†† coincided with these views of Professor Sedgwick, and traced the probable period and duration of the anticlinal disturbance of the Isle of Wight. He concluded that it was gradual and prolonged.

* Annals of Philosophy, vol. xix. p. 339 to 355.
† On the Geological Structure of Sussex.
‡ Annals of Philosophy, vol. xxvi. p. 360.
§ Trans. Geol. Soc. 2nd Series, vol. ii. part ii. p. 279 to 285.
|| Philosophical Magazine and Annals of Philosophy, 1829.
¶ Proceedings Geol. Soc. vol. i. p. 239.
** Ibid. vol. i. pp. 289 and 294.
†† Principles of Geology, Art. *Eocene strata*.

In 1833 Dr. Mantell* gave a further description of the Bognor rocks, and a more complete list of their organic remains.

In 1834 M. Elie de Beaumont† entered into the theoretical considerations of the period of the disturbance of the Isle of Wight, and the hydrographical state of the district during the Eocene period. He considered the strata to have been elevated after the accumulation of the freshwater formation, and contemporaneously with the elevation of the main axis of the Alps. The lignites of Alum Bay he thought synchronous with those of Soissons.

In 1835 Mr. Woodbine Parish, jun.‡, gave a list of the organic remains of the Bognor rocks.

In 1838 Mr. Bowerbank§ carefully measured some of the lower freshwater beds of Headon Hill, and noticed their want of organic remains.

In 1838 M. d'Archiac|| grouped the strata of the Isle of Wight into subdivisions parallel with those he has so well introduced in the French series, but still adhering to the divisions of Webster. He did not consider the period of the anticlinal disturbance to be satisfactorily proved.

In 1839 Mr. Bowerbank¶ described the strata at White Cliff Bay, and showed the great vertical range and abundance of the London clay fossils. He added a list of the organic remains he found in stratum "*d*" of Alum Bay, and these he considered to be of well-known London clay species. He viewed the sands, plastic clay and London as alternations of one group.

In 1839 the Rev. Mr. Clark** detailed the coast section from Poole harbour to the chalk at Stutland.

And in 1840 Mr. Bowerbank†† described several new species of shells and corals from Bracklesham Bay, and showed that species characteristic of the calcaire grossier were there common‡‡.

The details of the lithological characters of the different strata I have given in the sections, Plate IX. figs. 1 & 2, and need not here recapitulate. In these sections the strata are numbered, but I have also used the letters affixed to them in Mr. Webster's section of Alum Bay. There are a few points however connected with this subject to which I beg to call attention.

Both at Alum and White Cliff Bays the surface of the chalk on

* Geology of the South-East of England.

† Mémoires pour servir à une déscription géologique de la France, vol. iii. p. 153.

‡ Trans. Geol. Soc., 2nd Series, vol. vi. p. 313.

§ Mag. Nat. Hist., New Series, vol. ii. p. 674.

|| Bulletin de la Soc. Géol. de France, tome x. p. 168.

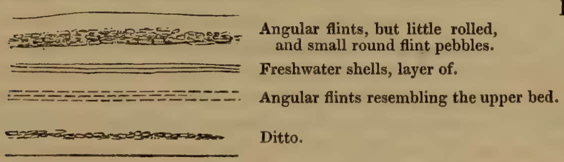
¶ Trans. Geol. Soc., 2nd Series, vol. vi. p. 169.

** Mag. Nat. Hist., New Series, vol. iii. p. 390. †† *Ibid.* vol. iv. p. 23.

‡‡ Since the above was written, Professor Edward Forbes and Capt. Ibbetson have, at the last Meeting of the British Association at York, given an excellent account of the strata at White Cliff Bay, noticing particularly the great vertical range of organic remains and their abundance in stratum "*d*."—See Report of Brit. Assoc. for 1844.

which the tertiary beds repose is as usual much worn, and overlaid by a few feet of sand with green-coated slightly rolled flints, and some small flint pebbles. To this succeeds also, in both places, a considerable thickness of bright-coloured mottled clays, and then an important bed ("*d*") of sandy brown clay with Septaria. So far the sections are nearly identical in character, but above this bed a considerable difference of lithological structure exists. At Alum Bay we find a series of variously coloured siliceous sands with some greensands and carbonaceous clay, the whole almost free from calcareous matter. At White Cliff Bay, on the contrary, we have much less siliceous sand and carbonaceous clay, and more greensands, marls and calcareous sands. In the overlying freshwater, or rather, as they might probably be better termed, the fluvio-marine series, limestones are, on the contrary, more developed at Headon Hill than at White Cliff Bay. At Alum Bay as many as ten or eleven layers of pebbles may be traced in the vertical beds; they are marked "P" in the sections (Plate IX. fig. 1 & 2). In White Cliff Bay they are also numerous, but their number cannot be well ascertained owing to the many breaks in the cliffs. An unusual condition connected with this subject may be here noticed. In the lower limestones and sandstones, which, thin and unimportant at White Cliff Bay, swell out and become in places conglomeratic at Bembridge, not only do we find the common small round black flint pebbles imbedded in the rock, but also numerous angular flints, but little rolled, just as they are found in the common flint gravel. The following is a section of a block of this calcareous sandstone.

1.



Even within small distances the lithological changes of some of the strata are considerable. The short projecting outcrop of the vertical beds precludes the exhibition of this fact at Alum and White Cliff Bays, but in the horizontal strata it may be constantly seen. Thus the thick bed of earthy limestone (No. 39) at Headon Hill passes in its range northward into a bed of sand; the thin limestones below this bed appear, on the contrary, to become more important in their range north-east. In the upper part of the series at Headon Hill, eighteen feet of hard limestone and indurated marl (71 and 72) almost entirely thin out before reaching Colwell Bay, so that the upper part of the freshwater or fluvio-marine series in its range northward and eastward loses much of its limestone, and presents thick masses of marls and clays—to this Professor Sedgwick has alluded.

At Hordwell Cliff, on the top of the London clay, there is a bed of sand fifteen feet thick overlaid by a few inches of grey clay; tracing the range of these two strata a few hundred feet to the eastward, the sand is found to pass from yellow to ash colour and to thin out, whilst the overlying clay swells out and attains a thickness of twelve to fourteen feet.

The beds below the London clay from Barton to Poole harbour and Stutland consist almost entirely of sands: the same beds at Alum Bay show nearly equal proportions of clay and sand, whilst at White Cliff Bay the clays are to sands about as two to one. The thick strata of mottled clays and brown clays ("*b* and *d*") at Alum Bay are not exhibited at Stutland; or if, as I rather presume them to be, they are hidden by the slope and talus of the cliff, their thickness must be very inconsiderable.

On the whole, it is evident that siliceous sands preponderate to the westward and clays to the eastward, and that in the fluvio-marine deposits calcareous and siliceous rock strata are, in the lower division, most fully developed on the north side of the Isle of Wight, and, in the upper division, at Headon Hill.

Another point that may be further briefly noticed in connexion with the changes in lithological character is the frequent and considerable variation in the thickness of most of the strata. At Alum Bay the mottled clays "*b*" are 90 feet thick, and at White Cliff Bay as much as 140 feet. So also at the former place stratum "*d*" is 195 feet thick, whereas at the latter place it is about 300 feet thick. The succeeding sands and London clay at Alum Bay are 1020 feet in thickness, and at White Cliff Bay 820 feet. The Lower Headon Hill sands at the former place measure 120 feet, and at the latter 195 feet. At Headon Hill the lower division of the fluvio-marine series is but seventy feet thick, whereas at White Cliff Bay it attains a thickness of 350 feet. The upper division of this last group is more important at Headon Hill, but not being in either case complete, will not admit of accurate comparison. The result of two measurements of the series included between the chalk and the upper division of the fluvio-marine group (known as the upper marine formation) gave at Alum Bay 1500 feet, and at White Cliff Bay 1800 feet. My object in alluding to these facts is to show the irregular and active conditions prevailing during the accumulation of these tertiary strata, which it is important to bear in mind in examining their organic remains, whose distribution exhibits material corresponding modifications.

Organic Remains.

Neither in the thin bed of sand immediately overlying the chalk, nor in the succeeding thick beds of mottled clays "*b*," have any animal remains been hitherto found, so far as I am aware, either at Alum Bay or White Cliff Bay. But at both places the mass of brown sandy clay "*d*" overlying the mottled clays is well-characterized by peculiar fossils. At Alum Bay their existence has been long known. Mr. Webster noticed them in 1816, Mr. Sowerby in 1821, Prof.

Sedgwick in 1822, and in 1839 Mr. Bowerbank enumerated fourteen species*.

From this locality I procured the following twenty species, besides teeth of *Squalus*:—

Dentalium (Ditrupa) planum.	Pyrula tricostata?
Pectunculus brevirostris.	Lutraria oblata?
Pholadomya margaritacea.	Rostellaria lucida?
Panopæa intermedia.	Cerithium, sp.
Rostellaria Sowerbii.	Fusus, sp.
Turritella imbricataria.	Cytherea, sp.
Vermetus Bognorensis.	Ostrea, sp.
Pinna affinis.	Corbula, sp.
Calyptræa trochiformis.	Venericardia, sp.
Pleurotoma undata?	Natica, sp.

At White Cliff Bay this stratum is considerably thicker, but the fossils in it are neither so abundant nor so well-preserved. I believe they have been hitherto overlooked †. Owing to the very rainy weather during my stay there, I found it difficult to preserve specimens. They are sufficient however to prove the identity of the bed with that at Alum Bay. The species which most abound are characteristic, such as

Dentalium (Ditrupa) planum.	Panopæa intermedia.
Pectunculus brevirostris.	Rostellaria Sowerbii.
Turritella imbricataria.	Pholadomya margaritacea.

In the 750 feet of varied and brilliantly coloured strata between this stratum and stratum "B" at Alum Bay, no animal remains have, I believe, yet been found. Traces of vegetable matter in the shape of lignite, and some few impressions of leaves are however common ‡.

Without a careful examination of this part of the series at various points in its range from Alum Bay to White Cliff Bay, it would be premature to decide whether these beds thin out or whether they become fossiliferous, and are represented by strata Nos. 5 to about 16 at the latter place §. This is a point which, if I could have found leisure, I had purposed to investigate more fully; I beg however to direct attention to it as one of considerable interest.

* The species enumerated by Mr. Bowerbank (Geol. Tr. 2nd Ser. vol. vi. p. 172) are as follows:—

Venericardia planicosta.	Nucula amygdaloides.
—— margaritacea.	Turritella conoidea.
Mya (Panopæa) intermedia.	—— elongata.
Ostrea, sp.	—— edita.
Venus, sp.	Murex innexus.
Cardium semigranulatum.	Buccinum desertum.
Nucula similis.	

He also mentions that he found a well-preserved specimen of the *Cancer Leachii*, and I have since seen in his collection the *Cardium semistriatum*, *Natica labellata*, *Rostellaria Sowerbii*, *R. rimosa*, and two species of *Pleurotoma*.

† Since the above was written they have been fully noticed by Prof. E. Forbes and Capt. Ibbetson; and a notice concerning them was read at the York meeting of the British Association.

‡ Mr. Pratt has recently obtained some beautiful impressions of leaves in a bed of white and red clay, corresponding, as well as I can make out, with the stratum 17 of my section.

§ The latter case is the more probable.

In the greensands and brown clays of stratum "B" at Alum Bay organic remains abound, dispersed in distinct masses and groups. The lower part of the stratum, where it is much mixed with greensand, contains very few shells with some vegetable remains. At about twenty-seven feet from the bottom the clay becomes almost free from greensand, and contains numerous patches of the small *Nummulites elegans*. Above these the *Corbula pisum* abounds. The clay then again passes into a clayey greensand, a change accompanied by the almost entire disappearance of organic remains. A layer of Septaria and small flint pebbles then form an abrupt line of separation to a dark grey clay full of fossils, of which the principal are *Pleurotoma colon*, *Voluta luctator*, *Fusus longævus*, *Conus dormitor* and *Nummulites lævigatus*. The fossils again become scarcer in ascending, occurring only in irregular patches, and almost disappearing before the top of the stratum is reached.

The other fossils of this stratum "B" are well-known as common London clay species, and need not here be enumerated. In addition to the usual species I may however mention, that I found one specimen of the *Cyrena obovata*, and a *Spatangus* resembling the large one of the calcaire grossier (see description of Plate).

At White Cliff Bay, where the non-fossiliferous strata are limited to the sands No. 5, about 100 feet thick, we find a great vertical development of animal life, corresponding however only in part with that of stratum "B" at Alum Bay. At Alum Bay its vertical range is about 250 feet, and the species are not much grouped; whereas at White Cliff Bay its vertical range is about 600 feet, and the species are for the most part distinctly grouped, forming frequent bands of the *Venericardia planicostata*, *Turritella imbricataria* and *Ostrea*. The Venericardia and Turritella abound in the centre of this group, in one part of which also Foraminifera are common, and in one part of it I have found a few Miliolites resembling the *M. saxorum* of Lamarck (*Trinocularia*, D'Orb.) and some Gyrogonites. The following are among the species I obtained from these strata:—

Venericardia planicostata.
—— globosa.
Turritella sulcifera.
Nummulites elegans.
—— lævigata.
Nucula similis.
Sanguinolaria Hollowaysii.
Pecten corneus.
Ostrea flabellula.
Solen obliquus.
Fusus longævus.
Calyptræa trochiformis.
Corbula pisum.
Turbinolia sulcata.
Pyrula, 1 sp.
And a Natica and Cerithium of the same species as occur in the overlying freshwater deposits.

Mr. Bowerbank was the first to notice the fossils of these beds, which he, I think, justly considers to be the equivalent of the Bracklesham Bay strata, from which he and Mr. Edwards have procured a much larger and a very beautiful series of fossils. The upper beds of this division corresponding with stratum "B" of Alum Bay are most indistinctly exposed at White Bay, and have yielded fewer fossils: consequently the fauna above-mentioned, occurring low down in this division, must not be considered the equivalent in time of that at Alum Bay, where, as at Barton, the large development of organic remains is in the top beds of this group. At Alum Bay these clays are succeeded by about 150, and at White Cliff Bay by about 200 feet of sands, in which no organic remains have yet been found at either place.

We next arrive at a series of considerable interest formed at Alum Bay, or rather Headon Hill, by a group of green marls and earthy limestones, about 150 feet thick, containing in its lower part but very few fossils, apparently only a few *Cytherea incrassata*; but in the upper part it is full of *Planorbis obtusus*, *Limnæa fusiformis* and *Melanopsis carinata*, and the other shells of the so-termed lower freshwater formation.

At White Cliff Bay this series attains a thickness of about 300 feet, and is characterized by singular groups of fossils. In the lowest bed we find the *Voluta spinosa*, and another species of *Voluta*, *Ostrea flabellula*, *Natica sigaretina*, *Pleurotoma colon*, *Cytherea incrassata*, *Calyptræa trochiformis*, and other London clay and marine species, associated with the *Cyrena obovata*, *Fusus labiatus*, *Melania fasciata*, *Neritina concava*, *Potamides acutus*, and *Paludina lenta*, species common to many of the overlying beds.

Next follow strata Nos. 23 and 24, containing fewer marine and more estuary and freshwater shells, but still with the same characteristic species of *Voluta*, *Turritella*, *Fusus*, *Cyrena*, *Potamides* and *Paludina*.

The marine species gradually disappear, and we find stratum No. 26 characterized by the *Melania fasciata* and *Cyrena obovata*.

In Nos. 27 to 30 occur the *Potamides acutus*, *Cyrena obovata*, *Paludina lenta*, and *Potamomya plana*.

And in the marls and limestones, Nos. 31 to 35, ending the series, the organic remains are almost, if not altogether, freshwater; they consist almost entirely of several species of the *Limnæa* and *Planorbis*.

At Headon Hill this division is succeeded by about twenty feet of marl (No. 60. Pl. IX.), with rounded flint pebbles, and containing

Fusus labiatus.	Neritina concava.
Melania fasciata.	Melanopsis fusiformis.
Potamides or Cerithium, several sp.	Cyrena obovata.
Ostrea.	Corbula.
Natica or Ampullaria.	Nucula,—and many others (see p. 246).

The following characteristic species will serve, I think, to identify stratum 36, at White Cliff Bay, with this so-called upper marine of Headon Hill. Here also the beds are slightly conglomerate.

An Ostrea—the same as that which abounds at Colwell Bay.	Melania fasciata.
	Neritina concava.
Potamides cinctus.	Melanopsis fusiformis.

These are the most abundant species in these strata, but many other species occur, of which a large portion are yet undescribed.

At Headon Hill this bed is overlaid by a series of nearly 200 feet of marls and earthy limestones, containing principally the

Paludina lenta.
Cyrena obovata.
—— cuneiformis.
Potamides concavus.
—— ventricosus.
—— cinctus.
Limnæa longiscata.
Planorbis euomphalus.
—— obtusus.
Melanopsis.
Melania fasciata.

and at White Cliff Bay by 100 feet of clays and marls, containing also almost exclusively the *Paludina lenta*, *Melanopsis carinata*, *Melania fasciata* and *Cyrena obovata*, and only a few specimens of *Limnæa* and *Planorbis*.

At Headon Hill I found in one of the limestones of this series (No. 69) a few teeth and bones. The former have been identified by Professor Owen as belonging to the *Palæotherium crassum* and *P. medium*.

Some of the bones were those of the Turtle, remains of which I met with also in stratum No. 74 of Headon Hill.

The distribution of the organic remains of this division will be more fully noticed at the end of this paper *.

In introducing local subdivisions and groups it may be convenient not only to consider the strata, with regard to their palæontological and lithological characters, but also to attend to those traces of minor disturbances effected during their accumulation, which may often usefully serve as lines of separation to the different groups. Inasmuch also as the effects resulting from these minor disturbances afford evidence of greater or lesser changes in the hydrographical condition of the district during the period when the formations were in course of accumulation, making slight breaks, but not destroying the continuance of like genera and species, although modifying their distribution, they may, I think, conveniently serve as points of division in the series. This is more especially the case, since these disturbances having been greater in one part than in another, the changes effected necessarily differ in importance, the condition of the fauna varying in the ratio of the amount of change, of which the effects are likewise almost always more or less visible in the lithological character of the beds.

There has been great difference of opinion with regard to the theoretical arrangement of the tertiary series of the Isle of Wight; some agreeing with Mr. Webster (to whom we are indebted for the first systematic attempt at classification), that they can be divided into "sands and plastic clays and London clay, with two freshwater and one upper marine formations;" others, on the contrary, contending that all the members of the lower part of the series alternate, rendering a division into London and Plastic clays impracticable, and considering that the upper freshwater and marine strata also alternate.

Now I do not think that Mr. Webster intended to separate the plastic and London clays into two formations, as we now understand

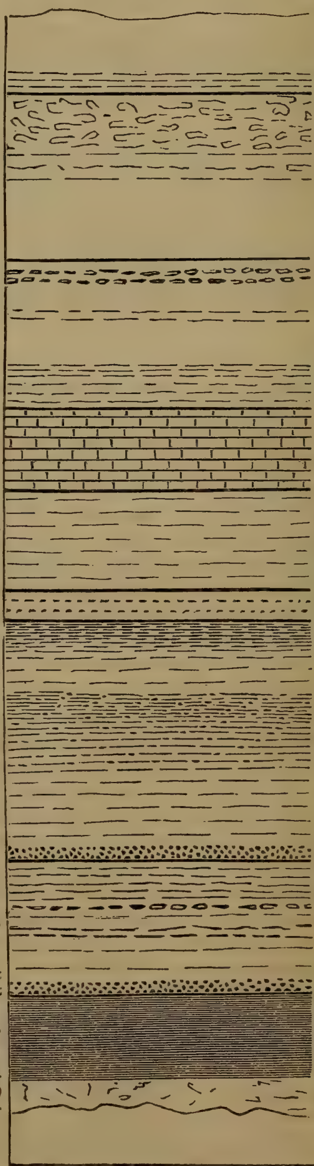
* See also the sections and their explanations at p. 252. In the preceding paragraph only the general grouping and most marked phænomena are noticed.

the word. He merely gave them as two divisions of the same formation, the former always underlying the latter and exhibiting a distinct character; and in this view I fully agree with him. He was doubtful however where the line of separation should be drawn, and hesitates where to place the brown clay stratum "*d*." In lithological character he found it resemble the London clay, but its organic remains, *which he distinctly notices*, he considered as resembling those of the Woolwich beds. In fact, in his accounts of the tertiary formations of the Isle of Wight, both in the work of Sir Henry Englefield and in the Transactions of the Geological Society, he has well and ably described the geology of Alum Bay and Headon Hill, and soundly established such subdivisions as the then existing state of our palæontological and stratigraphical knowledge warranted. He proposed no fixed and positive system, but rather pointed out the analogies of the series with the classification then recently introduced by Cuvier and Brongniart into the Paris basin, and left it to be modified and completed as further observations might render necessary.

I purpose to restrict the term plastic clay solely to the mottled clays (which term would probably be preferable) marked "*b*" at Alum and White Cliff Bays. They are in both instances separated from the chalk only by a layer of a few feet of sand, pebbles, and large green-coated flints; but this bed, though unimportant here, is the representative, as I hope to show on a future occasion, of important fossiliferous beds at the east of the London basin, and at the north and east of the Paris basin. This layer may be called the lower sands. It is singular, that of all the varied beds of the tertiary series of England and France, the most persistent in its range, the most uniform in its composition, and the most regular in its organic remains (at present, I believe, it is only known to exhibit, and that rarely, traces of vegetable remains), are these mottled plastic clays. The whole of the beds below stratum "B" at Alum Bay have been considered as a great development of the limited series of sands and clays exhibited under the London clay at Woolwich, Lewisham, &c. I do not however think that their synchronism can be maintained; it is limited, I conceive, to the lower part only of Alum Bay. Cuvier partly limited the term "Argile plastique" to the variable and mottled clays without fossils occurring very generally below the "Calcaire grossier." The lignites and fossiliferous clays which occasionally intervene between this and the calcaire grossier he considers as subordinate, and designates them "fausses glaises." M. d'Archiac makes the clays and lignites together subordinate in his first and lowest group of the Eocene formations.

In France the geological position of these clays is constant over the larger portion of the Paris basin. It is represented, I conceive, solely by stratum "*b*" in the Isle of Wight, and underlies the whole of the London basin west of London, ranging north to Hertford and Bishops Stortford. The uniform absence, or at all events, the extreme rarity of animal remains in this division throughout its entire range, is a singular feature. The reasons for assuming the synchro-

2. General Section of the Paris Basin with reference to the conditions most resembling the Hampshire Basin.



	Arrangement according to M. d'Archiac*.	*Subdivisions.*	Divisions of Cuvier, C. Prevost, C. d'Orbigny, *etc.*	*Hampshire Basin.*
MIOCENE.	*6th Group.* Calcaire lacustrine supérieur.	2. F. limestones (Calc. à Helix). 1. Clays and millstones.	Travertin supérieur.	U.F.W. Form.
	5th Group. Grès et sables supérieurs.	3. Sandstones. 2. Sands. 1. Marls.	Grès de Fontainebleau.	Upper Marine Formation.
EOCENE.	*4th Group.* Calcaire siliceux, ou Calc. lacustre moyen.	5. Millstones and clays. 4., 3. Freshwater marls and limestones.	Travertin moyen.	Lower Freshwater Formation.
		2. Gypseous series.	Terrain gypseux.	
		1. Freshwater marls and limestones.	Travertin inférieur ou Cal. siliceux.	
	3rd Group. Grès et sables moyens.	3. Limestones. 2. Sandstones. 1. Sands.	Grès de Beauchamp.	Lower Marine Formation.
	2nd Group. Système calcaire.	4. Marls. 3. Upper Calc. grossier.	Caillasse.	
		2. Calc. grossier.	Calcaire grossier.	
		1. Glauconie grossière.	Calcaire chlorité.	
	1st Group. Sables et grès inférieurs.	6. Sands and clays. 5. Shelly beds (Lits coquilliers). 4. Sands.	Sables glauconifères.	Plastic Clay Formation.
		3. Conglomerates & sands (Grès et poudingues). 2. Clays, lignite, etc. F. limestone.	Terrain de l'argile plastique.	
		1. Sands (Glauconie inférieure) and calc. pisolitique.	Calc. pisolitique.	
CHALK				

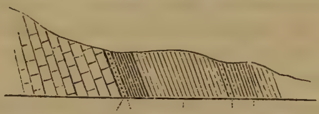
* Bulletin de la Soc. Géol. de France, vol. x. p. 172.

nism of these non-fossiliferous beds, and for limiting this subdivision to the lower portion only of the Alum Bay section, will be shown more fully in treating of stratum "*d*."

In the meantime I beg to refer to the accompanying sections.

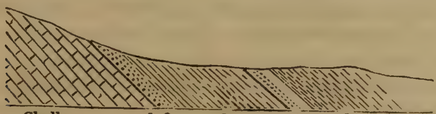
The first of these (2) is a general section of the Paris basin, viewed with reference to the maximum development of marine conditions in the lower groups, as being the conditions approximating the most closely to those of the Hampshire basin. In this diagram the divisions are taken from Brongniart and Cuvier, D'Archiac, Constant Prevost, Ch. d'Orbigny, &c., and the strata are represented of the average thickness on a scale of one inch to a hundred feet.

3. SECTION between KINGSCLERE and HUNGERFORD *.

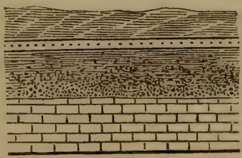


The next diagram, No. 3, drawn on the same scale, shows the extension of the mottled clays, in diminished importance, at the western extremity of the London basin.

4. SECTION between BASINGSTOKE and ODIHAM *.



5. SECTION near HERTFORD *.



No. 4 shows the same division in greater thickness at a point in the London basin further to the east; while No. 5 shows that these beds also range in the northern part of the basin.

The "lower sands" and the "mottled clays" with the thin over-

* The references in these diagrams are as follows:—

6. Bognor beds.
5. Pebble beds; frequently with ironsand.
4. Sands (light-coloured).
3. Mottled clays.
2. Sand.
1. Conglomerate of flints, green and ochreous sand.

The Bognor beds in (3) consist of brown and dark clays with *Panopæa intermedia*, *Pectunculus brevirostris* and *Dentalium planum*. In (4) they are brown or reddish clays, and contain *Pholadomya margaritacea*, *Vermetus Bognorensis* and *Dentalium planum*. In (5) they are brown sandy clays with *Pectunculus brevirostris* and *Panopæa intermedia*.

It seems proved by the distinct superposition of these beds that all of them are of the same age; namely, that of the lower group in the Isle of Wight.

lying bed of sand "*c*" at Alum Bay, may be considered as the first and lowest group of the Eocene strata of the Isle of Wight (Pl. IX.). They appear to me to mark a distinct period in the hydrographical condition of the tertiary epoch. Similar causes, judging from like results, were then evidently in operation over the greater part of the Paris, Isle of Wight and London basins. Whether the condition in the Isle of Wight basin were a deep sea-bottom or shallow waters, or whether the strata were accumulated rapidly or slowly, there is no evidence here to decide.

A careful examination shows that the surface of the upper thin sand "*c*" of the last group at Alum Bay has been worn and eroded, but in a much less degree than the surface of the chalk, by the action of water, and that on it are deposited strata differing both in lithological character and in their fauna from the preceding group, and indicating, by its underlie of coarse sand and large rounded flint pebbles, a considerable and sudden increase in the transporting powers of the water.

The organic remains of this division are extremely well-characterized, and form in the Isle of Wight and London basins an excellent geological horizon. Mr. G. Sowerby, as well as Mr. Bowerbank, have noticed the fossils of this bed as being well-known London clay fossils, and so far back as 1822 Prof. Sedgwick thought that they resembled the fossils of the Bognor rocks. Dr. Mantell and Mr. W. Parish have enumerated 30 or 32 species of fossils from the Bognor rocks. Of the 20 species I have found in stratum "*d*" at Alum Bay, 15 agree with those from Bognor. They include the most typical forms and groups, such as a species of *Pholadomya*, the *Panopæa intermedia*, *Pinna affinis*, *Pectunculus brevirostris*, *Dentalium planum*, *Vermetus Bognorensis* and *Rostellaria Sowerbii*. If the preceding mottled clays maintained a striking constancy of lithological character over a very wide area, these Bognor beds present a no less remarkable constancy in their palæontological character in the Hampshire and London basins. The fossils above enumerated characterize them equally at Alum Bay, Bognor, Basingstoke, Newbury, Sunning, Watford, Hertford, and many other places in the neighbourhood of London. See sections 3, 4 and 5, *ante*, p. 235.

The uniformity of characters prevailing in the first divisions of sands and mottled clays, which form the base of the tertiary formations throughout large areas of the Paris, Hampshire and London basins, indicating a widely-spread and continuous sea, and suggesting the origin of the detritus to have been probably from few and like sources, ceases at the end of that period, after which the increasing variety of the synchronous strata in the different basins proves the increasing disruptions and severance in the original connexion. Whatever may have been the depth and character of the waters at this epoch in the Isle of Wight basin, a subject that we shall be able to enter upon more fully in treating of the important fossiliferous beds of this age in the north of France and south-east of England, that a sudden change of some importance took place is evident; first, from the considerably increased transporting power of the waters for a short time, the result of which has been to cover large areas of the London and Hampshire basins with a layer of from six inches to three or four feet thick of rolled flint pebbles, varying in size from a pea to an egg; secondly, from the sudden appearance (without transition or alternation) of a lithological structure not exhibited in any of the underlying tertiary strata, and evincing by its continuance the permanent nature of the change; and thirdly, by the presence of a distinct group of organic remains differing considerably from that of the beds below.

On examining the fossils of the Bognor beds at Alum Bay, it will be noticed that the deep-sea mollusca are absent; and that, on the contrary, their most characteristic and widely-spread genera form a group indicating marine waters of very moderate and tolerably uniform depths (e. g. *Pinna*, *Vermetus*, *Calyptræa*, *Panopæa*, *Pholadomya*, *Turritella*, &c.).

Sir Henry De la Beche, in his 'Theoretical Geology,' assigns, on the authority of Mr. Broderip, a depth not exceeding about twelve to sixteen fathoms to the genera constituting this group; and Prof. E. Forbes, in his Report on the Testacea of the Ægean Sea, gives further evidence to the same point; whence we may assume the predominating littoral and shallow-sea character of the testacea of this period. At the same time all the genera are essentially marine, unless we except the *Ostrea* and *Cerithium*, which also inhabit estuaries; but as the species of these genera occurring in this division are found so constantly associated with well-known and essentially marine families, their presence does not invalidate the argument. The weight of evidence is, I think, so far as the Hampshire basin is concerned, in favour of these beds having been deposited in an open and not a deep sea; whence, as these beds are here from 200 to 300 feet thick, and they are further overlaid by a great thickness of other marine strata, it follows that to have retained a constant fauna throughout so considerable a vertical range, the conditions under which they were formed must have changed progressively in adaptation to the prolonged existence of the same animal life. If therefore these Bognor beds exhibit throughout nearly their entire thickness a group of testacea, indicating a sea-bottom not often attaining a depth of thirty to forty fathoms, and averaging more probably not more than ten to twenty fathoms, this would clearly be insufficient for the accumulation of the mass of detritus necessary to form strata, which when desiccated are 200 to 300 feet thick. At the same time their lithological character denotes a tranquil and uniform deposit during some length of time: and as the evidence of fossils proves that the condition of animal life was similar at the end to that which existed at the commencement of this period, it follows that there must have been throughout its duration a quiet and gradual subsidence of the bed of the sea, immediately preceded, as before mentioned, by a disturbance sufficiently powerful and sudden partially to interrupt the continuity of deposit with the Paris basin, a circumstance rendering the recognition of the foreign equivalents of the Bognor beds more difficult than with the preceding division.

In the third division of his first group of 'Sables inférieurs' M. d'Archiac places an irregular and variable deposit, termed by him 'Grès et poudingues,' and consisting of siliceous sands, imperfect sandstones and pebble beds, which immediately overlie the 'Argile plastique' and lignites. These conglomerate beds are overlaid successively by three other divisions, which complete his first group of the Eocene strata, a group succeeded by the 'Glauconie grossière' and 'Calcaire grossier,' which he places in his second group (section p. 234). The three divisions above named he terms, in ascending order, 'Sables divers,' 'Lits coquilliers,' and 'Sables et glaises.' They consist of a very irregular mixture of siliceous and calcareous sand, concretions and imperfect earthy impure limestones, with frequent greensands and a good deal of clay. These beds pass one into another, rarely occur together, and are very irregular in their range and thickness. Taking the base of the Bognor beds as the diverging point in the mineral composition of the Paris with the Hampshire and London basins, it will be observed, that in the ascending series calcareous sands and limestones predominate in France, and argillaceous beds in England. It is not however until a later period that the lithological characters present their greatest dissimilarity.

The four above-mentioned divisions (3 to 6, section p. 234) of M. d'Archiac's lowest Eocene group do not hold in the English series; but it is probable that taken together they are represented partly by the Bognor beds. This appears to be the case for several reasons. In the first place the superposition is in the same order. Secondly, the commencement of both series indicates some change and disturbance in the Eocene seas. Thirdly, some similarity of mineral structure is traceable, and this in a somewhat marked manner, since the calcareous and sandy character of these beds at Bognor is well-known, and at White Cliff Bay they contain much greensand; whilst in France, in contrast with the general character of the French marine Eocene strata, they are also much mixed with greensands, yellow and brown clays, which frequently form compact and tenacious beds, and give rise to numerous springs from the percolation of water through the sands and limestones of the calcaire grossier. It is also probable, fourthly, by the analogy of organic remains; for notwithstanding that the fauna of the Bognor beds in England is very limited in species, it everywhere presents a very typical and constant group of fossils. In France the series is more developed than in England, and the organic remains are confined almost exclusively to the 5th division, viz. the 'Lits coquilliers,' a deposit almost as rich in fossils as the calcaire grossier. Most of the species are the same as those found in the calcaire grossier; but those which are distinct are in sufficient number to entitle the bed to be considered as a separate division. M. d'Archiac* enumerates 197 species from the 'Lits coquilliers,' and describes twenty seven of them as characteristic of

* Mém. de la Soc. Géol. de France, vol. v. p. 268.

these beds. M. Melleville's* distinctions are still more positive. I do not pretend to say that the Bognor beds are the exact equivalents of the 'Lits coquilliers'; but as these latter exhibit a varied and large marine fauna in part peculiar to the lower Eocene group in France, so in England do the Bognor beds maintain a fauna, certainly more restricted, but nevertheless equally distinctive and characteristic of that epoch.

As before mentioned, the Hampshire series exhibits a group of genera rich in individuals, but few in species, such as *Vermetus*, *Pinna*, *Pholadomya*, &c., indicating a marine littoral or a shallow sea deposit. The French beds, on the contrary, in the north and north-east of the Paris basin (in the central and southern districts this group thins out), contain many more genera, mostly rich in species, and show an admixture of freshwater shells of the genera *Melanopsis* and *Paludina* with numerous estuary shells, such as *Cerithium*, *Ampullaria*, *Cyrena*, &c., associated with marine forms, many of them inhabiting greater depths than those found in the Bognor rocks. As we have, therefore, evidence of conditions varying from a river-mouth to a tolerably deep sea-bottom, it follows that, from the more numerous zones of depth thence resulting, we might expect a greater variety of testacea than we meet with in the more uniform shallow sea deposit of the Bognor rocks. As corroborating this view of the influx of fresh waters into a sea, for the most part shallow, may be noticed an interesting fact mentioned by Professor E. Forbes in his Report on the Invertebrata of the Ægean Sea†, namely, that, with few exceptions, individuals of the same species are there dwarfish compared with their analogues in the Western Mediterranean, and he attributes this fact to the influx of the brackish waters of the Black Sea. Now the very same result is observable in the 'Lits coquilliers'; for M. d'Archiac, in his valuable paper on the Geology of the Département de l'Aisne (Mém. de la Soc. Géol. de France, vol. v. p. 271), states that they are distinguished, not only by distinct fossils but by varieties, constantly smaller, of species occurring in the calcaire grossier.

Of the species of testacea found in the Bognor beds in Hampshire and Sussex (thirty to thirty-two in number), the following eighteen occur in the 'Lits coquilliers' and 'Sables inférieurs'‡:—

Anomia lineata, *Sow.* (? A. tenuistriata, *Lam.*)
Cassidaria carinata, *Lam.*
Fusus rugosus, *Lam.* ?
Globulus sigaretinus, *Sow.* (Natica sigaretina, *Def.*)
Infundibulum trochiforme, *Sow.* (Calyptræa trochiformis, var. *Lam.*)

* Annales des Sciences Géologiques, vol. ii.

† Report of Brit. Assoc. 1843, p. 152.

‡ One of the most constant and characteristic fossils of the lower beds of the 'Lits coquilliers' is the *Nummulites planulatus* of M. d'Archiac (*N. elegans*, Sow.). Another characteristic species is the *Bifrontia laudinensis*. In this country they have only been found higher in the series, and the latter is common at Bracklesham; but this at present is an anomaly. The *Panopæa intermedia*, a characteristic species from the Bognor beds, is I believe identical with the *Corbula dubia* of Deshayes, a fossil of this series in France.

Nucula similis, *Sow.* (N. margaritacea, *Lam.*)
Ostrea flabellula, *Lam.*
Panopæa intermedia, *Sow.* (? P. remensis, *Mel.*, Corbula dubia, *Desh.*)
Cardium semistriatum, *Desh.*
Pholadomya margaritacea, *Sow.*
Pectunculus pulvinatus, *Lam.*
Pinna affinis, *Sow.* (P. margaritacea, *Lam.*)
Pyrula tricostata, *Lam.*
Teredina antenautæ, *Sow.* (T. personata, *Lam.*)
Turritella edita and T. conoidea, *Sow.* (T. imbricataria, var. *Lam.*)
Venericardia planicostata, var. *Lam.* (? V. Suessonensis, *d'Arch.*)*
Pleurotoma undata, *Lam.*
Natica labellata, *Lam.*

In Belgium also, M. Galeotti† mentions the *Pholadomya margaritacea*, a *Pectunculus*, (apparently *P. brevirostris*) *Cassidaria carinata*, a *Calyptræa* and a *Teredina*, as occurring amongst the fossils of his lowest group (système inférieure).

Combined with the other characters, this list affords strong presumptive evidence that the 'Lits coquilliers' and the Bognor beds are members of the same group, and nearly synchronous. The number of species common to the two is considerable, and gives a per centage equal to, or greater than, that of the species common to the calcaire grossier and the London clay. The difference of sea-bottom, clays predominating in the one and calcareous sands in the other, would, even under conditions otherwise similar, develope a somewhat different fauna. At the same time, amongst the fossils found in this group in England and France, there are a few, such as the *Pholadomya margaritacea*, *Ostrea bellovacina*, *Rostellaria Sowerbii*, *Panopæa intermedia*, &c., which rarely or never occur in either country in any of the overlying strata; but as some of these species range down to the chalk in parts of the Paris basin, further evidence is probably necessary before we can draw exact parallels. A greater number of English fossils are needed, and a more accurate comparison of the species of the two countries is still required, but there are sufficient indications to form in both countries a lower Eocene group characterized by a partially peculiar fauna; and whatever may be their foreign equivalents, it may I think be presumed, that the strata Nos. 4 to 6 at Alum Bay and Nos. 3 and 4 at White Cliff Bay are synchronous with the Bognor rocks, forming together a distinct and well-marked division. (See Pl. IX. and the description of the plate p. 252 *et seq.*).

It may be objected that the fossils of the Bognor rocks are those of the London clay. Some few of them no doubt are so, but as a group they are perfectly distinct and singularly constant; and it is from the circumstance of these two divisions occurring in common superposition in the London basin, that the fossils of the two have been constantly given without distinction as London clay fossils‡.

Now if the Bognor beds were accumulated in a shallow sea, any additional and thick marine deposit over them would not have

* I have since seen this species in M. d'Archiac's collection. It appears to be identical with the species I have found in the Isle of Wight, and apparently also with the one from Bognor.

† Mém. de l'Acad. Roy. de Bruxelles, vol. xii.

‡ This has been much the case formerly in France with regard to the 'Lits coquilliers,' the 'Glauconie grossière,' the lower calcaire grossier and the upper calcaire grossier, and renders the present question still more difficult to determine.

been practicable without a further hydrographical change; whereas at both Alum Bay and White Cliff Bays we find them overlaid by several hundred feet of marine beds: it therefore follows that a considerable deepening of the sea must have taken place subsequent to the formation of the Bognor beds, and prior to or during the accumulation of the overlying sands and clays forming the mass of the London clay in the Isle of Wight, and at Bracklesham Bay and Barton.

That this disturbance was of greater importance than any of the preceding ones in the Eocene period, is evident from the more greatly altered palæontological and lithological conditions of the deposits. In France the preceding argillo-siliceous system is succeeded by the well-known calcareous system of the calcaire grossier, and in England by the argillaceous system of the London clay. The change however is not sudden; the lower beds, both in France and Hampshire, still continue to exhibit some evidence of similar origin, and in the former country the 'Glauconie grossière' underlies the calcaire grossier; while in the latter we find at the Isle of Wight a like predominance of argillaceous and calcareous greensands in the lower London clay beds.

The period in question was one of slow but considerable transition; and as such it is characterized by coarse drift sands and variable strata, resulting from the repeated change of land and sea levels. Whether the whole of the series between the Bognor beds and the Headon Hill sands at Alum Bay and White Cliff Bay are synchronous, is a point which requires for its elucidation a careful examination of the district between these two places. I think it is probable however that they will be found to be so. At Alum Bay no animal remains have hitherto been discovered in the lower part of this series, although at White Cliff Bay they abound; and at both places the remains of vegetables and plants are common. Should a further palæontological examination confirm the view that the Bognor beds are synchronous with the 'Lits coquilliers,' then the superposition of the strata between them and the upper London clay will agree with that of the glauconie grossière. In both cases the action of strong currents in the production of coarse sand and gravelly beds is exhibited, accompanied always by more or less green-coloured sand. Although perfectly distinct in lithological appearance, the fossils of the glauconie grossière can scarcely be distinguished from those of the lower calcaire grossier, into which it passes; and of these two divisions this series of beds in the Isle of Wight may therefore prove to be the equivalents, although in greater development. The *Venericardia planicostata*, *Turritella sulcifera* and *Nummulites lævigatus*, &c., abound alike in both countries in the coarse sandy lower beds.

It is notwithstanding the case, that in this lower part of the series the number of species at present found in the Isle of Wight is not sufficiently great to establish an extensive comparison. In the range of these beds further to the eastward they become however highly fossiliferous; for although their superposition is not exhibited, there can be, I think, little doubt that the Bracklesham Bay beds belong to this period, as the mineral composition is the same; and all, or almost all, the fossils which occur at White Cliff Bay, in the strata marked 9 to 11, are met with at Bracklesham; but at this latter place they are associated with numerous other species, identical for the most part with those of the glauconie grossière and lower calcaire grossier. More than sixty or seventy species have already been identified as common to the Bracklesham beds and the calcaire grossier (moyen), and Mr. Edwards and Mr. Bowerbank are daily adding to the list*.

In addition to the greater vertical range of organic remains in this series at White Cliff Bay than at Alum Bay, the fauna of these two localities presents some differences both in genera and species. As the superposition is however identical, the beds being in both cases overlaid and underlaid by similarly characterized strata, there can be little doubt of their synchronism; and the difference of the faunas must be attributed to the different hydrographical conditions under which they were accumulated.

In further evidence of the gradual changes in operation during this period, it may be noticed, that in the London clay at White Cliff Bay and Alum Bay we meet with indications of those fluvio-marine conditions, which at a later period prevailed in fuller development ; for I have found in the upper London clay at Alum Bay the "*Cyrena obovata*," and in the same division at White Cliff Bay the "*Potamides cinctus*," or if not that species, at all events a species identical with one in the overlying freshwater deposits, and a Natica or Ampullaria also analogous with one occurring in the overlying beds. Of the freshwater deposits the *Cyrena obovata* is one of the most characteristic shells.

Again at Alum Bay in the centre of stratum No. 29 may be seen a well-defined line of separation, marked by a sudden passage from clayey greensands to tough brown clays accompanied by a drift of pebbles underlying the latter. These two divisions of stratum No. 29 are also marked by different groups of testacea; the *Pectunculus*, *Sanguinolaria*, *Solen*, *Pecten*, &c. of the lower division being succeeded in the upper one by *Voluta*, *Pleurotoma*, *Conus*, &c. These latter constitute a deeper sea group than the former, showing a depression of the sea-bottom, and delaying for a period those freshwater conditions to which this locality was tending; for it was in the former or lower part that the *Cyrena obovata* occurred. Such is also the case with *Potamides cinctus* at White Cliff Bay; but the division of the strata is not there so well exhibited, as that portion of the cliff is much covered and broken. There is however there an evident difference, both palæontological and lithological, in the upper and lower strata of the London clay, although it is not so visible as at Alum Bay, which appears to have been nearer the centre of disturbance, as all the changes are there more abrupt and marked than at White Cliff Bay, where they exhibit more gradual transitions, indicating a disturbing force decreasing in effect as we proceed

* Since writing the above I have seen in M. A. d'Orbigny's collection a series of specimens from the glauconie grossière of Chaumont. As a group they present a strong analogy with those from Bracklesham Bay; and the same remarkable abundance of the *Venericardia planicostata* characterises both localities.

eastward, and ending possibly in a point of comparatively slight change and of nearly uniform deposit,—conditions applicable to the contemporaneous strata of the central and eastern portions of the London basin.

We now enter upon what may be termed, for the sake of distinction, the Fluvio-marine deposits, forming lithologically a distinct local group, exhibiting divisions of condition, but not of age, and palæontologically connected with and passing into the group below. These beds have therefore no relation with those similar ones partly of freshwater origin, which are known as the lower and upper freshwater and intervening marine formations of the Paris basin (groups 4, 5 and 6 of diagram 2).

The argillaceous strata last described are suddenly succeeded by a thick bed of sand without organic remains, but this bed is apparently of marine origin, since Professor Sedgwick has shown that the equivalent bed at Hordwell contains marine shells, and also that in the lower part of Hempstead Cliff marine or estuary fossils predominate. Further, the lower marls and clays of the overlying formations described as freshwater contain marine fossils. As this sand bed is well-exhibited and well-known at Headon Hill, where it forms the base of the hill, it may be convenient to term it the Headon Hill sand. It was formed during a period when the sea became shallow, estuaries replacing the open sea, and at a time also when a drift was deposited different from that previously accumulated; marls and earthy limestones succeeding the quartzose and green sands and pure clays.

At White Cliff Bay we find in stratum No. 21, immediately overlying the Headon Hill sands, an assemblage of fossils, presenting a singular mixture of marine, estuary and freshwater shells. Amongst them are the following species: *Cytherea incrassata*, *Voluta spinosa*, *Pleurotoma colon*, *Calyptræa trochiformis*, and other marine shells, associated with the *Potamides cinctus*, *Cyrena obovata*, *Paludina lenta*, *Melania fasciata*, &c. (and *Planorbis* according to Prof. E. Forbes and Captain Ibbetson).

In stratum No. 24 we have the same estuary and freshwater shells, with only the *Voluta* and *Cytherea* among marine forms, and, in addition to those species already quoted we find *Neritina concava*, and a *Natica* identical with an unnamed species from the calcaire grossier of Damery.

In 26 I only observed *Cyrena obovata* and *Melania fasciata*.

In 28 the *Potamomya plana* occurs with the *Potamides cinctus*, *Cyrena obovata*, and *Paludina lenta*.

In 29 and 31, *Paludina lenta* and *Serpula tenuis* are found; and in 32 the *Limnæa* and *Planorbis*.

At Alum Bay, or rather Headon Hill, this part of the series (Nos. 31 to somewhere about 56) is much less developed, and, as I have before mentioned, it affords only slight evidence of the partially marine conditions of the lower part, ending however, as at White Cliff Bay, with well-characterized freshwater marls and earthy limestones with Limnæa and Planorbis.

The palæontological changes exhibited in this series may have taken place without any further change of level. The slightly varying mineral composition, and the gradual change in the fauna, result probably from the tranquil filling-up of the estuary and the eventual barring-out of the salt water.

With reference to the so-called upper marine formation, the strata No. 56 to 61 in the Headon Hill, and No. 36 (which I consider its equivalent) in the White Cliff Bay section, it overlies the preceding group, from which it is not to be distinguished by stratification or mineral character, except that it contains some small flint pebbles. This however is a difference of some importance, as showing an increased moving force of water, and it indicates therefore an influx of the sea resulting probably from a slight further subsidence, and again restoring for a time, as evidenced by the organic remains, the conditions of the former estuary. The marine and estuary testacea, which had disappeared in the beds immediately preceding, now re-appear in considerable abundance, accompanied by some new species.

At White Cliff Bay the change has not been so important as at Headon Hill. At the former place one or two species of *Ostrea*, with the *Potamides cinctus*, *P. ventricosus*, *Melania fasciata*, *Cyrena obovata*, *C. cuneiformis*, and *Melanopsis* are common. At the latter place, however, a greater number of species occur, of which the most characteristic are, in addition to those just mentioned, *Fusus labiatus*, *Potamides acutus*, *Neritina concava*, a *Cerithium* and a *Natica* identical with species from the calcaire grossier of Damery, and probably also *Ampullaria Willemetii.*

At White Cliff Bay these beds pass upwards into thick strata of green marls and clays, of which almost the only fossils are *Paludina lenta*, *Cyrena obovata*, *Melania fasciata*, *Melanopsis* and *Potamides.* This does not indicate so much of a freshwater condition as does occasionally its equivalent at Headon Hill, which has been termed the upper freshwater formation. As before observed, the estuary fauna at No. 56 succeeds suddenly to the freshwater one, but in ascending order the change is more gradual, several estuary species, such as *Melania fasciata*, *Melanopsis fusiformis*, *Potamides ventricosus*, and *P. concavus*, appearing in No. 61. No. 62 is a thin bed full of *Planorbis* and *Limnæa*; and in the thick mass of earthy limestones marked Nos. 67 and 68, the several well-known species of these genera abound, and are associated with some teeth of the *Palæotherium* and bones of a Tortoise.

Slight changes of subsidence have again modified the higher beds to a small extent:—the upper part of the last stratum is partially a conglomerate, and in the marls which succeed we find the *Cyrena obovata*, and in stratum 70 *Melania fasciata*; in 71 the *Planorbis* and *Limnæa* again appear; in 72 bones of the Tortoise, with *Paludina lenta* and *Neritina concava*; in 73 *Cyrena obovata*; and in the bed No. 75 at the top of the series, and immediately underlying the gravel and sand, we find, in a brown clay having traces of lignite, *Melania fasciata*, *Potamides cinctus*, and *Cyrena obovata*, estuary testacea, which we have therefore traced throughout the entire series of these fluvio-marine strata, both at Headon Hill and White Cliff Bay. It will be observed, however, that, on the whole, marine conditions are more predominant at the latter than at the former place.

In these remarks, having merely in view the unity of the series, I have only given the characteristic and more abundant fossils, worked out and marked on the spot from the different beds. The sequence appears complete and unbroken, the whole series consisting of deposits more or less marine and estuary, with interpolated freshwater beds, all characterized respectively by the same organic remains, varying only according to the variable conditions of the waters; at one time the abode of the ***Potamides, Melania, Cytherea, Neritina, Cyrena***, and ***Fusus***; and at another, more particularly, of the ***Planorbis*** and ***Limnæa***. All these fossils range at intervals throughout the series, associated, when under predominating marine conditions, with other marine and estuary genera, and exhibiting no break in the sequence beyond that which would result from a contemporaneous fauna, subject to variations of marine and freshwater agencies.

With respect to the age and synchronism of these fluvio-marine deposits, I feel considerable hesitation in hazarding an opinion. We still want further evidence, and we especially require a more extended and careful comparison of the marine testacea with those of the Paris basin. At an early period in the history of tertiary geology they were considered to represent the lower freshwater, upper marine and upper freshwater formations of Cuvier and Brongniart; and this was assumed, first, from a supposed unconformable superposition on the London clay; secondly, from their having been accumulated, like the Paris series, under predominating freshwater conditions, and exhibiting a very similar sequence of strata; and, thirdly, from analogy of organic remains.

With respect to the first reason, there can, I think, be little doubt, as I shall endeavour to prove further on, that all the beds of the series, from the chalk to the top of the fluvio-marine beds, are in conformable stratification.

With regard to the second reason, it is now known that analogous freshwater conditions prevailed to some extent in the Paris basin prior to this period; for the upper strata of the calcaire grossier are frequently argillaceous, and contain subordinate beds of white and green freshwater marls, sands, and fine earthy limestones, closely resembling some of the overlying freshwater deposits, and, like them, containing also several species of ***Paludina, Limnæa, Planorbis***, and ***Melania***, showing evidence therefore of the commencement of freshwater conditions in the upper calcaire grossier —conditions traceable also occasionally in the grès de Beauchamp, and subsequently increasing in force, and ranging, with slight interruptions, to the completion of the Paris beds *.

* Constant Prevost has ably argued in support of his theory of affluents, that

The third reason, the subject of organic remains, requires a more lengthened notice. On this point, the main evidence on which the contemporaneity of the beds was considered to be established, consisted in the occurrence of the following fossils in the Isle of Wight and at Hordwell:—

Limnæa columellaris, *Sow.*
—— longiscata, *Brongn.*
—— minima, *Sow.*
—— maxima, *Sow.*
—— pyramidalis, *Sow.*
—— fusiformis, *Sow.*
Planorbis cylindricus, *Sow.*
—— euomphalus, *Sow.*
—— lens, *Brongn.*
—— obtusus, *Sow.*
—— rotundatus, *Brongn.*
Ancylus elegans, *Sow.*
Ancillaria subulata, *Sow.*
Melanopsis brevis, *Sow.*
—— carinata, *Sow.*
—— fusiformis, *Sow.*
—— subulata, *Sow.*
—— ancillarioides, *Desh.*
Paludina lenta, *Sow.*
—— concinna*, *Sow.*
—— angulosa, *Sow.*
—— minuta, *Sow.*
Melania costata, *Sow.*
—— fasciata, *Sow.*
—— minima, *Sow.*
—— truncata, *Sow.*
Nerita aperta, *Sow.*
Neritina concava, *Sow.*
Potamides acutus, *Sow.*
—— cinctus, *Sow.*
Potamides concavus, *Sow.*
—— duplex, *Sow.*
—— margaritaceus, *Sow.*
—— plicatus, *Sow.*
—— ventricosus, *Sow.*
—— rigidus, *Sow.*
Fusus labiatus, *Sow.*
Murex sexdentatus, *Sow.*
Helix globosus, *Sow.*
Cerithium funatum, *Sow.*
Bulimus costellatus, *Sow.*
—— ellipticus, *Sow.*
Cyrena obovata, *Sow.*
—— cuneiformis, *Sow.*
—— pulchra, *Sow.*
Corbula nitida, *Sow.*
—— cuspidata, *Sow.*
Venus incrassata, *Sow.*
Mytilus affinis, *Sow.*
—— Brardii, *Fauj.*
Nucula deltoidea, *Lam.*
Potamomya plana, *Sow.*
—— gregaria, *Sow.*
Psammobia solida, *Sow.*
Tellina ambigua, *Sow.*
Pollicipes reflexus, *Sow.*
Unio Solandri, *Sow.*
Serpula tenuis, *Sow.*
Balanus unguiformis, *Sow.*

To these I have to add the following:—

Infundibulum trochiforme, *Lam.*
Melania marginata, *Lam.*
Venericardia (globosa?), *Sow.*
Pleurotoma colon, *Sow.*
Voluta spinosa, *Sow.*
Ostrea flabellula, *Lam.*
—— (crepidula?), *Desh.*
Dentalium entale, *Sow.*

In Mr. Bowerbank's collection I have also seen *Sanguinolaria compressa*, Sow., *Globulus depressus*, Sow., *Modiola elegans*, Sow., and a *Pupa*; in Mr. Edwards's collection the *Cancellaria evulsa*, Sow., *Mitra pumila*, Sow., *Psammobia solida*, Sow., *Lucina divaricata*, Lam., with species of *Scalaria*, *Turritella*, *Tellina*, *Nematura*, *Helix*, new sp., and other genera; and in the collection of the Geological Society presented by Mr. S. Wood, we have *Melanopsis buccinoidea*, *Cyrena deperdita*, *Buccinum desertum*, *Neritina uniplicata*, and *Natica glaucinoides*.

The former of these two lists appears at first sight sufficiently di-

in the Paris basin all the marine formations have their synchronous freshwater deposits—that they are interpolated and not superimposed. For numerous cases in point see his "Essai sur la Formation des Terrains des Environs de Paris," Acad. des Sciences, 1827, and his numerous papers in the Bull. de la Soc. Géol. de France.

* Probably the young of *P. lenta*.

stinct and characteristic. The great bulk of the specimens are named by English naturalists, and few foreign species are given by their foreign synonyms, those which are so being precisely the ones, such as *Limnæa longiscata*, *Planorbis rotundatus*, *P. lens*, &c., which at the period of publication were supposed to be peculiar to the freshwater formations of the Paris basin.

But in reality we have in the seventy-eight species quoted above, (taking also their synonyms) twenty-three French species.

Limnæa pyramidalis, *Brard* and *Sow.* (L. cornea, *Brongn.*)
—— longiscata, *Brongn.* and *Sow.*
Planorbis lens, *Brongn.* and *Sow.*
—— rotundatus, *Brongn.* and *Sow.*
Melanopsis ancillarioides, *Desh.* (M. buccinoidea, *Fer.*)
Corbula nitida, *Sow.* and *Desh.*
Nucula deltoidea, *Lam.*
Cerithium funatum, *Sow.* (Cerithium variabile, *Desh.*)
Potamides cinctus, *Sow.* (C. cinctum, *Desh.*)
—— acutus, *Sow.* (C. acutum, *Desh.*)
—— plicatus, *Sow.* (C. plicatum ? *Lam.*)
—— ventricosus, *Sow.* (C. ventricosum, *Desh.*)
Ancillaria subulata, *Sow.* (Ancilla subulata, *Lam.*)
Globulus depressus, *Sow.* (Natica depressa, *Desh.*)
Infundibulum trochiforme, *Lam.* and *Sow.* (Calyptræa trochiformis, *Desh.*)
Melania marginata, *Lam.*
Voluta spinosa, *Lam.*
Ostrea crepidula, *Desh.*
—— flabellula, *Lam.*
Psammobia solida, *Sow.* (P. rudis, *Lam.*)
Lucina divaricata, *Lam.*
Natica glaucinoides, *Desh.*

NOTE. It is doubtful whether the *Venus incrassata* of Sowerby is synonymous with the *Cytherea incrassata* of Deshayes, a well-known fossil of the lower part of the 'Grès de Fontainebleau.' M. Nyst of Brussels in his recent work * says distinctly that they are not the same species, but that the English species agrees rather with a Belgian one from the sandy calcareous beds of the middle Eocene period.

In addition to these foreign species found in the Isle of Wight, eight English species, viz. *Paludina lenta*, *Cyrena cuneiformis*, *C. deperdita*, *Mya* (*Potamomya*) *plana*, *Tellina ambigua*, *Dentalium entale*, *Pleurotoma colon* and *Cancellaria evulsa*, occur also in France.

Let us now examine the distribution of these thirty-one species in the French strata. Of the whole number I believe that only *Planorbis lens* and probably also *Limnæa cornea* are limited in their range to the 'Calcaires lacustres.' The *Planorbis rotundatus* has been found in some of the divisions of the 'Argile plastique'; and, according to M. d'Archiac, it occurs associated with *Limnæa longiscata* in the upper beds of the calcaire grossier†, but characterizes more especially the overlying freshwater deposits. The *Cyrena cuneiformis* and *Melanopsis buccinoidea* are characteristic of the 'Argile plastique' of the department of the Aisne‡ and the

* Déscription des Coquilles et Polypiers Fossiles des Terrains Tertiaires de la Belgique, p. 181.

† Mém. de la Soc. Géol. de France, vol. v. p. 236; also the Mém. of Constant Prevost.

‡ Mém. de la Soc. Géol. de France, vol. v. p. 303.

Marne*; and in the same formation the *Potamomya plana*, *Tellina ambigua*, *Paludina lenta* and *Melanopsis ancillarioides* occur occasionally; they rarely or never extend higher in the series.

The *Melania marginata*, *Natica depressa* and *N. glaucinoides* range from the 'Lits coquilliers' to the upper calcaire grossier†. The *Corbula nitida*, *Psammobia rudis* and *Voluta spinosa* are well-known calcaire grossier species, but occasionally the latter two range rather higher; the *Cancellaria evulsa*, *Pleurotoma colon* and *Cerithium ventricosum* are met with in the 'Lits coquilliers'; and the *Nucula deltoidea*, *Ancilla subulata*, *Calyptræa trochiformis*, *Lucina divaricata* and *Ostrea flabellula* are found in all the beds from the lower sands to the upper marine and freshwater deposits, and the *Cyrena deperdita* in the 'Grès moyens.'

The relations of the several species of the genus *Potamides* of Sowerby to those of the *Cerithium* of the French authors are rather ill-defined, and, from the great number of unnamed species, the subject requires further investigation. The *Cerithium cinctum* and *C. plicatum* are rather characteristic of the upper marine and freshwater deposits; whilst *C. acutum* and *C. concavum* are common in the upper 'Calcaire grossier,' *C. acutum* and *C. ventricosum* in the 'Lits coquilliers,' and *C. variabile* in the lignites of the 'Argile plastique‡.'

In addition to these recognised species, I have found in the calcaire grossier of Damery a species of Natica and a Fusus, not distinguishable from specimens from Headon Hill.

Thus the representative forms of the period of the 'Sables inférieurs' are more abundant even than those of the formations above the 'Calcaire grossier,' and as a group the forms of this latter deposit evidently predominate.

Referring again to the first list with regard to their geological range in this country, we find the following thirteen in the London clay of Barton, Alum Bay, or Bracklesham Bay:—

Dentalium entale.	Sanguinolaria compressa.
Ancillaria subulata.	Lucina divaricata.
Cancellaria evulsa.	Infundibulum (Calyptræa) trochiforme.
Mitra pumila.	Globulus (Natica) depressus.
Pleurotoma colon.	Modiola elegans.
Voluta spinosa.	Buccinum desertum.
Ostrea flabellula.	

Again, the *Melanopsis fusiformis*, *Paludina lenta*, *Cyrena obovata*, *C. cuneiformis* and *C. deperdita* are well-known and common fossils at New Cross and Woolwich in the beds under the London clay, and the *Cerithium funatum* at Newhaven; and Mr. Sowerby quotes the *Fusus labiatus* as occurring at Woolwich or Plumstead, *Potamomya plana* at Plumstead, and *Neritina concava* at Charlton.

It thus appears that nearly all the species which are known elsewhere show relations with the earlier Eocene strata.

Of the new species (nearly forty in number) at present confined

* Annales de l'Acad. de Rheims, Mém. of Rondot, p. 15.

† Mém. de la Soc. Géol. de France, vol. v. pp. 236, 261 and 272.

‡ Deshayes (Coq. Foss.) quotes the *Melania inquinata* and *Helix dubius* from the Isle of Wight, and M. d'Archiac (Bull. Soc. Géol. vol. x. p. 212) the *Ostrea crepidula*.

to the Isle of Wight, it is to be hoped that a more extensive comparison with the numerous French species which have yet to be described, will establish many analogues. In the meantime they do not of themselves afford sufficient evidence, since they are as likely to be new species of the age of the calcaire grossier as of the Fontainebleau sandstone. It is not from them that we can fix the age of the deposit; but the superposition of the deposit, as determined by their known associates, will on the other hand prove their date. They must therefore for the present be excluded from the scale, and our conclusions must be founded solely upon the evidence of the species which are known in other strata whose position is recognised.

With regard to the vegetable remains of these fluvio-marine strata, they cannot be taken in exact evidence. The *Gyrogonites* occur, it is true, in large numbers in the upper freshwater beds of Paris; but they are also common in some of the plastic clay beds of Epernay, and they occur likewise in the calcaire grossier. The *Carpolithes* also cannot be looked on as characteristic, nor can the animal remains be any longer considered in this light, since the remains of *Palæotherium*, *Anoplotherium* and *Lophiodon*, at first supposed to be characteristic of the period of the freshwater gypseous marls of Montmartre, have been found by M. Robert in the upper calcaire grossier at Nanterre, and since then by others in several places in the calcaire grossier. I have also met with remains of the Lophiodon and Crocodile in the sands above the plastic clay of Epernay*, and M. Ch. d'Orbigny has found them in the calcaire pisolitique at Meudon.

It is therefore, I think, very problematical whether the present grouping of the Isle of Wight tertiary formations, with reference to their foreign equivalents, can be maintained. The evidence is slightly conflicting, but still the weight of it is very considerably in favour of their being on the whole of an older date than that usually assigned to them. The occurrence of a bed of London clay ("B,") supposed to represent the calcaire grossier, succeeded by sands referred to the grès de Beauchamp, and then, as is the case with these formations in the Paris basin, overlaid by a series of freshwater green marls and earthy limestones, countenanced the hypothesis of a like chronological order, by exhibiting a very analogous lithological sequence. But according to M. d'Archiac, about half the fossils found in the grès de Beauchamp are peculiar to it†; and of the other half, which are common also to the calcaire grossier, only about nine species, or not quite three per cent. of the whole, are met with in the lower tertiary beds. In ascending through the lower freshwater, the upper marine and the upper freshwater formations of the Paris basin, a further departure from the fauna of the lower tertiary beds is perceptible, and very few species of the calcaire grossier are met with.

* Bull. de la Soc. Géol. de France, vol. ix., and others. Mr. S. Wood has a fine lower jaw of a Crocodile from Hordwell, and Mr. Bowerbank a palate of Myliobates from Headon Hill.

† Ibid., vol. ix. p. 69. The only one here characteristic is the *Cyrena deperdita*.

To view in its strongest light the palæontological evidence in favour of the supposed synchronism of the Isle of Wight freshwater or fluvio-marine strata with the freshwater strata of the Paris basin, let us now, without breaking the fossils into groups according to the several divisions of these deposits, consider generally all the fossils of this series in the two countries, and see what identity can be established between them. About 400 species are known in these groups in France, and we have found about eighty in England. Now out of this number it appears that not more than ten or twelve species are common in these strata to the two countries; that not one-half of this small number can be regarded as characteristic of the beds over the calcaire grossier, while the majority of these common species range downwards, some into the calcaire grossier and some as low as the plastic clays: whereas a comparison of the fauna of these Isle of Wight fluvio-marine strata with that of the calcaire grossier has shown that out of the thirty-one species having French analogues, as many as twenty-four are found in and below the calcaire grossier, and some of these are characteristic forms. It has also been shown that as many as twenty-two or twenty-three species of this fluvio-marine fauna have been found in and below the London clay; that several of the species most common in the upper group at White Cliff Bay are met with in the middle group; and that no positive line of separation can be drawn there between the London clay and overlying beds, but that they pass palæontologically one into the other.

From this evidence, I am therefore inclined to consider the freshwater and estuary strata of the Isle of Wight to be synchronous or nearly so with the upper calcaire grossier. It may be objected, that, as these strata contain a considerable number of fossils peculiar to them, such cannot be the case. I have already stated why we should refuse to receive these new species as evidence of change of formation. Might we not, in fact, expect that the different geographical position and more freshwater condition of the strata in this locality would cause material modifications in the fauna, although still, as a whole, it may assimilate far more to that of the calcaire grossier and lower beds than to that of the more recent beds of the Paris basin, notwithstanding the prevalence during the accumulation of the latter of hydrographical conditions very similar to those existing during the formation of the Isle of Wight upper Eocene group?

That a parallelism of strata accompanied by identity of organic remains should exist over a sea-bottom subject to constant and variable but slow changes of subsidence and elevation is not probable: the greater deepening in one part than in another would allow both a greater thickness of deposit and a greater development of testacea; a littoral fauna might continue in one place, exhibiting little or no change, and at a distance it might gradually pass into others representing various zones of depth; or again, a rich and nearly constant marine fauna might exist in one part, whilst in another part a slow movement of subsidence or elevation of the same sea-bottom would destroy some genera and species and introduce others, either decreasing their number and bringing in genera of a wider geographical range as the sea deepened, or else by a contrary movement gradually replacing the deep-sea testacea by others inhabiting shallow waters, estuaries and fresh waters. When the sea was once more deepened, the original fauna which had been preserved in a part of the neighbouring seas not subject to the same disturbances might again be distributed over the sea-bottom, so that there might be formed a deposit of small thickness and uniform palæontological character, the equivalent of a series of greater thickness and very variable fauna, but exhibiting nevertheless, as a condition of synchronism, and at each return to similar conditions, a tendency to the development of similar animal life.

With regard to the disturbances which have affected the Isle of Wight tertiary deposits, I have endeavoured to show the probability that a slow and quiet subsidence of the sea-bottom was taking place, commencing at least as early as the deposit of the Bognor beds, and continuing throughout the overlying marine sands and clays, gradually diminishing or ceasing as we reach the fluvio-marine strata, and at that period filling up the estuary and occasionally barring out the sea.

On the subject of the effects of the powerful disturbance by which the strata at Alum Bay and White Cliff Bay have been placed in a vertical position, it is evident that no unconformability of superposition has thence resulted. Commencing at the chalk, the strata are at first inclined at an angle of about 75°. This inclination shortly increases to 88°; and at the upper part of the Bognor beds the strata are slightly reversed. They then continue nearly vertical to the fossiliferous clay stratum "B," where their dip is 80°. From this point upwards through the 250 feet of the London clay a gradual decrease in the dip may be observed. At a distance of 100 feet from the bottom of this bed it is 75°: eighty feet further it is 70°; it then rapidly decreases, first to 68°, and then to 60°. At the junction of the London clay and Headon Hill sands it is only 55°; twenty feet higher it is 45°; and 100 feet above this last point the green marls and limestones have a dip of 21° in the same direction. (See Pl. IX. fig. 1.) It is clear, therefore, that although not affected to the same extent, they are so in equal ratio, the force of the disturbance acting laterally from the chalk at the present sea-level to the lower part of the green marls and limestones. In further evidence of this it will be observed that the end of the green marls and limestones nearest to Alum Bay dips at 21° for a short distance, and that the strata are then fractured—the disjointed edges of the mass nearest to Alum Bay being eight feet below the level of the mass from which it is separated, this mass being prolonged northward at a very slight and uniform dip. (See Pl. IX. fig. 1.) Now this detached mass bears in itself evidence of having experienced the action of a protruding force; for if we prolong the plane of the larger and less-disturbed portion of Headon Hill, we shall find it intersect the plane of this small mass at angles of about 16°, and that the angle of depression, below the principal plane, subtends northward, and that of elevation southward. Since however no general movement of depression of the strata on the north could have produced the corresponding angle of elevation, with the sands below as a fulcrum, it follows that this angle of elevation must have resulted from an elevatory force acting from the south, and consequently must have been the one passing through the Alum Bay strata.

At White Cliff Bay the effects of this disturbance are far more distinctly marked in the fluvio-marine beds. All the lower green marls and limestones exhibit through a thickness of 300 feet a dip varying from 80° to 85°. The operation of the disturbance ends rather abruptly about the centre of the series. At this point the limestone strata Nos. 32 and 34 outcrop at an angle of 82°, but curve immediately and rapidly, and resume, without break, and at a short distance to the northward, a position nearly horizontal. (See Pl. IX. fig. 2.)

It appears therefore that this important disturbance took place subsequently to the formation of the whole of the Isle of Wight tertiary series, but that there is no evidence to show its exact age*. Unlike the slow and comparatively tranquil changes of level in progress during the period we have treated of, this last and great change appears to me to have been one of active agency and of comparatively short duration.

EXPLANATION OF PLATE IX.

Fig. 1. Section exhibited at White Cliff Bay, at the Eastern end of the Isle of Wight.

	Description of Strata.	Thickness of the beds. Feet.	Association of genera and characteristic species in the chief fossiliferous beds.
	Gravel on the top.		
Upper Group. Headon Hill marls and limestone. (Fluvio-marine series.) Upper division.	38. Striped yellow, grey, brown and greenish clays with marly sands and a thin layer or two of hard indurated marl and a few seams of shells.	50?	37. Melanopsis fusiformis. Paludina lenta. Melania fasciata. Cyrena obovata.
	37. Green, and mottled red and green clays and marls.	45	36. Ostrea, 2 sp. Melania fasciata. Cyrena obovata.
	36. Dark grey clay beds and light-coloured indurated marl with *Ostrea*. A few rolled flint pebbles.	10	C. cuneiformis. Potamides acutus.
	35. Very light-coloured marl passing upwards into dark green marl.	5	P. cinctus. Melanopsis. Serpula.
		110	

* In the absence of data in our island to prove the age of this disturbance, we may refer to the opinion of Elie de Beaumont, who considers it to belong to the period of the elevation of the western chain of the Alps, with which it is parallel. This system of elevation, according to the same authority, took place at the end of the tertiary period, and immediately preceding the period of the diluvium and drift. (Recherches sur quelques-unes des Révolutions de la Surface du Globe, p. 65.)

Group	Division	Description of Strata.	Thickness of the beds. Feet.	Association of genera and characteristic species in the chief fossiliferous beds.
Upper Group, continued. Headon Hill marls and limestone (Fluvio-marine series).	Upper division	34. Hard light-coloured limestone with numerous fossils.	110 9	34–31. Limnæa longiscata.
		33. Dark grey marls passing upwards into very light-coloured greenish white marls.	5	Planorbis euomphalus. —— rotundatus.
		32. Light yellow earthy limestone—lower part soft and porous, upper part hard.	12	
		31. Beds scarcely exposed, apparently light green marls passing upwards into laminated grey marls with a few shells*.	80 ?	29–28.
	Lower division.	30. Light yellow limestone.	1½	Potamides cinctus. Cyrena obovata.
		29. Indistinct. Apparently light green marls, sometimes mottled with red, and containing a few shells and nodules of ferruginous clay.	40 ?	—— cuneiformis. Potamomya plana. Paludina lenta. Serpula tenuis.
		28. Alternating beds of striped brown clays and striped greenish grey marls with a few layers of iron sandstone: shells numerous but friable, and much broken.	24	Melanopsis. 26.
		27. Striped ash-coloured and yellow sand.	7	Cyrena obovata. Melania fasciata.
		26. Light green and grey marls, with a few subordinate central layers of ash-coloured and ochreous sands,—a few seams of shells.	39	24. Fusus labiatus. Ostrea flabellula. Cytherea incrassata.
		25. Yellow and light coloured sands.	8	Potamides cinctus.
		24. Alternating brown, grey and greenish grey sandy clays and marls—in places full of shells and small crystals of selenite—passes upwards into a fine ash-coloured sand with impressions of shells.	22	Melanopsis. Neritina concava. Melania fasciata. Cyrena obovata (frequently bored).
		23. White and ochreous sand.	4	Natica.
		22. Compact thick-bedded light greenish grey marly sand with light yellow and brown partings—contains numerous tolerably firm casts and impressions of shells very delicately marked, but no shell remaining.	36	Voluta. Turritella. Fishes, bones, and scales. 21. Terebellum. Voluta spinosa.
		21. Light greenish marl with one bed of lignite, crystals of selenite, and numerous fossils—passes upwards into a laminated brown clay without shells, which again passes upwards into 22.	52	Pleurotoma colon. Ostrea flabellula. Potamides cinctus. Neritina concava. Calyptræa.
Middle Group. London Clay series.	Upper division†.	20. *Headon Hill Sands.*—Fine light yellow sand, with a few ochreous and ash-coloured bands:—passes upwards into a light yellow sand with occasional tinges of red colour, and in the upper part alternating with beds of ironsand. It contains a thin seam of small black flint pebbles, and no fossils.	202	Cytherea incrassata. Venericardia. Fusus labiatus. Melania. Paludina lenta. Ostrea. Planorbis. Bones and scales of fishes. Dentalium entale. Cyrena obovata.
			751	

* And *Gyrogonites*, found by Prof. E. Forbes and Captain Ibbetson.

† This division may be above or below No. 20.

Middle Group, continued. London Clay series.

Division	Description of Strata.	Thickness of the beds. Feet.	Association of genera and characteristic species in the chief fossiliferous beds.
Upper division.		751	
	19. Laminated brown clay passing upwards into massive clayey sand of a greenish-grey colour.	37	
	18. Fine bright yellow sand with a few thin seams of ash-coloured clay.	44	
	17. An imperfectly exhibited series of brown and grey clays, finely laminated with brown and yellow sand, containing subordinate green clays and marls. In the upper part the sand predominates. A few small flint pebbles scattered throughout. Fossils.	162	
	16. Brown clay. Numerous *Foraminifera*, with *Ostrea* and *Venericardia*:—passes upwards into dark greenish marly sand perforated in places by tubes of green-coloured sand containing a few shells and small crystals of selenite.	32	16. Fusus longævus. Corbula revoluta. C. pisum. Dentalium entale. Calyptræa. Turritella. Anomia striata. Natica. Nummulites elegans. Cerithium or Potamides (cinctum). Venericardia planicostata. Ostrea, 3 sp. Flustra.
	15. Light-coloured, compact and fine-grained sandstone.	4	
	14. Imperfectly exhibited. Apparently grey, brown and greenish clays with a few shells—passes upwards into a light yellow sand.	86	14–12. Venericardia planicostata. —— ? globosa. Turritella sulcifera. Calyptræa trochiformis. Ostrea. Corbula globosa. —— revoluta. Anomia. Natica. Dentalium entale.
Lower division.	13. Brownish grey clay and calcareous greensands with a layer of pebbles and numerous shells, but the junction with upper bed not shown. 12. Finely laminated brown clay passing upwards into grey sand, and then into dark grey clay with vegetable impressions. A thin layer of shells about eighteen feet from the bottom.	54	Pectunculus. Nummulites lævigatus. Nucula. Miliolites (Triloculina). Tellina. Turbinolia sulcata. Voluta spinosa. Cytheræa. Teeth of Squalus.
	11. Massive light and dark-coloured slightly calcareous greensand with small soft white calcareous concretions. In the upper half numerous shells and teeth of fishes.	62	11. Pecten cornea. Turritella sulcifera. Nummulites elegans. N. scabra (? lævigatus). Sanguinolaria Hollowaysii. —— compressa. Anomia striata. Dentalium. Venericardia planicostata. Nucula similis. Solen obliquus.
	10. Laminated grey clay with some beds of calcareous greensand, a few layers of ironsand, and one or two beds of lignite about one or two feet thick. A strong ferruginous spring issues from the junction with 11, converting part of the beach into an ironstone conglomerate. ? A few pebbles. Passes into 11.	76	
	9. Calcareous clayey green and ironsand, with numerous shells. Upper part greensand only, with only one seam of shells. Shells grouped in genera.	52	
	8. Alternating beds of greensand and finely laminated grey and brown clay. A few thin seams of lignite—passes into the overlying bed (9.).	18	
	7. Yellow sand.	10	
	6. Grey sandy clay and brown clay finely		
		1288	

	Description of Strata.	Thickness of the beds. Feet.	Association of genera and characteristic species in the chief fossiliferous beds.
Middle Group, cont. (London Clay series.) Lower division.	laminated with yellow sand. A few subordinate beds of impure greensand and seams of iron-sandstone, and a few imperfect septaria. At the bottom ten inches of flint pebbles about the size of a swan's eggs. Vegetable impressions. Few or no shells.	1288 95	
	5. Broad striped sands of various shades of yellow passing upwards into nearly white sand. Two feet of iron-sandstone at the bottom.	98	4. Pectunculus brevirostris. Venericardia. Panopæa intermedia. Nucula. Rostellaria. Fusus. Pholadomya margaritacea.
Lower Group. Bognor beds.	4. Massive brown clay passing upwards into dark clayey greensand, and then into light greenish sand, separated from No. 3 by a layer of small flint pebbles in blackish sand. Shells not abundant. Some septaria.	75	3. Dentalium (Ditrupa) planum. —— ? entale. Venericardia. Pecten ? Cytherea. Turritella. Ostrea flabellula.
	3. Grey and brown clay with some layers of ironsand in one place ten feet thick; lower part more compact, clayey and of brownish grey colour; contains several layers of septaria, with some iron pyrites and rather numerous but very friable fossils*. *Ditrupa* abounds.	232 ?	
Mottled clays.	2. Mottled, red, greenish, puce-coloured and brown clay; predominant colour red. No fossils. Clay used for tiles.	140	No animal remains discovered.
	1. Yellow sand with flints; not exposed; thickness said to be two or three feet.	2	
		1930	

Chalk, in vertical beds. Many fossils, especially small corals. Strike S. 8° E.

Fig. 2. Section exhibited at Alum Bay, on the North-western side of the Isle of Wight.

Gravel, consisting of rather angular chalk flints imbedded in a small quantity of loose yellow sand—passes downwards into yellow and whitish sand with patches and irregular layers of the same gravel.

Upper Group. (Fluvio-marine series.) Headon Hill marls and limestones—Upper division.	75, 74. Whitish sand and thin calcareous sandstone irregularly interstratified with a few hard conglomerates. About ten feet from the underlying clays occurs one foot of brown clay and imperfect lignite, and one foot of greenish marl with shells.	40 ?	75–72. Paludina lenta. Cyrena obovata. C. cuneiformis. Melania fasciata. Potamides concavus. P. ventricosus. Turtle.
	73. Red clay mottled with yellow and green coloured clay and marls and layers of whitish sand.	20	
	72. Greenish grey, brown, grey and yellow laminated sandy clays and marls :—in the upper part numerous very imperfect		
		60	

* Prof. E. Forbes and Captain Ibbetson state that they have observed *Cyprina planata* in these beds (3 & 4).

Upper Group, continued. (Fluvio-marine series.)

Headon Hill marls and limestones—Upper division.

Description of Strata.	Thickness of the beds. Feet.	Association of genera and characteristic species in the chief fossiliferous beds.
crushed shells:—concretions of impure ironstone in the centre.	60 15	
71. Light yellow and brown hard limestone, weathers roughly:—traces of *Planorbis* in patches of clay.	10	
70. Light greenish marly limestone, with one foot of green marl and one foot of red clay beneath.—*Note.* This and the preceding bed become softer and thin out to the eastward.	10	71–62. Limnæa obovata. Cyrena. Melanopsis carinata. Planorbis euomphalus.
69. Series of light green, yellow and brown marls, with a few shells—contains irregular layers of hard siliceous concretions and a few argillo-ferruginous concretions.	20 ?	
68. Light yellow calcareous rock; in the upper part a few angular pebbles. There are two layers of hard siliceous concretions, one in the middle and the other at the bottom. *Planorbis* and *Limnæa* abundant. This rock becomes much softer and more sandy to the eastward.	20	
67. Very soft calcareous rock full of *Planorbis* and *Limnæa*, with remains of *Palæotherium* and *Turtle.*	5	
66. Grey sand.	1	
65. Striped light green sand and marl. Numerous *Cyrena.*	10 ?	
64. Brown sand.	1	
63. Dirty green clay.	1½	
62. Very soft earthy limestone full of *Planorbis.*	1½	
61. Indurated green marl.	4	
60. Light greenish and whitish marls with a few rolled pebbles. *Ostrea* common.	8	61–53. Ostrea, 2 sp.
59. Light green marl.	5	Natica.
58. Greenish yellow sandy marl overlying brown clay. Shells numerous. Traces of vegetables common between the two clays. (? *Gyrogonites.*)	5	Fusus labiatus. Melania fasciata. Neritina concava. Melanopsis.
57. Light green marl; a few shells in the upper part, and three inches of brown clay full of shells underlying it.	4½	Cyrena obovata. Potamides cinctus. P. ventricosus.
56. Indurated marl, with a few shells, and two inches of lignite below.	3	P. concavus. Corbula.
55, 54. Indurated marl overlaid by six inches of green marl—both full of shells.	1½	Balanus.
53. Green marl passing into yellowish green; full of shells.	4	
	190	

		Description of Strata.	Thickness of the beds.	Association of genera and characteristic species in the chief fossiliferous beds.
			Feet.	
Upper Group, continued. (Fluvio-marine series.)	Headon Hill marls and limestones—Lower division.	52. Striped grey clay and whitish sand.	190 10	
		51. Light grey clay.	1	
		50. Light yellow sand.	3	
		49. Light brown clay.	2	
		48. White and yellow sand.	3	
		47. Brown laminated clay with irregular patches of lignite.	1½	
		46. Light green marl interlaminated with grey and yellow sand.	4	
		45. Soft light yellow earthy limestone with shells—contains a central layer of three inches of marl full of shells.	5	45–42. Limnæa.
		44. Light greenish marl with shells.	1½	Planorbis. Melanopsis.
		43, 42. Earthy limestone with a few shells, and underlaid by six inches of calcareous sand full of shells.	1½	
		41. Green marl passing into striped greyish sand and grey clay: very irregular. Shells numerous. One inch of green and black clay underlies it.	6	40–37.
		40, 39, 38. Light-coloured sands underlaid by two inches of dark clay full of shells, and then three inches of a brown calcareous band full of shells. An irregular seam of lignite.	1	Cyrena? Cytherea incrassata. 29. Ampullaria acuta.
		37, 36. Olive-green clay and marl passing into bright green with bands of white sand in the lower part. Few shells.	3½	A. patula. Dentalium costatum. Pleurotoma prisca.
		35. Green marl passing into grey, with an irregular and thin underlying band of lignite.	6	P. macilenta. P. exorta. Voluta lima.
		34. Sandy and dirty green clay.	1	V. luctator.
		33, 32. Sand, speckled brown and white, passing into light brownish white sand.	2	V. spinosa. Fusus longævus.
		31. Mottled green, yellow and red clay, passing into bright ochreous sand; very irregular.	4	F. bulbiformis. F. errans. Conus dormitor.
Middle Group. (London Clay.)	Upper division.	30. White sand (very pure and used for glass-making) passing into yellow clay.	100?	Nummulites lævigatum. N. elegans. Venericardia globosa. Pectunculus scalaris.
		29. Commencing at the top is a black clay with a very few shells in seams and patches—in descending it becomes browner, and very fossiliferous. At point X (see Pl. IX. fig. 1) is a layer of large septaria underlaid by a seam of small flint pebbles, immediately below which is thirty feet of greensand, in which fossils are extremely scarce—this then passes gradually into a brown clay with numerous shells and remains of *Foraminifera*, and then again into green sands with a few very small flint pebbles and traces of vegetable matter, but with few shells. In these beds we find six or seven layers of septaria. (Stratum "B" of Webster.)	280	Sanguinolaria Hollowaysii. Buccinum desertum. Nucula similis. Turritella conoidea. Crassatella sulcata. Corbula globosa. ——— pisum. C. revoluta. Spatangus. Cyrena obovata. Venus? Murex tricarinatus. Rostellaria rimosa. Ancillaria canalifera. Cancellaria evulsa.
			626	

	Description of Strata.	Thickness of the beds.	Association of genera and characteristic species in the chief fossiliferous beds.
		Feet.	
MIDDLE GROUP, continued. (London Clay.)		626	
	28. Yellow sands passing successively into sands of white, yellow and ochreous tints, with six inches of large pebbles at top.	42	
	27. Tough light bluish clay, capped by a thin seam of dark red clay, and passing downward into a brown sandy clay with five layers of lignite, varying in thickness from six inches to two feet.	71	
	26. Bright-coloured sands successively ochreous, striped white and red, white, ochreous, brown (with pebbles), yellow, white, red, striped white and yellow.	77	
	25. Whitish sands succeeded by yellow and yellow and red-striped and brilliant red sands. Three straggling layers of small flint pebbles.	70	
	24. Dark grey clay with a seam of lignite one foot thick. Laminated dark clay with whitish sand and thin lignites. Very light grey lumpy clay with peculiar vegetable remains, and an underlying bed of fifteen inches of finely laminated light grey sandstone. Laminated dark grey clay with lignite and a layer of septaria.	98	28–7. No organic remains of animals yet discovered.
Lower division.	23. Brown, yellow, white, yellow and brown striped sands. Red and yellow sands.	41	
	22. White sands striped with brown.	24	
	21. Pale and bright yellow sands.	13	
	20. Black and brown clay laminated with brownish and whitish sand. The weathered upper edges light-coloured for many yards. Traces of lignite.	60	
	19. Light grey clay.	5	
	18. Whitish light yellow, reddish bright yellow, ochreous and yellow striped sands.	39	
	17. White foliated clay, very fine and compact, and spotted and striped with red.	4	
	16. Yellow sand with a little red. Three inches of iron-sandstone underneath.	11	
	15. Light green sand.	9	
	14. Ochreous sand.	10	
	13. Black clay, passing into whitish sands with seams of lignite, and this again into black clay. Grey sand with partings of grey clay and seams of lignite.	59	
	12. Finely laminated tough brown and grey clay.	17	
	11. Thick-bedded black sand. Passes into (10).	16	
	10. Ash-coloured sand with greenish-coloured stripes. Passes into (9).	17	
	9. Finely laminated grey sand and clay; the clay preponderating.	29	
	8. Grey sand and clay resembling (9), but more sandy.	14	
	7. Bright yellow sand with underlying iron-sandstone.	24	
		1376	

		Description of Strata.	Thickness of the beds.	Association of genera and characteristic species in the chief fossiliferous beds.
			Feet. 1376	
LOWER GROUP.	Bognor beds.	6. Dark brown sandy clay with two layers of septaria. A few remains of shells and traces of plants occur in this bed, together with a seam of small flint pebbles. Top of the bed darkest and most fossiliferous. A small fault dipping 50° W. occurs in this bed.	40	6–4. Panopæa intermedia. P. virgula. Pectunculus brevirostris. Vermetus Bognorensis. Rostellaria Sowerbyi. Pholadomya margaritacea. Turritella imbricataria, var. Pinna affinis. Ostrea, 2 sp. Dentalium (Ditrupa) planum. Venericardia planicosta, var. ? Suessonensis. Pyrula. Calyptræa trochiformis. Natica. Fusus. Corbula. Cerithium. Pleurotoma. Lutraria.
		5. Sulphur-yellow grey sand with seams of dark grey clay. No fossils. Passes into (4).	18	
		4. Dark brown clay, with several layers of septaria, and one thin band of calcareous greenish grey sandstone. The lower part slightly red. At the bottom a thickness of one to two feet is mixed with sand, and contains large rounded flint pebbles. Another layer of small flint pebbles occurs near the centre. Organic remains, which are scarce in the lower part, are numerous higher up, especially in the bed containing the small pebbles. Among the large pebbles at the bottom sharks' teeth are found, and in the lower part of this stratum also Mr. Bowerbank found the *Cancer Leachii*. Reposes upon a slightly uneven surface of (3).	135	
	Mottled clays.	3. Yellow sands and clays with traces of lignite. Irregular.	4	
		2. *Mottled clays* with traces of lignite. The following, in descending order, are the colours of the nine layers composing this stratum. In each layer the colours are mottled:—red and very light bluish grey and yellow; light and dark slate-coloured; red and yellow; brown, red and yellow; red, lavender, puce and yellow; brown and blue; red and grey; grey and brown; blue, red and brown; brown and blue. The layers are indistinctly separable.	86	No organic remains of animals yet discovered.
	Lower sands.	1. Coarsish dirty yellow sand with large flints underlying, of the same character as those of the upper chalk layers, and a few small round flint pebbles.	3	
			1664	

CHALK, with flints. Upper surface worn and uneven.

NOTE.—Mr. Webster's sands and plastic clay include strata Nos. 1 to 28 at Alum Bay, and the London clay of that author is No. 29. The strata are more subdivided at Alum Bay than at Whitecliff Bay, chiefly on account of their being more perfectly exhibited in the former. It should be understood that the lines of separation between the upper and lower divisions of the upper group at Headon Hill are only approximative, and that the lists of organic remains do not include all those found, but are intended to intimate that such species or genera occur in some part of the series associated with others, which are either less abundant or more necessary to the argument, and which therefore in the latter case are mentioned in the text.

2. *Notice accompanying a Specimen of a* Calcareous Band *in the* Plastic Clay *from the Bed of the* Thames. By George Rennie, Esq., F.G.S., Treas. R.S.

The accompanying concrete of shells, clay, &c. was taken from the bed of the river Thames, in Limehouse Reach, about three and a half miles below London Bridge, situate between the City Canal entrance on the east, and the Commercial Dock entrance on the west side. The shoal from which the specimens are taken has been hitherto a great detriment to steam-vessels navigating the above Reach at low water, and measures are in progress to remove the same by means of dredging-engines, which have been in operation for seven or eight months; great difficulty is found in breaking through the strata or crust with the iron buckets attached to the engines, which have been carried away on many occasions, although steel-pointed. Gunpowder is occasionally resorted to to break up the strata, after which it is easily removed. The specimen is about the thickness usually found, resting on a bed of clay, and covered by loose gravel, or Thames ballast, three or four feet deep, which forms the bed of the river*.

March 11, 1846.

T. H. Braim, Esq., Principal of Sydney College, Australia, was elected a Fellow of the Society.

The following communications were read :—

1. *Geological Report on a portion of the* Beloochistan Hills. By Captain N. Vickary.

[Communicated by Sir R. I. Murchison, G.C.S., F.G.S.]

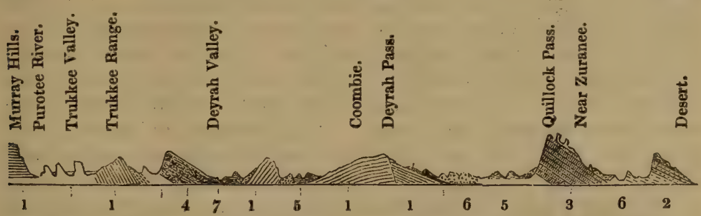
The hill country visited extends from Shahpoor on the western side to Goojeroo on the east, a distance of about ninety miles, and from the sandstone range, bordering the Desert, to the Murray Hills, in a northerly direction about fifty miles. The strike, and the direction of the ranges and of the valleys is nearly east and west, and the mean dip of the beds southerly.

There are seven parallel ranges of mountains gradually increasing in height from the low sandstone range bordering the Desert to the Murray Hills, the most northern point visited. The low sandstone range bordering the Desert was scarcely touched upon, but from its appearance I conclude that it does not differ in structure from the second sandstone range; it dies away towards the west, but appeared to extend in an easterly direction as far as the eye could reach.

* The rock in question is no doubt the representative of the Bognor rocks, and the fossils contained in it are *Cyrena deperdita* and *C. cuneata*, but chiefly the former species.

The second sandstone range in which the Jullock, Gundava, and other passes are situated, extends also to an unknown distance in an easterly direction, but towards the west, near Shahpoor, it approaches and eventually abuts upon the first limestone range.

North. SECTION from MURRAY HILLS to THE DESERT. South.



No. 7. Conglomerate of Deyrah Valley.
6. Sandstones and clays.
5. Bone gravel.
4. Conglomerate.
No. 3. Sandstone of second range.
2. Sandstone of first range.
1. Nummulitic limestone.

I annex a section running nearly north and south, that is, at right angles to the direction of the mountain ranges, and along the pitch of the strata. It is drawn up from memory, and though not exactly correct, is sufficiently near the truth.

Between the place called Ooch and Shahpoor low sandstone hills make their appearance, belonging to the outer range. The dip of the strata is different on different hills, but the mean inclination is south (that is towards the Desert), at about 12°. A diluvial gravel is spread over the whole, the boulders varying from the size of a man's head to the smallest pebble; these boulders are present on the highest parts of the sandstone ranges, and are derived from the nummulitic limestone to the northward; they contain the same fossils, and have the same mineral structure. Ooch is a remarkable place, and deserves a special notice: it is a point upon which I should be disposed to think volcanic force may have formerly acted. It is a valley about half a mile in breadth and two and a half miles in length, and its direction is curved, at first tending towards the east, but soon turning north-east and N.N.E. The sandstone dips *from* the valley on each side at an angle of about 15°, presenting an abrupt face inwards of about 200 feet in height. The surface of the rock is strewed with nummulitic limestone, which consists of gravel with a few small quartz pebbles intermixed, and the sandstone is partially capped with a more recent gravelly sandstone of from two to four feet in thickness, containing numerous Nummulites and a few rolled mollusca. Beneath the sandstone there is an aluminous clay, and the whole is penetrated with veins of foliated gypsum, some of which are of considerable thickness, but neither the sandstone nor aluminous clay afford fossils. The central portion of the valley is highly saline, as are most of the springs; the saline matter (chiefly soda?) effloresces, and could be collected in any quantity. I was told that a tepid spring existed in the centre of the valley, but I was unable to discover it.

From Ooch to Jullock Pass, in an easterly direction forty miles, there is little change in the geological aspect of the country,—the same sandstone beneath, and the surface covered with the same diluvial gravel. The only difference to be noted in the Jullock Pass (the second sandstone range) is, that the sandstone is thrown up to a greater elevation. It is identical with the Ooch sandstone, and is capped with similar nummulitic boulders, while the base is the same fine-grained sandstone as that just mentioned, without fossils*. The elevation of the highest points above the pass is not more than 400 feet, but these elevations form a well-marked range parallel to the limestone ranges on the north, and also parallel to the lower sandstone range flanking the Desert. The direction of the range is nearly east and west, and the dip tolerably regular to about 15° south, or a little to the east of south. There are numerous passes through this range; they are clefts formed at the time the sandstone was upheaved, and the drainage of the mountains to the north is effected through them.

About six miles from the Jullock Pass, in a north-easterly direction, we enter the Mun Valley. We here find, first, low hills of sandstone crowned with considerable quantities of rust-coloured rounded stones, which have apparently been subjected to heat. In some of these hills I remarked that the pebbles formed a distinct bed again capped with sandstone. They contain an inconsiderable quantity of iron, and have much the appearance of having been ejected from a volcano. They are often fissured or hollow, or containing red and yellow ochre, and occasionally sulphur, and even sand. There are no distinct volcanic rocks in the neighbourhood, but I noticed to the westward some small conical hills which I was unable to visit. We next meet with a low range of hillocks distinctly stratified, dipping at about 6° south, composed of a cemented dark-coloured gravel, with considerable quantities of fossil bones imbedded; the bones exist in great numbers, and some were so large and heavy that I found it impossible to carry them away. Proceeding across the valley in a northerly direction, sandstone hills crowned with the same rust-coloured round stones are again found, and it is to be remarked that the nummulitic boulders are also spread over these hills. Proceeding about a mile farther north, we come upon a thin seam of boulder conglomerate resting on nummulitic limestone; the boulders are evidently rolled and waterworn portions of the nummulitic limestone beneath. I observed this conglomerate in many other places of considerable thickness, and I have reason to think that all the boulders and gravel overlying the sandstone hills and outer valleys were derived hence. At Trukkee this conglomerate attains a considerable thickness, amounting to several hundred feet; in other places it is replaced by the sandstone resting directly on the limestone.

Next in descending order comes the nummulitic limestone *in situ*; its usual colour is a very dark blue, in some places changing to a grey, and in others, as at Doza Khooshtie, a pale yellow, and is then

* I had no instrument for ascertaining heights.

arenaceous. In some localities where a deep section was exposed, I remarked that the limestone became slaty in its structure, and contained fewer of the Nummulites and sometimes none. In this lower portion there are fine specimens of a species of *Cancer*; I have been as yet unable to refer it to any described species. The dark blue variety of limestone is intensely hard and sonorous, and has apparently been exposed to considerable heat, by which the calcareous matter of the shells has been volatilized, leaving nothing but casts. This limestone is of great thickness, and is the rock which constitutes all the higher ranges of mountains in this part of Beloochistan.

There are four parallel ranges of mountains formed by this limestone, running nearly east and west, the most northern of which visited, viz. the "Murray range," is the highest, and I imagine reaches an elevation of about 3500 feet above the sea. The rock is easily identified, whenever it occurs, by the vast number of Nummulites it contains, and by its other fossils: the low rocky hills upon which Roree and Sukken are situated are an outcrop of the same limestone containing similar fossils, and in colour resembling the pale arenaceous limestone of Doza Khooshtie. At the upheaving of the limestone a number of deep clefts seem to have been formed, mostly running north and south, or transverse with respect to the mountain ranges: many of these do not exceed ten feet in breadth*, but equal in depth the mountains in which they are formed. That they were not formed by the erosive action of water is apparent, because the salient points on one side (and the fracture is still sharp) have their re-entering points on the other; and in fact a convulsion of nature might again close them, in which case they would dovetail and fit exactly.

All the mountains in this part of Beloochistan exhibit the same effect of great disturbance, and much of the drainage of the country is at present effected through such fissures. The range to which the name of 'Trukkee' is applied is the most remarkable in this respect. These clefts extend even to the sandstone of the outer ranges; but the rock being there of a more yielding nature has suffered from the action of the elements, and the clefts (or passes) are wider, while the limestone usually exhibits them in their original sharp escarpments. I have reason to think that this nummulitic limestone extends over a very large tract of country, specimens brought from the vicinity of the Tukht-i-Sulliman having been shown to me by Lieut. Cunningham of the Bengal Engineers, which certainly belonged to the same formation. A similar rock is used for architectural purposes at Cantuel, and it takes, I was told, a tolerable polish. At Num, where I first came upon this limestone, it dips at about 20° south, passing in that direction beneath the conglomerate and sandstone, about a mile and a half farther to the north. At the pass leading to the Deyrah Valley there is a remarkable slip or fault of the limestone strata, the dislocation amounting to about 300 feet. The limestone at the base here dips at about 20°, that above being

* The breadth of some is even less than I have stated.

nearly horizontal; and at the upper margin of the fault there are some of the strata hanging at various angles. This fault extends east and west of the pass for many miles*.

From this pass, proceeding north, the stratification is nearly horizontal as far as Coombe, a place about 2100 feet above the sea. From Coombe, in a northerly direction, the limestone gradually obtains a dip to the north, amounting at its base to about 20°, and then becomes lost beneath low sandstone hills. I was unable on the line of march to give these interesting sandstone hills the examination they merited; they are composed of various-coloured sandstones, with the strata dipping in a northerly direction at about 10° or often less, thus corresponding so far in dip with the limestone; but the point of connexion between the latter rock and the sandstone escaped my observation: this is to be regretted, as the subject is one of importance. These hills are interesting from the vast quantity of fossil bones and fossil wood which has been entombed within them; both are scattered about in vast profusion, and many cart-loads of the bones could be collected from off an acre of ground.

The wood bears the appearance of having been drifted and water-worn previous to fossilization. I noticed palms and dicotyledonous trees, one of which had a structure resembling pine; some of the broken stems had a diameter of two feet, and the quantity exposed upon a small area was truly wonderful. I could only collect as many of the bones as I could carry on my own person, but amongst these are bones of the mastodon or elephant, portions of the tusk of the same (no molars were observed), part of the jaw of hippopotamus, various bones of crocodiles with broken jaws of the same, and many others which it will take time to make out. Thus it would appear that on the northern and southern base of this limestone range (the first proceeding northwards from the Desert), there are strata having the same character, and that in both places similar fossil bones are found imbedded in a loosely cemented gravel, containing shells of *Paludina* and *Cardium*.

About five miles to the north, advancing towards the Deyrah Valley, a deep-bedded boulder conglomerate is met with; and one mile further the nummulitic limestone again crops out, the strata dipping north at about 45°. This range of limestone forms the southern side of the Deyrah Valley, and, it will be observed, dips into it; at the base it supports a stratum of conglomerate, which is lost in the valley.

The Deyrah Valley stretches nearly east and west, corresponding with the mountain ranges; its mean breadth is about four miles, and its length perhaps forty miles. The soil is alluvial, and is in many places covered with boulders of nummulitic limestone.

The northern side of the valley is flanked with a range of hills composed of stratified boulder conglomerate. The boulders are nummulitic limestone, and the strata dip into the Deyrah Valley

* The point of fracture exposed is highly glabrous, as if it had been exposed to a grinding action.

at angles varying from 20° to 35°: the northern aspect of this range is precipitous.

Immediately north of this conglomerate there is a very narrow valley abutting at the foot of the Trukkee nummulitic limestone range; this valley is broken by many small hills of a conical shape, composed of calcined clays of various colours, containing sulphur and scoria; and these seem to have been volcanic vents emitting gaseous vapours, and perhaps occasionally ejecting stones, but never lava. No igneous rocks exist in the country visited, nor is any rock older than the nummulitic limestone to be found.

The Trukkee range, at the foot of which these appearances are presented, is composed entirely of nummulitic limestone, and attains an elevation of about 3000 feet above the sea. The strata dip southwards towards the Deyrah Valley at angles varying from 45° to 60°, and they form a continuous mural barrier or a natural fortification on a stupendous scale, through which there are many passes formed by clefts in the manner noticed above. I traced this range holding the same mural character for about seventy miles from east to west; and I also noticed other ancient conical hills at its base, about twenty miles east of Deyrah. Near the foot of the same range, at Kissooker, there is a tepid spring. At the time I noted its temperature the air was 70° and the spring 71° of Fahrenheit. There are other tepid springs in these hills, one of which at Doza Khooshtee bursts up through a fissure in the limestone; but I did not note its temperature. From the appearance of the limestone, which in many places at Doza Khooshtee is rapidly disintegrating, and from some calcined clays which I noticed, there is little doubt that an old volcanic vent existed in that neighbourhood.

The Deyrah Valley requires further notice, and appears to have been formed by subsidence; but however that may be, I am certain that the conglomerate at one time rested on the limestone, because there are still detached portions of it resting conformably on the limestone. The opposite or southern side of the Deyrah Valley exhibited the same evidence, although not so distinctly, and a beautiful section of the limestone is seen in the pass or cleft through the Trukkee Hill. The floor of the pass is on a level with the base of the mountain, and the higher (outer) strata are full of fossils; but moving onwards through the pass and towards the north the limestone becomes of a lighter colour, and further on obtains a slaty stratification containing few fossils. From this point to the Murray Hills there are numerous confused and broken hills, at a lower elevation, which have undergone great disturbance, but I was unable to inspect them closely.

The Murray Hills are composed of nummulitic limestone; they present a precipitous escarpment to the southward, and the stratification is nearly horizontal. The range is higher than any of those between it and the Desert.

No minerals of any account were met with. Sulphur and alum exist, but not in sufficient abundance to be of commercial value; but alum is worked further to the eastward, although not in the district visited. Iron exists in small quantities; iron pyrites abound in nodular masses in the limestone, and there are gypseous veins at Doza Khooshtee. When noticing the pale yellow variety of limestone, I forgot to mention that it often contains nodular, ramified or tabular masses of flint, which frequently manifest a resemblance to stems of marine algæ and sponges. Doza Khooshtee and Trukkee are two remote points which exhibit this formation. A white marble, which would answer for statuary purposes, is found in the Trukkee range.

The aspect of the country is barren in the extreme, but in some places there is sufficient soil to repay the cultivation. Near the anticlinal axis of the first limestone range the disintegrated limestone forms a good soil, which has been cultivated. The alluvium of some of the valleys is also fertile, particularly that of Deyrah. The native plants of this region are peculiar, but few in number, not exceeding 200 species.

The hasty examination given to these mountains will, I hope, be a sufficient apology for many defects in the details now furnished. It requires more time than a marching soldier can command, to follow out fully a geological inquiry in a broken and mountainous country. It happened more than once that I passed over most interesting ground during the night, and even in the daytime other duties often required my undivided attention.

I cannot close this report without tendering my sincere thanks to His Excellency Major-General Sir Charles Napier, G.C.B., for the assistance so liberally afforded in giving me carriage for my specimens,—an instance of regard for the interests of science rarely manifested in India.

Description of the Fossils from the Nummulitic Limestone of Beloochistan.*

POLYPARIA, three or four species.

ECHINODERMATA.

Cidaris Schmidelii, Goldf.

A large and fine specimen probably referable to this species, having spines similar to those described by Goldfuss. His species however belongs to the Jurassic series, so that the identity may be doubtful.

Spatangus acuminatus, Goldf. Sow. Geol. Tr. 2nd ser. vol. v. t. 24. f. 23.

—— *obliquatus*. Sow. G. Tr. v. t. 24. f. 22.

—— *elongatus*. Sow. G. Tr. v. t. 24. f. 24.

In the collection there is a crushed specimen nearly allied to this species, but it appears to have had a more ovate form. There are also three or four other species of Echinodermata.

FORAMINIFERA.

Fasciolites ellipticus. Sow. G. Tr. v. t. 24. f. 17.

Nummulites acutus. Sow. G. Tr. v. t. 24. f. 13.

Lycophris Ephippium. Sow. G. Tr. v. t. 24. f. 15.

—— *dispansus*. Sow. G. Tr. v. t. 24. f. 16.

* This description has been drawn up by Mr. Morris.

CRUSTACEA. One or two species.

MOLLUSCA.

Cardium ambiguum. Sow. G. Tr. v. t. 24. f. 2.

Ostrea callifera, Lam. Sow. G. Tr. v. t. 24. f. 7.

Chama —— ?

Spondylus —— ?

Pecten. Two species, and some casts of other genera of Conchifera.

Nautilus —— ?

Globulus obtusus. Sow. G. Tr. v. t. 24. f. 10.

Cypræa depressa. Sow. G. Tr. v. t. 24. f. 12.

Turbinellus bulbiformis. Sow. G. Tr. v. t. 24. f. 11.

An imperfect cast of a specimen probably belonging to this species.

Seraphs —— ? A cast only. The species is the same as that obtained from Baboa Hill, and near to *S. convolutus*, Min. Con.

There are also some other casts of univalves and a Serpula, but they are indeterminable.

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2. *On Markings in the* HASTINGS SAND *Beds near Hastings, supposed to be the Footprints of Birds.* By EDWARD TAGART, Esq., F.G.S.

THIS communication was in the form of a letter addressed to the President, and accompanied a specimen of one of the bodies described. The markings in question appear to have been observed by several persons at Hastings; but they have not been found consecutive, or having any distinct relation to one another. They are of large size, the one presented to the Society measuring sixteen inches in length; but there does not appear, either from this specimen or from the account communicated by the author, any decisive evidence as to their origin.

MARCH 25, 1846.

1. *On the Geology of the* FALKLAND ISLANDS. By C. DARWIN, Esq., F.R.S., F.G.S.

THE Falkland Islands being a British colony, and the most southern point at which palæozoic fossils have hitherto been discovered, I am induced to lay a short account of the geological structure of these islands before the Society. They stretch from 51° to 52° 30′ south, and extend about 130 miles in longitude. My examination was confined to the eastern island; but I have received, through the kindness of Captain Sulivan and Mr. Kent, numerous specimens from the western island, together with copious notes, sufficient to show the almost perfect uniformity of the whole group.

The low land consists of pale brown and bluish clay-slate, including subordinate layers of hard, yellowish, sometimes micaceous, sandstone: in the clay-slate organic remains are exceedingly rare, whilst in some of the layers of sandstone they are extremely numerous, the same species being generally grouped together. Messrs. Morris and Sharpe have kindly undertaken to describe these fossils in a separate notice: they consist (as I am informed by them) of three new species of *Orthis*, which have a Silurian character; three of *Spirifer*, which rather resemble Devonian forms, and approach closely to some of the Australian species described by Messrs. G. B. Sowerby and J. Morris*; one species both of *Atrypa* and *Chonetes*, the latter approaching very closely some of the varieties of *C. sarcinulata* of Europe; an *Orbicula* and an *Avicula*, the species not determinable; and lastly, a fragment of a *Trilobite* and numerous traces of Crinoidea, apparently related to the genus *Actinocrinus*. The concurrence of these several organic forms in this remote part of the southern ocean, giving to the aggregate so close a general resemblance with the palæozoic groups of the north, is an interesting circumstance. None however of the species appear absolutely identical with northern forms, or with the Silurian and Devonian mollusca described by M. A. d'Orbigny from the Bolivian Cordillera; these latter, eleven in number, are likewise all distinct from, though several are most closely related to, northern forms: two crustaceans however and a Graptolite appear to be identical with European species. With respect to the thirty-four or thirty-five palæozoic mollusca from Australia†, Mr. Morris has come to the conclusion that all are new, with the exception of one Terebratula: some of the species, moreover, have required the institution of new genera. Mr. Lonsdale has likewise found that the palæozoic Australian corals are almost all new species. Although the frequent and close general resemblance of the palæozoic fossils in very distant parts of the world is extremely remarkable, especially when we compare intra- and extratropical districts (as in the case of those described by M. d'Orbigny), yet I conceive that the opinion, that the further we look back in time, the more widely distributed the same species of shells were, must be greatly modified.

We should bear in mind, that at the present day shells inhabiting seas, which instead of being divided by impassable barriers of land stretching north and south, are bordered by coasts running east and west or are interspersed with islands, often have enormous ranges: Mr. Cuming informs me, that he has upwards of a hundred species of shells from the eastern coast of Africa identical with those collected by himself at the Philippines and at the eastern coral-islands of the Pacific Ocean: now the distance from these islands to Eastern Africa is equal to that from pole to pole. Under similar circumstances Dr. Richardson has found that fishes have immense ranges. Moreover we should bear in mind, how few genera of shells are confined to particular regions of the world, that is, if we compare

* Strzelecky's Physical Description of New South Wales, &c., p. 279 *et seq.*
† Strzelecky, *ante cit.*, and the Appendix to C. Darwin's Volcanic Islands.

the extra-tropical zones together and the inter-tropical zones together. Hence, from the distribution of existing mollusca, we ought not to feel surprised at the fossil species of the same period, in the most distant quarters of the same great zones, being sometimes identical, or differing only by specific characters. It is however right to add, that not only all the existing shells of the Falkland Islands and of Tierra del Fuego are specifically different from those of the northern hemisphere, but I think that they differ more palpably in form than do the palæozoic species from the same quarters: in this comparison however of the living shells, the littoral species are included; and these no doubt always show the effects of climate and other external influences more plainly than deep-water genera, such as probably were Spirifer and Orthis.

The low clay-slate and sandstone districts of the Falkland Islands are broken by numerous ranges varying in height from a few hundred feet to between 2000 and 2500 feet, and all composed of stratified quartz. This rock varies from an arenaceous mixture to a pure white granulo-crystalline mass; it sometimes contains minute imperfect scales of mica arranged in parallel planes, and often small specks of a white substance, like earthy feldspar, exhaling an aluminous smell, but quite infusible under the blowpipe. Occasionally the rock assumes a curious brecciated appearance (apparently of concretionary origin), in which angular fragments of nearly pure quartz are imbedded in an opake siliceous paste, partly formed of the white earthy matter. I have observed these white and yellowish earthy specks in the quartz rocks of several other countries, and likewise in a calcareous rock in one of the Cape Verd islands, produced by the flowing of submarine lava over a recent shelly mass. The rock in this latter case is compact; and in a series of specimens, the gradual separation of the little specks of earthy matter, either through their mutual attraction, or more probably by the segregating influence of the stronger attraction of the atoms of carbonate of lime, could be most distinctly traced. There is good evidence that the quartz of the Falkland Islands has been softened by heat; and the analogy is so perfect between the little earthy specks in the two cases, that I believe they have been similarly produced.

I nowhere actually saw the superposition of the clay-slate* on the quartz, but in several places on the sea-shore I traced the most gradual transitions between these two widely different formations. It was particularly curious to observe how insensibly the gently inclined planes of stratification in the quartz disappeared, and the highly inclined cleavage-laminæ of the clay-slate, extending in their usual course, appeared: it was impossible to point out where the strati-

* Captain Sulivan seems to have found on the western island subordinate beds of a conglomerate or coarse grauwacke. On this island there appear also to be traces of tertiary and boulder formations, corresponding with those of Tierra del Fuego. Captain Sulivan observed on the western island numerous basaltic dikes.

fication ended and the cleavage commenced. From the manner in which the clay-slate and sandstone often come up on each side to the base of the quartz ranges, I have no doubt that this rock is a lower and more arenaceous formation metamorphosed.

The many parallel ranges of quartz in the eastern part of the group extend east and west, but in the more westerly parts they run W.N.W. and E.S.E.: on the west side, however, of the great Sound between the two main islands, there is, according to Captain Sulivan, a fine range, 2000 feet in height, at right angles to the usual direction, and extending N.N.E. and S.S.W. The outline of the indented coast, and the position of the outlying islets, are in accordance with these axes of elevation. The cleavage-planes of the clay-slate strike almost invariably in the same direction with the quartz ranges: the laminæ are either vertical or highly inclined, generally at an angle above 50°, and dip either north or south, but most frequently to the south. The coincidence in direction (but not in dip) between the stratification of the quartz and the cleavage of the slate was strikingly seen at the western end of the Wickham Heights, which bend from their usual east and west line into a W. 35° N. course; and here at the foot of the hills I found the slate with an almost vertical cleavage striking in the unusual line of W. 30° to 40° N. I may add, that I found on the mainland of South America the cleavage-planes, with a high but variable dip, extending uniformly over extremely large areas, in the same direction as at the Falkland Islands, and in the same line with the prevailing axes of elevation, but intersected at right angles by other subordinate axes: I will not however here enlarge on this subject.

The beds of sandstone included in the clay-slate in the lower and less troubled parts of the island are either horizontal, or dip in various directions, most commonly to the south, at angles between 10° and 20°. I repeatedly observed that the clay-slate had exactly the same highly inclined cleavage above and below these beds. Where this occurred, the sandstone generally broke, when struck, in the line of the cleavage, and transversely to its own planes of division, and the seams were full of fossil shells: Professor Sedgwick* has remarked the same fact in beds of limestone similarly situated; and it shows that the molecular arrangement even of these compact rocks has undergone some change. The strike of the cleavage, although coincident with the main lines of elevation, seems to have no reference to the minor flexures; and it preserves a remarkable uniformity whether the stratification of the clay-slate (distinguishable only by the intercalated beds of sandstone) has remained horizontal, or has been tilted at small angles in various directions. Captain Sulivan, who was so kind as to observe carefully the cleavage of the rocks, has however given me a drawing and minute description of some clay-slate beds, exposed in a cliff on the southern coast, in which the cleavage in some of the beds strikes perpendicularly without having been in the least influenced by the minor flexures; whilst in others

* Geological Transactions, 2nd Ser., vol. iii. p. 477.

it is exactly at right angles to each flexure. The beds have been crushed into numerous successive folds, one of which is represented in the following woodcut.

1.

A, D, F. Beds of clay-slate, with cleavage-laminæ perpendicular to the horizon.
E and part of C. Similar beds, with the cleavage at right angles to every flexure.
B and parts of C. Beds of imperfect, non-laminated clay-slate, with intercalated seams of sandstone represented by the dotted parts.
F. Nucleus or core of clay-slate formed by the lateral crushing of the strata, about two feet high and one foot broad.
These nuclei occur in almost all the folds.

Captain Sulivan states, that in some of the strata the cleavage "in every part, however much twisted, was perpendicular to the horizon;" in others "it was perpendicular to every curve." I have never myself seen an instance of this structure, and I believe it is a new and interesting case.

The remaining facts which I have to give refer entirely to the structure of the ranges, composed of quartz rock. In crossing the eastern island in a N.N.W. and S.S.E. direction, in a line intersecting the head of Berkeley Sound, we find north of it several low, parallel, interrupted, east and west ranges, with their strata all dipping a little west of south, at angles varying between 20° and 40°. South of Berkeley Sound the first range we come to is a short one, rising like all the others through the clay-slate formation: the strata near the summit of the principal hill are most regularly arched, with a curvature of 28° in the line of our imaginary section, and of from 14° to 16° in the line of the ridge: on the summit itself they are horizontal. A regular, flat-topped, oval dome (of which a section is here given) has thus been produced. A valley having been hollowed out near the summit, a very curious scene of natural architecture is presented, which excited the utmost astonishment in the old voyager Dom Pernetti. At the northern and southern base of this hill, the strata, instead of being, as near the summit, dome-shaped, dip directly inwards at angles of 40° and 50°: I have little doubt, from what I saw in other places, that these strata form parts (as shown by the dotted lines in the section) of outwardly bulging

2.

Dome-shaped hill of quartz, with strata dipping inwards at both the northern and southern base.

flexures, produced apparently by the weight of the superincumbent mass on the lower part when in a pasty state.

Proceeding in our southern course, a second short east and west range is met with, formed of three principal hills, of which the first (960 feet high) is anticlinal with a broken summit. The second hill is also anticlinal, with horizontal strata on its broad summit, showing traces of curvature towards the edges: the inclination is rather greater on the south than on the north side. Between this second and third hill there is an anticlinal hillock, the strata on its south side dipping at an angle of 59°, and its summit folded as represented in the diagram. We here see that the upper part of the axis-plane, to use a convenient term of the Professors Rogers, has been pushed over to the south. Throughout the third hill the strata at first appear all conformable, dipping from 50° to 55° N. by E.; but on examination I found a small portion, only fifty yards across in the line of the dip, inclined at an angle of 26° southward; and the tips of the adjoining beds were, as represented in the diagram, abruptly arched. Hence this hill has been formed by a mass of strata doubled on themselves, with the axis-plane thrown quite over to the south, as was the case with the upper part alone in the above-mentioned hillock.

3.

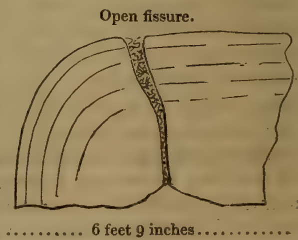
Hillock of quartz with summit of axis-plane thrown over to the south.

4.

Strata of quartz dipping 50° to 55° north, with a fold in the middle, only fifty yards across.

I have described this hill more particularly on account of a curious appearance presented by the arched parts of the strata. The arching has been so abrupt, that in some loose fragments, presenting a natural section, the radius of the curve is seen to be only seven feet. The end section of one such fragment, twelve feet in length, is accurately given in the following woodcut (No. 5), but allowance must be made for a little displacement from an open fissure crossing it. In this case the convex or outer and exposed surface is remarkably even and smooth; it is traversed in the line of the axis of curvature by numerous parallel veins, from the tenth to the twentieth of an inch in thickness, and from half an inch to two inches apart from each other: these often thin out at both ends, but where one thins out, another commences either a little above or below. The veins are partially filled by transverse threads of quartz very

5.

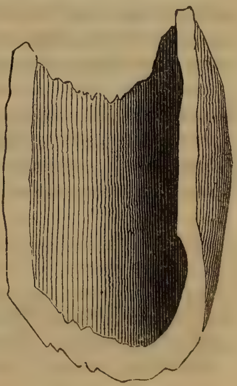


Base of an arched fragment of quartz.

imperfectly crystallized. The quartz-rock must obviously have been in a pasty condition, when it suffered without fracture such abrupt curvatures; and it was impossible to examine these veins without recognising in them the effects of the stretching, and in the fibres or imperfect crystals of quartz, the adhesive nature of the ductile mass *. This hill, as well as the two others in the range, show traces of a *quâquâversal* or dome-shaped stratification; and we can thus understand the occurrence of some few veins at right angles to those numerous ones in the line of the principal curvature; for there must have been some stretching in two directions. I may add that the arched strata in the more regularly dome-shaped hill before described (No. 2), were intersected by a rectangular network of similar veins, almost equally numerous in both directions. All these greatly arched masses of quartz are very brittle.

Referring once again to the fragment last figured (No. 5), it is seen to be divided by interrupted lines of stratification, concentric with the outer and convex and now accidentally exposed surface, but firmly united together. Captain Sulivan however found in another place innumerable similar fragments, in which the concentric layers were separate, so that the ground was strewed with gigantic semi-cylinders of quartz, like draining or ridge tiles; he measured one, represented in the diagram annexed (No. 6) and found it twenty feet in length, with a nearly regular diameter of twelve feet. In this instance the edges or rim on both sides are of equal thickness; but in some other cases, whilst the rim on one side was two feet thick, on the other it thinned off to a knife-edge, evidently in consequence of the unequal pressure it had undergone.

6.

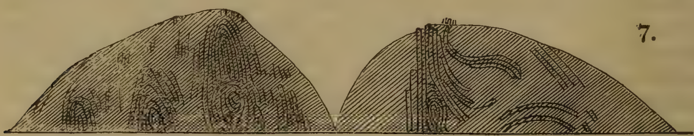


Crossing a wide valley of slate and sandstone we come to the chief mountain-axis of the island, varying from 1500 to 2500 feet in height, and running nearly east and west. The strata on its northern flank dip northward; on the summit, which is from one to two miles broad, they are horizontal; on its southern side they are almost vertical with a southerly dip, and with their summits close to the horizontal beds abruptly arched; so that in this main range we have the same peculiar form of elevation, so common in all the smaller hills. At the southern base the strata were in some places folded in the

* In a paper by M. Elie de Beaumont read before the Soc. Philomathique, May 1839 (L'Institut, 1839, p. 161), it is stated that M. Gaudin was able to draw out threads of melted quartz: M. Gaudin also found that quartz (differently from alumina) retained its viscidity for some time when cooling,—a fact to be borne in mind when we attempt to account for the remarkable flexures which nearly all the quartzose ranges in this island, and likewise in many other parts of the world, have undergone.

shape of upright arched gateways. I may mention that fifteen miles to the westward, at the foot of this same range, I found two hillocks of quartz only twenty yards apart, with the strata dipping at exactly the same angle of 40° to S.S.W., and therefore apparently quite conformable; but on close inspection the ends of the beds on the inner side of one hillock were seen to be arched in such a manner, as to show that they had been doubled on themselves, with the axis-plane inclined at an angle of 40°.

A wide undulatory district of slate and sandstone extends southward of the main range; but on the coast, Captain Sulivan again found two east and west quartz ranges: one of these is transversely intersected by a creek (near Port FitzRoy), and two good sections, a hundred feet in height, are exposed. These are given in the following diagram on account of the complexity of the curvatures,



7.

almost resembling those produced by the mingling together of two viscid fluids; and because in crossing the country any one would be apt to think that the dome-formed hills had been produced by single impulses from below, whereas we now see that perpendicularly beneath one dome, another may lie hidden in the solid rock*.

I will not take up the time of the Society by giving any further details on the geology of these islands; nor would the foregoing account have been worth communicating, had it not been for the interest which is justly taken in ancient fossils coming from a very distant quarter of the world.

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2. *Description of Eight Species of* Brachiopodous Shells *from the* Palæozoic Rocks *of the* Falkland Islands. By John Morris, Esq., F.G.S., and Daniel Sharpe, Esq., F.G.S.

Plates X., XI.

1. Chonetes Falklandica, *sp. n.* Pl. X. fig. 4.—Transversely semi-oval; upper valve convex, with a slight mesial depression; lower valve rather concave; surface covered with fine bifurcating rays

* It is singular in how many points the old quartz-rock of Anglesea, as described by Professor Henslow in his admirable paper in the Cambridge Phil. Trans. (vol. i. p. 359), agrees with that of the Falkland Islands. The quartz of Anglesea is granulo-crystalline, and contains white earthy spots and a little mica; it passes insensibly into an overlying chloritic schist, and this again into clay-slate. The strata have been in a pasty condition, and have been singularly curved: they strike in the same direction with the laminæ of the overlying slates, but their average inclination is less.

crossed by a few concentric lines of growth. Hinge area linear, of the breadth of the shell; hinge line furnished with fine spines.
Width $\frac{7}{8}$ of an inch, length $\frac{1}{2}$ an inch.

This shell so closely resembles some of the forms of the *Chonetes sarcinulata* (*Leptæna lata*, Sil. Syst.) of the Ludlow rocks, that, if found in England, it might probably have been mistaken for a variety of that species; it is however somewhat flatter, more square and rather larger. The spines on the hinge line are not well preserved in the specimens examined, but traces of them may be distinctly seen. The *C. Falklandica* may be considered as belonging to the same group as *C. sordida*, *C. Hardrensis*, *C. Buchiana*, all of which are closely-allied species to the *C. sarcinulata*.

2. ORTHIS SULIVANI, *sp. n.* Pl. X. fig. 1.—Semi-ovate; ventral valve nearly flat, dorsal valve gibbose; surface covered with fine sharp bifurcating striæ, increasing towards the margin toa bout 150, crossed by 3 or 4 concentric lines. Hinge line neal as wide as the shell, hinge area broad and triangular. Interior of both valves striated for about $\frac{1}{4}$ of an inch round the edge, producing a fringed appearance in the cast.
Width $1\frac{5}{8}$ inch, length $1\frac{1}{2}$ inch.

There is a slight resemblance between this species and the *Atrypa reticularis* of the Silurian System; it is however a true Orthis and has a finer striation than that shell; in the latter genus it is most nearly related to an Orthis common to the Coniston, &c. beds of the Silurian formation, about to be described and figured by Professor Sedgwick.

This species has been dedicated to Captain Sulivan, who was employed in the survey of the Falkland Islands, and who materially contributed towards the enlargement of the geological collection from them.

3. ORTHIS TENUIS, *sp. n.* Pl. XI. fig. 4.—Nearly semicircular; both valves flat and covered with fine bifurcating striæ, increasing to about 200 at the margin, and crossed by a few concentric lines. Hinge area of the width of the shell, linear. The cast is scarcely thicker than a sheet of paper and faintly marked by the striæ.
Width $1\frac{1}{2}$ inch, length $\frac{7}{8}$ of an inch.

Nearly allied to the *Orthis expansa* and *O. grandis* of the Lower Silurian rocks.

4. ORTHIS CONCINNA, *sp. n.* Pl. X. fig. 2.—Semi-oval; both valves slightly convex, covered with very fine bifurcating striæ, increasing to about 120 at the margin, and crossed by a few concentric lines. Hinge area of the width of the shell and nearly linear.
Width 1 inch, length $\frac{3}{4}$ of an inch.

This species is closely allied to the *Orthis tenuis*, but it is less flat and of a more rounded form.

5. ATRYPA PALMATA, *sp. n.* Pl. X. fig. 3.—Nearly hemispherical; the ventral valve flat or slightly concave in the middle, with the edges a little depressed, the dorsal valve highly convex; valves with 15 or 16 prominent rounded ribs, equal to the furrows between them. Hinge line less than the width of the shell and nearly straight.

Width $\frac{3}{4}$ inch, length $\frac{5}{8}$ of an inch.

The equal rounding of the ribs and furrows gives a peculiar wavy or palmate appearance to the surface of the shell, which is not of common occurrence, but of which we have instances in the *Atrypa hemisphærica* of our Caradoc sandstone, and in the *Orthis callactis* of Dalman. The resemblance between our species and the *A. hemisphærica* is very striking.

6. SPIRIFER HAWKINSII, *sp. n.* Pl. XI. fig. 1.—Shell transversely elongated; front rounded; 5 imbricated ribs on each side, the two middle ones acute, prominent, and nearly equal to the mesial ridge, which is slightly furrowed; the lateral ribs diminish in importance as they approach the edge; intervening furrows rather wider than the ridges and rounded. Hinge area of the width of the shell, broad and longitudinally striated.

Cast of the dorsal valve; beak prominent, with a deep mesial depression, only 3 ribs distinctly marked on each side towards the front of the shell; rest of the east nearly smooth.

The cast of this species bears great resemblance to that of *S. speciosus* from the Eifel.

Width 2 inches, length nearly 1 inch.

7. SPIRIFER ANTARCTICUS, *sp. n.* Pl. XI. fig. 2.—Transversely fusiform, nearly equivalved, with 20 to 24 prominent, sharp, imbricated ribs; mesial ridge of the ventral valve similar in form to the ribs, but larger and more elevated; mesial furrow of the dorsal valve deep and angular. Hinge area of the width of the shell, very broad and triangular, with well-marked longitudinal lines.

Cast; ribs well-defined; beak of the dorsal valve straight and very prominent, with a deep mesial furrow and a slight furrow on each side.

Width $3\frac{1}{2}$ inches, length $1\frac{3}{8}$ inch; height of hinge area $\frac{5}{8}$ of an inch.

8. SPIRIFER ORBIGNII, *sp. n.* Pl. XI. fig. 3.—Gibbose, nearly semicircular; about 20 prominent, rounded, imbricated ribs; mesial ridge broad, elevated, flattened above and slightly furrowed; mesial furrow deep and rounded. Hinge area of the breadth of the shell, narrow.

Cast; ribs well-defined; beak of the dorsal valve heart-shaped, with a sharp deep mesial furrow and 2 or 3 nearly obsolete furrows on each side; ventral valve, cast of the mesial ridge traversed for the upper half of its length by a sharp slit, which divides the top of the ridge into two points.

Width $2\frac{1}{2}$ inches, length $1\frac{1}{4}$ inch.

The specimens examined of these three species of Spirifer are so imperfectly preserved, that it is impossible to obtain good specific characters; they are however very distinct from each other; but it may be stated that they also bear a general resemblance to the species of Spirifer described in Count Strzelecki's work on Australia, and a careful comparison might be hereafter advantageously instituted with better-preserved specimens.

The number of species collected by Mr. Darwin from the Falkland Islands is too limited to justify any close comparison with the palæozoic fauna of other portions of the globe, still however their allocation is rather interesting: of the eight species above described, all belong to the family of Brachiopoda, which appear to have constituted the chief portion of the fauna of that locality, and there is also a species of *Orbicula* (Pl. X. fig. 5), too imperfect to be described; these are associated with numerous traces of Crinoidal stems, an *Avicula*, and fragments of a *Trilobite*.

The individuals belonging to the various species of *Spirifer* were few in number; those belonging to *Orthis*, *Chonetes* and *Atrypa* appear to have been abundant or rather gregarious in character, just as we find some species of *Terebratulæ* at the present period abounding on the sand and mud-banks beneath the sea.

In their alæform character and the paucity of ribs, the species of Spirifer approach those obtained from the altered limestones and sandstone of Southern Australia and Van Diemen's Land; they likewise bear some resemblance to Devonian species from the Eifel, and to some forms described by M. d'Orbigny from South America.

The Orthidæ, of which the individuals are numerous in the Falkland Islands, have not yet been observed in Australia, and are rarely met with on the continent of South America: as regards their affinity, they bear considerable resemblance to some species of the northern regions which characterise the Lower Silurian strata, as described in the 'Silurian System' of Sir R. Murchison. Thus we cannot attempt to place the beds in the Falkland Islands which have supplied these specimens, on the level of any particular portion of the European scale of formations, but must be contented with saying that they belong to a part of the palæozoic series of which the position is still undetermined. In the intermixture, abundance and analogy of form of the species of *Orthis*, *Atrypa* and *Chonetes*, they bear a still more remarkable resemblance to the collection made by Captain Bayfield from North America.

The *Chonetes Falklandica*, as previously observed, is scarcely separable from *C. sarcinulata*, a species having a wide geographical and vertical range.

The general occurrence and extensive distribution of many species of Brachiopoda, either identical in character or analogous in form, in the palæozoic strata, has always been a subject deeply interesting to the palæontologist, and has given rise to the opinion, that a more equable temperature, a greater uniformity of physical character and surface arrangements may have been instrumental in producing this extension in the northern regions during the palæozoic period; and the valuable researches of Mr. Darwin have also revealed to us that the existing conditions of some portions of the southern hemisphere at the same æra were favourable to the development of other species of the family Brachiopoda nearly related to those which in Northern Europe characterise the rocks of the palæozoic æra.

EXPLANATION OF THE PLATES.

Plate X.

Fig. 1. *Orthis Sulivani*, sp. n.
- *a.* Ventral valve, exterior.
- *b.* Dorsal valve, exterior.
- *c.* Ventral valve, interior.
- *d.* Dorsal valve, interior.

2. *Orthis concinna*, sp. n.
- *a.* Dorsal valve, exterior.
- *b.* Dorsal valve, interior.

3. *Atrypa palmata*, sp. n.
- *a.* Ventral valve, exterior.
- *b.* Dorsal valve, exterior.
- *c.* Dorsal valve, interior.
- *d.* Ventral valve, interior.

4. *Chonetes Falklandica*, sp. n.
- *a.* Ventral valve, exterior.
- *b.* Dorsal valve, interior.
- *c.* Ditto, ditto.

5. *Orbicula* (undetermined).

Plate XI.

Fig. 1. *Spirifer Hawkinsii*, sp. n.
- *a.* Ventral valve, exterior.
- *b.* Dorsal valve, interior.

2. *Spirifer antarcticus*, sp. n.
- *a.* Ventral valve, exterior.
- *b.* Dorsal valve, interior.

3. *Spirifer Orbignii*, sp. n.
- *a.* Dorsal valve, interior.
- *b.* Ventral valve, interior.
- *c.* Dorsal valve, exterior.

4. *Orthis tenuis*, sp. n.
- *a.* Ventral valve, exterior.
- *b.* Dorsal valve, interior.

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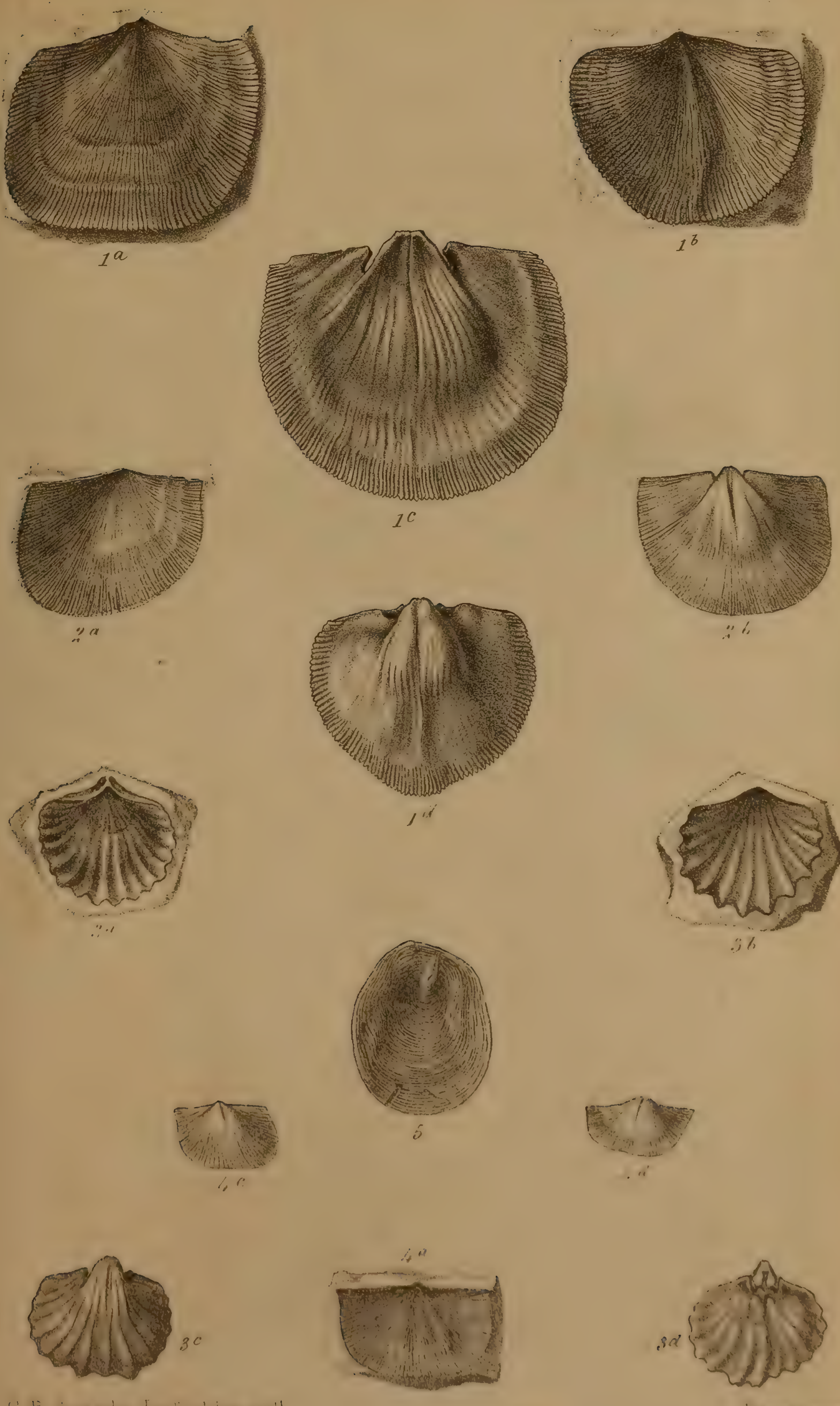
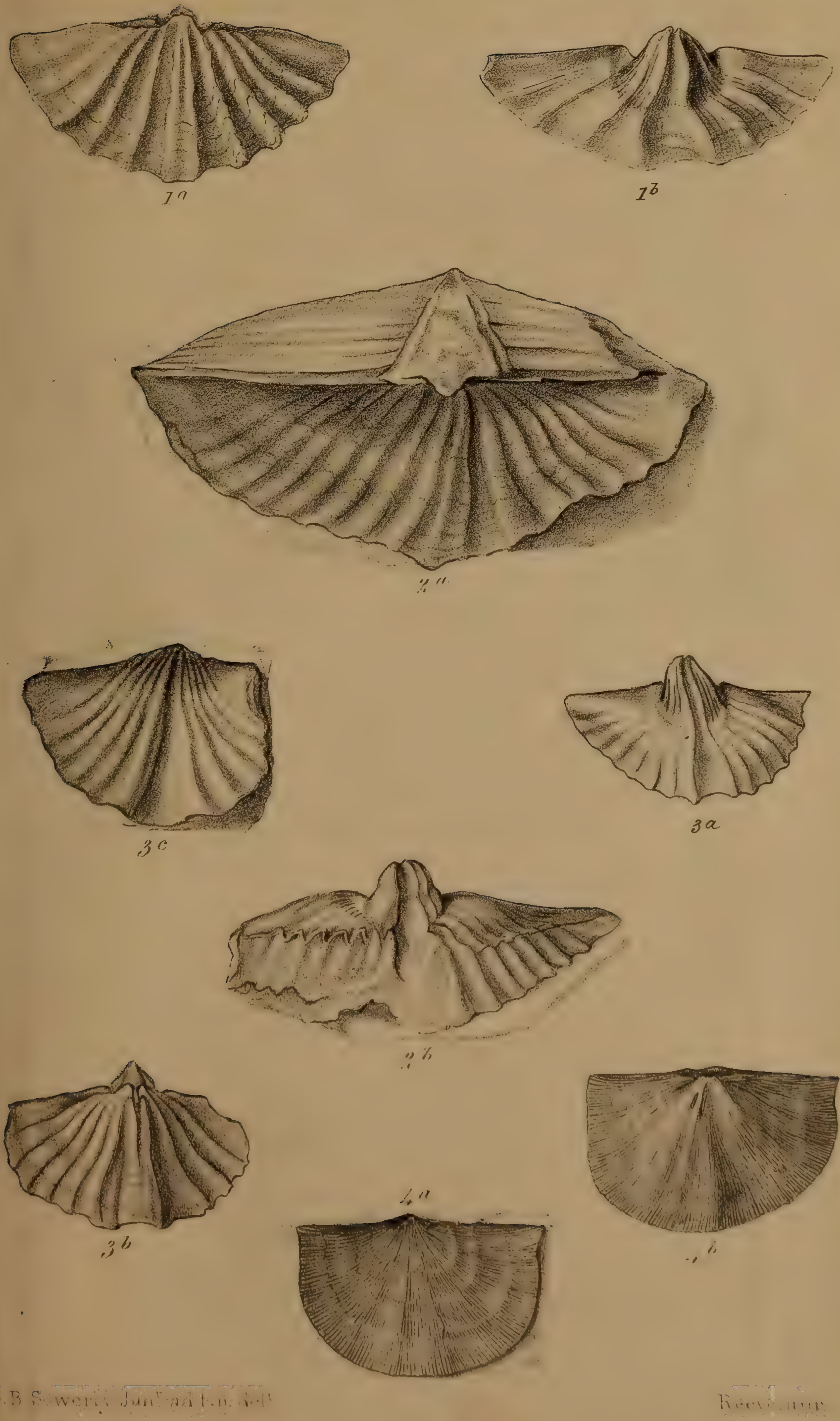
3. *Notice on the* Coal-Fields *of* Alabama; *being an extract from a Letter to the* President *from* Charles Lyell, Esq., F.R.S., *dated Tuscaloosa, Alabama, 15th February* 1846.

Since my arrival in Alabama I have devoted part of my time to the investigation of the carboniferous rocks, and have obtained information respecting some coal-fields, the very existence of which in this State was unknown to me in 1844, when I compiled the Map of the Geology of the United States, published in my 'Travels.' On my way southwards, I had learnt from several persons in Georgia that the city of Mobile was supplied with bituminous coal, brought down the



G. B. Sowerby Junr ad. lap. del.t

Reeve imp.



G. B. Sowerby Jun.r ad nat. del.t

Reeve imp.

Tombecbee River from Tuscaloosa, a navigation of about 400 miles. This coal is procured from the neighbourhood of Tuscaloosa, a place situated near the centre of Alabama, and more than a hundred miles further south in a direct line than the southern limit which I had assigned to the Appalachian coal-field, which I supposed to terminate near the great bend of the Tennessee River.

The fact of coal occurring near Tuscaloosa had been previously mentioned to me by Mr. Conrad, but he was uncertain respecting its age; and the circumstance of its occurrence near the Falls of the river, not far from the northern outcrop of the cretaceous strata, together with the fact of its quality being preferred to all other coal for the manufacture of gas at Mobile, made me suspect that it might prove to be of the age of the Richmond coal, which is also bituminous, situated near the Falls of the James River, and which, as Professor W. B. Rogers has pointed out, is newer than the ancient carboniferous series.

In order to determine on the spot the question in regard to its age, I ascended the Tombecbee from Mobile to Tuscaloosa, where at the University I found Professor Brumby, who had examined with considerable care the geographical boundaries of the productive coal-measures and the structure of the region. With him I made an excursion to some of the pits, or rather open quarries of coal, where the edges of the beds of several seams have been dug into by different individuals entirely ignorant of mining operations, but with no small success, the quality being good at the point of the natural outcrop. I found the coal-seams covered everywhere with beds of ordinary black carbonaceous slate full of impressions of more than one species of Calamite, with ferns of the genera *Sphenopteris* and *Neuropteris*, and impressions of *Sigillaria* and *Lepidodendron*. In some of the beds *Stigmaria* has also been met with not unfrequently, and I recognise a specific identity between several of the most common of these coal plants, and those which I formerly obtained from the mines of Ohio and Nova Scotia. I also observed the complete difference between these fossil plants and those most characteristic of the newer or Virginian coal-field near Richmond, which I lately had an opportunity of examining on my way south. The strike of the coal-beds in Alabama is also, where I have seen them, north-east and south-west, agreeing with the general direction of the Allegany Mountains, of which, geologically speaking, they are evidently a southern prolongation. They are, in fact, portions of the great Appalachian coal-field, with all the same mineral and palæontological characters, the beds having been bent into similar ridges to those of the Alleganies, with corresponding dips to the north-west and south-east; and we have no reason to suppose that Tuscaloosa, in lat. 33° 10′ south, is the extreme southern limit of the formation, for the carboniferous strata are merely concealed from observation south of this point by the lower gravelly and sandy beds of the cretaceous group which extends to Tuscaloosa.

In the eastern part of Alabama, a zone of hypogene or granitic rocks separates the tertiary and cretaceous strata of the Atlantic plain from the older formations of the Allegany Mountains, as is usual along the eastern border of the United States. This granitic formation still appears at Wetumpka on the Alabama River, where the lower cretaceous rocks, as I learn from Professor Brumby, rest on mica schist; but on reaching the Cahawba further west, and the Warrior River at Tuscaloosa, we find the carboniferous strata concealing the granite, and coming, as before stated, into direct contact with the cretaceous rocks, which I have seen resting unconformably upon the coal at the Falls at Tuscaloosa. At this junction the cretaceous group consists of beds of quartzose gravel, such as I have seen intimately connected with cretaceous fossils at Montgomery on the Alabama River. At Tuscaloosa the underlying gray, micaceous sandstone of the coal is full of Calamites and impressions of Lepidodendron and Sigillaria, which I beheld with no small interest, as they constitute, if I mistake not, the extreme southern limit to which the peculiar vegetation of the ancient carboniferous æra has yet been traced, whether on the western or eastern side of the Atlantic. It is due to Mr. Conrad to state, that in an outline map of the Geology of Alabama made during his tour in 1833, and which he presented to me in 1842, with permission to publish any part of it, I find the northern boundary of the lower cretaceous deposits in their course through the States marked out with considerable approach to accuracy.

The several members of the carboniferous series which I have seen while in company with Professor Brumby, within a distance of between thirty and forty miles north-east of Tuscaloosa, consist, first, of productive coal-measures, containing the usual white quartzose sandstones and grits, with greenish and yellowish sandstones, some of which are thinly laminated and ripple-marked, and contain Calamites. These form the highest beds, and below them shales and clays predominate with several subordinate seams of coal, from three to upwards of four feet thick. Below these beds, of which I saw a thickness of many hundred feet, there lies, secondly, a great deposit of quartzose grit, of which millstones are sometimes made, and which reminded me of our millstone-grit, and of the fundamental conglomerate of the Appalachian coal-field. It passes downwards into thinly laminated sandstones and dark slates of small thickness. This group is succeeded (3) by fetid limestones, with chert and hornstone, usually without fossils, but in some of the siliceous beds of which, casts of Encrinites, Producta, Orthis and several corals abound. This inferior formation, which may perhaps belong entirely to the carboniferous series, also contains still lower down a limestone charged with iron; and an enormous mass of brown hematite appears to constitute a regular bed, and not a vein, and to be destined one day, like the coal, to be a source of great mineral wealth to Alabama.

It would have been impossible for me, during my short visit, to form more than a conjectural opinion respecting the structure of this coal-field, still less to determine its geographical area, had not these subjects been previously studied with great care and scientific ability by Mr. Brumby. Of the extent of the coal in Alabama he published a brief account in 1838 in Barnard's Almanac, and communicated the same to Dr. Silliman; and from the observations which we have lately made together, and from his notes and information, it may be inferred that a section from the north-west to the south-east, passing through the basins of the Warrior and Cahawba rivers, would present an anticlinal axis along the line of the watershed between the two rivers, in the middle of which the beds are highly inclined, and often vertical, while on both sides the productive coal-measures occur in separate basins, their strata having a slight dip, and being in many places nearly horizontal. These views will best be explained by the annexed section.

SECTION across the ALABAMA COAL-FIELDS.

Length of section 50 miles.

In regard to the most western of the two coal-fields, or that on the Warrior River (the principal tributary of the Tombecbee), it has been found by Professor Brumby to be no less than ninety miles long from north-east to south-west, with a breadth of from ten to thirty miles, extending through the counties of Tuscaloosa, Walker, Jefferson and Blount, on both sides of the Warrior River and its several branches. Throughout all this area, seams of bituminous coal crop out; but the number and thickness of these it has as yet been impossible to ascertain, no survey having been made. They must however be numerous, for I saw several separated by a slight thickness of intervening strata at points between eleven and twenty miles north-east of Tuscaloosa; and I am informed, that in one place in the bed and banks of the Warrior River three seams are exposed to view, one above the other, the lowest and largest being ten feet in thickness.

The more eastern coal-field, or that of the Cahawba, is nearly of equal length and breadth, terminating southwards at Centreville, where it meets the lower cretaceous beds, and extending from thence through Bibb, Shelby, Jefferson and St. Clair counties, to the source of the Cahawba River. In this also numerous beds of coal of good quality have been found, and worked to slight depths.

A third coal-field on the northern confines of the State of Alabama, is that of the Tennessee Valley. It is separated from the two former by a broad but low chain of mountains, running nearly east and west, which intervenes between the Tennessee and the sources of the Warrior and Cahawba rivers. These mountains, according to Professor Brumby, consist of strata older than the productive coal-measures, and similar to those seen by me in Rook's Valley.

The coal on the Tennessee, above alluded to, may perhaps be continuous with that of the great Appalachian coal-field. I hope hereafter to be enabled to give a more full account of the fossil plants of these Alabama coal-fields, a comparison of which, since they form the extreme southern limit of the carboniferous flora, with those of the north, will deserve particular attention.

London, June 23, 1846.—The above observations were written at Tuscaloosa in February last, and sent from thence to the Geological Society. On my return to England I found the paper already in type, and about to be printed off, but an opportunity having been offered me of adding this note, I submitted the specimens to my friend Mr. Charles J. F. Bunbury, F.G.S., who immediately compared them with published plates and the fossil plants in the Society's collection. The result of his examination confirms the conclusions to which I had arrived, and his specific identification of several of the Alabama remains with well-known European fossils is highly interesting. Although the decomposed state of the matrix in which the plants were obtained, near the outcrop of the strata where the shales are changed into soft, pale, laminated clays, has occasioned the loss of some of the Ferns and Sigillariæ, Mr. Bunbury has nevertheless been able to give a list and description of the following sixteen forms:—1. *Sphenopteris latifolia*, Ad. Brongn. 2. *S. Dubuissoni*? Ad. Brongn. 3. *Sphenopteris*, allied to the last, perhaps a variety of the same. 4. *Neuropteris tenuifolia*, Ad. Brongn. 5. *Neuropteris Grangeri*, or *N. gigantea*? 6. *Calamites cannæformis*. 7. *Calamite*, obscure specimen allied to the foregoing. 8. *Lepidodendron elegans*, var.? 9. *Lepidodendron* allied to *L. dilatatum*, Foss. Flora. 10. *Lepidophyllum*? 11. *Sigillaria*, decorticated. 12. *Stigmaria ficoides*. 13. *Poacites*? 14. *Bechera tenuis*, n. sp., very nearly allied to *B. grandis*, Foss. Flora. 15. *Asterophyllites? flaccida*. 16. *Phyllites*, resembling the leaf of *Sparganium*.

The palæontologist will perceive at once that no less than half of the species in the above list agree with well-known European fossils of the old carboniferous formation, and the rest belong to genera which are common in our coal-measures, and may perhaps agree with European fossils when procured in a better state of preservation. The leaves resembling Sparganium, however, which are very abundant, appear to Mr. Bunbury to be new.

When we recollect that the Tuscaloosa coal is found in lat. 33° 10′ north, and that several of its most common fossils are of the same species as those of Northumberland in lat. 54° north, at a distance of nearly 5000 miles (the broad Atlantic Ocean now intervening), we cannot but be struck with this new proof of the wide extension of a uniform flora in the Carboniferous period, especially as Alabama is situated much farther south than any region in which this ancient flora had previously been studied, whether in Europe or North America. Geologists will therefore rejoice to learn that Professor Brumby is fully alive to the importance of a more full investigation of the plants of the country, of which he will soon, it is hoped, have it in his power to form a large collection.

C. L.


Ormes


Scale of Colours
Metamorphic Rocks
Porphyry & Felstone
CAERNARFON BAY
Porth Dynllaen
Clynog
Criccieth
Barmouth
Bardsey I
Hells Mouth
Rhuddlan
Denbigh
Dutch Bank
The Gimblet
MAP
of
PART OF NORTH WALES,
to illustrate
Mr D. Sharpe's Memoir

PROCEEDINGS,

ETC.

POSTPONED PAPERS.

Contributions to the Geology of NORTH WALES. By DANIEL SHARPE, Esq., F.G.S.

PLATES XII., XIII.

[Read March 6th, 1844.]

THE author made a tour in North Wales, having two objects principally in view: the first, to classify the stratified rocks of that country; the second, to ascertain what are the beds that lie below the Silurian rocks of Sir R. Murchison, and whether those beds contain any organic remains.

After first observing the structure of those parts of the country where the order of superposition in the beds was already known, he proceeded to examine other districts where the arrangement of the rocks is more obscure and complicated.

Upper Silurian Rocks.—Llangollen district.

He began by studying the Llangollen district, described by the late Mr. Bowman*. He agrees with that geologist in referring the Upper Silurian rocks in that neighbourhood, partly to the Ludlow and partly to the Wenlock series of Sir R. Murchison.

Ludlow series.—This series, in descending order, consists of

1. Thin, grey, micaceous beds, containing *Terebratula navicula*, *Leptæna lata*, several species of *Cypricardia*, and other fossils.
2. Liver-coloured shales.
3. Blue shale.

The distinction which exists in the English border counties, between the Upper and Lower Ludlow beds, cannot here be made out; nor is there any trace of the Aymestry limestone. There are so few fossils in the greater part of the Ludlow and Wenlock series in North Wales, that it is by differences of colour or mineral composition that one is often obliged to distinguish them. The Ludlow series is of soft texture, is readily decomposed by weathering,

* See Trans. Geol. Soc. Manchester, vol. i. p. 194.

and is rarely affected by cleavage. The Ludlow rocks of Llangollen dip at a low angle, and pass conformably below the mountain limestone of Eglyseg Crags. To the west and south they are bounded unconformably by lofty hills belonging to the Wenlock series, which appear to have been elevated before the deposition of the Ludlow rocks; and the latter, since they were deposited, appear to have been little disturbed.

Outlier of Mountain Limestone at Guerclas, west of Corwen; and district of Ludlow Rocks west of Corwen, and of the Nant Morwynion fault.—On passing from Corwen along the Holyhead-road to the left bank of the Dee, from Lower Silurian rocks, having an eastern strike, and hereafter to be noticed, you enter on a district of more recent origin, where the beds strike N., N.W., or N.E. The gravel which here covers the valley of the Dee conceals one of the principal faults of the country, the continuation of the Nant Morwynion fault, hereafter mentioned.

On the left bank of the Dee, at the north-east end of Cefn Mawr, is a detached outlier of mountain limestone, about half a mile long and a quarter of a mile wide, which is laid down on Mr. Greenough's map. It is a mile and a half west of Corwen.

It is well-exposed in open quarries, and consists of thick beds of light grey limestone, alternating with dark and black argillaceous shale, agreeing in character with the shale that, in the neighbouring districts of mountain limestone, is found in the lower part of that formation. The author obtained from these quarries many well-known fossils of the mountain limestone. The beds of this mass dip north-east, from a low angle up to 45°.

To the west of the limestone, and underlying it, is a rotten grey shale, readily decomposing into mud; which, at Pont Bryn, a mile further west, dips E.N.E. 45°. To the west of the Druid Inn, on the Holyhead-road, is a quarry of the same rocks, dippping E.N.E. 30°. These beds the author was able to connect with well-exposed beds of Ludlow shale, which stretch along the west side of the Nant Morwynion fault towards the head of the vale of Clwyd*. There, at the distance of about six miles from Guerclas, they pass conformably beneath the mountain limestone range of Pwll Naid, near Llanelidan, a range which extends from that point northwards along the western side of the vale of Clwyd. The Ludlow shale therefore is seen to be continuous from the limestone of Guerclas to that of Pwll Naid.

Wenlock series.—The beds of this series, in descending order, are the following:—

1. Thin beds of hard blue siliceous schist.

2. Light blue shales, with grey streaks of a lighter and darker shade. In the lower part the shales alternate with beds of excel-

* At Tyn-y-Celyn, situate in this district of Ludlow shale, two miles north-west of Bryn Eglws, the author found *Orthoceras filosum* (Sil. Syst. pl. 9. fig. 3). The Ludlow rocks dip very irregularly, and they are unconformable to the Wenlock series throughout the whole of this district west of the Nant Morwynion fault.

lent flagstone, the Denbighshire flagstone of Professor Sedgwick. These flagstones are largely quarried, and are worked along the planes of bedding. They are entirely free from cleavage; whereas a true slaty cleavage frequently affects the shale that alternates with the flagstone.

3. Thick beds of liver-coloured indurated shale, distinguishable only by their position from the similar shales (No. 2) of the Ludlow series.

4. Grey slate, the lowest bed of the Wenlock series according to Mr. Bowman. This slate is very largely quarried in the Glyn and Oernant quarries, north of Llangollen, at the southern foot of Cyrn-y-brain. It is worked along the planes of cleavage; but these being strongly marked by transverse lines of bedding, the slates are liable to split across. The dip of the beds at these quarries is south, from 45° to 80°; the dip of the cleavage is north, 45°.

5. Hard, gritty, blue shales, with lighter streaks, several hundred feet thick. This is, according to the author, the lowest bed of the Wenlock series in this district. Mr. Bowman made the aggregate thickness of the four beds which he describes, 3100 feet; and if to these this fifth bed be added, the aggregate thickness of the series will be about 3500 feet.

To the fossils previously noticed as belonging to this series by Mr. Bowman and Professor Sedgwick, the author adds three new species of *Creseis*, viz. *Creseis ventricosa*, *C. obtusa*, *C. gracillima*, a description of which is given in the appendix to this abstract.

The different species of Creseis are the most abundant fossils in the Wenlock series of North Wales. Frequently they quite cover the bedding planes of the large flagstones; and they occur also in beds of other texture and composition in the middle and lower parts of the series. Hence they are of great assistance in distinguishing the beds of the Wenlock period.

The Wenlock beds cover a considerable area round Llangollen: on the east they are bounded by Ludlow shales and mountain limestone. On the north, their boundary runs from Pant-glas, at the foot of the mountain limestone of Cefn-y-fedw, across Moel-y-faen to Bryn-Eglys. Along this line they rest conformably on the dark roofing-slate which is the uppermost of the Lower Silurian beds. Such a conformity between the Upper and Lower Silurian rocks is rarely observed in North Wales.

From Bryn-Eglys a fault runs in a south-eastern direction down Nant Morwynion to the Dee river, about three miles west of Corwen, and cuts off the Wenlock beds*. From that point on the Dee another fault strikes down that river, and for three miles of its course this second fault separates the Wenlock flagstones of Broneinion on the left bank of the Dee from the Lower Silurian beds on the right bank, at the northern extremity of the Berwyns. At Garth-newydd, about six miles east of Corwen, and south of the Dee, Wenlock rocks appear; and from this point their southern

* The same fault may be traced for many miles to the north-east of Bryn-Eglys.

boundary runs south-east through Llansaintfraid glyn Ceiriog to the mountain limestone north of Selattyn. Along this line the Wenlock beds rest unconformably upon the dark roofing-slate which is the uppermost of the Lower Silurian beds*. North of the Dee the Wenlock beds dip exactly south from 40° to 80°, and the cleavage planes usually dip north 45°. South of the Dee the prevailing dip of these beds is north-east from 5° to 10°; and the prevailing dip of the cleavage is north-east 50°. There are also several other faults, the principal of which are noticed by Mr. Bowman.

Recapitulation of the Author's Bala Section.

Since the author, in the sequel of his paper, makes frequent reference to the succession of Lower Silurian and Cambrian rocks near Bala, of which he has given an account in vol. iv. p. 10 of the Proceedings of the Society, it may be as well, for the clear understanding of the present abstract, to recapitulate the members of his Bala section in descending order. Of these he now ranks the first seven amongst the Lower Silurian beds, and the eighth and ninth amongst the Cambrian.

1. Good dark blue roofing-slate and flags, ending downwards in soft worthless argillaceous slate.
2. Dark blue fossiliferous limestone, with calcareous slates and soft brown shales —the Upper Bala limestone of Mr. Sharpe, and the Hirnant limestone of Professor Sedgwick.
3. Light grey, rather argillaceous schist and indurated shale, with few fossils.
4. Dark blue limestone, with calcareous shales and grits full of organic remains —the Bala limestone of Professor Sedgwick.
5. Very hard, grey, slaty grits, streaked occasionally or passing into brown—fossiliferous. The "Bala grits" of the author.
6. Grey impure limestone—fossiliferous. The Rhiwlas limestone of the author and Professor Sedgwick.
7. Slaty grits of Rhiwlas—fossiliferous.
8. Grey rotten clay-slate, weathering brown.
9. Dark blue slate of poor quality.

Mr. Sharpe now considers that he underrated the thickness of these beds in the paper referred to: in other respects he adheres to the views there given.

Lower Silurian Formation.

Lower Silurian Rocks north of the Dee.—The dark grey slate of Moel-y-faen, north of Llangollen, is the uppermost bed of the Lower Silurian formation: it is of good quality and is largely quarried. The beds dip S.W. by S. 70°; and the cleavage dips N.E. by N. 50°. It is continued through Bwlch-uchaf, on the southern flank of Cyrn-y-brain, when it strikes east. This slate is considered

* The main chain of lofty hills which separates the vale of Clwyd from that of the Alyn consists of Wenlock rocks, which are bounded on each side by a range of mountain limestone. At Moel Acre, near the south end of the chain, Creseis occurs in a hard liver-coloured slaty rock. East of Ruthin is a blue flagstone, alternating with shale, belonging to the middle of the Wenlock series. This chain in Mr. Greenough's map is coloured as belonging to the Ludlow series.

identical with the dark roofing-slate worked near Llansaintfraid glyn Ceiriog.

The high ridge of Cyrn-y-brain consists entirely of Lower Silurian rocks. These are bounded on the north, nearly along the line of the road to Wrexham, by the mountain limestone of Llandegla and the millstone grit of Moel Grugog. To the west the beds of Cyrn-y-brain are cut off by the continuation of the Nant Morwynion fault.

Lower Silurian Rocks south of the Dee.—The dark grey roofing-slate, the uppermost of the Lower Silurian beds, is worked in the vale of the Ceiriog, at the east end of Cefn Canol, west of Llansaintfraid. The same bed is worked on the right bank of the Ceiriog, at the northern foot of Fron Frys.

At Cefn Canol and at Fron Frys the planes of bedding and cleavage meet at the same angle, viz. 15°; but if the position of the two planes at Fron Frys be compared with their position at Cefn Canol, it will be found that each of them has been shifted $22\frac{1}{2}°$ in azimuth and 20° in inclination to the horizon; and this disturbance must have taken place since the planes of cleavage were formed.

	Strike.		Difference in Strike.	Inclination to Horizon.		Difference in Inclination.
	Fron Frys.	Cefn Canol.		Fron Frys.	Cefn Canol.	
Cleavage	E. $22\frac{1}{2}°$ S.	E.	$22\frac{1}{2}°$	N.N.E. 45°	N. 25°	+ 20°
Bedding	E. $22\frac{1}{2}°$ S.	E.	$22\frac{1}{2}°$	N.N.E. 30°	N. 10°	+ 20°
Angle at which the planes of bedding and cleavage meet.	....	....	....	15°	15°	

This bed of dark roofing-slate is continued to the north-west, until it is cut off about half-way between Llangollen and Corwen by the great fault of the Dee. South of the Ceiriog and below the dark roofing-slate of Fron Frys, is a series about 300 feet thick, consisting of rotten schists, full of organic remains; and including two beds of limestone, which have been described by Mr. Bowman and Professor Sedgwick. They dip N.E. 25°.

The lower bed of limestone is not very continuous, but thins off into numerous alternations of thin semi-calcareous bands. The fossils of these beds are much injured by cleavage. In the escarpment west of Fron Frys the author found the following species, besides others mentioned by Professor Sedgwick:—

Orthis costata.	Turbinolopsis elongata.
—— basalis.	—— pluriradialis.
—— n. s.	Favosites fibrosa.
Atrypa globosa.	Retepora, 2 species.

To the south occurs a great outburst of felspathic rocks, which Mr. Bowman has described; and on this line of section the Bala grits appear to be wanting. On following the line of the strike of the Fron Frys beds to Corwen, where there is no outburst of igneous rocks, one meets to the south of that town with a full development of the lower part of the Bala series. Corwen stands on the upper part of the hard, dark grey Bala grits, which in this instance are very slaty.

Proceeding from Corwen southwards, the following is the position of the beds in descending order.

	Dip of Bedding.	Dip of Cleavage.
Immediately south of Corwen	N. 25°	
By the road to Bala	N.E. by N. 15°	N. 63°
Near Corwen	N. 10°	
Softer beds as you approach Llandrillo	N. 5°	
Slate of Nant Cwm Dywyll	N. 30°	N. 55°

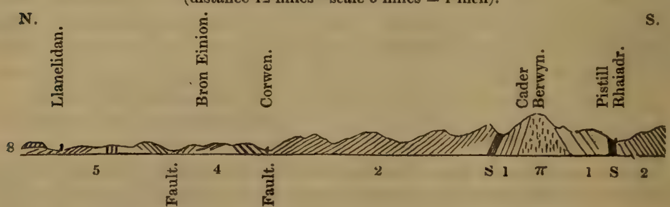
The low dip from near Corwen to Llandrillo accounts for the extent of surface over which the grits are spread. The lower beds, which commence about three miles south of Corwen, become more soft and argillaceous. They extend to about two miles south of Llandrillo, that is, about six miles south of Corwen. There they rest unconformably on a poor roofing-slate, which the author regards as the top of the Cambrian system. The slate is quarried in Nant cwm Dywyll, $2\frac{1}{2}$ miles S.S.E. of Llandrillo, and at the head of Blaen Iwrch, just below and east of Craig Berwyn.

On comparing the Lower Silurian rocks south of the Dee, near Llansaintfraid glyn Ceiriog, with those of the Bala district, the author finds the following points of agreement between them. Taking them in descending order, he finds in both series,—

1. A dark grey roofing-slate.
2. A series of rotten schists containing two beds of dark limestone, and full of Lower Silurian fossils.
3. Grey slaty grits, containing occasionally Lower Silurian fossils.

With this agreement in the mineral character, in the order of superposition, and in the organic contents of the two series of beds, he holds it scarcely possible to doubt of their identity; and especially he regards as fully established the identity of the two limestones of the Ceiriog and of Bala.

SECTION 1. From LLANELIDAN to PISTILL RHAIADR
(distance 12 miles—scale 5 miles = 1 inch).



8. Carboniferous limestone.
5. Ludlow series.
4. Wenlock series.
2. Lower Silurian schists.
1. Cambrian schists.
S. Slate.
π. Greenstone.

Cambrian Rocks of the Berwyns.

The Cambrian rocks form an irregular saddle in the middle of the Berwyns, about fifteen miles long from east to west, and three miles wide from north to south. The upper bed is the slate already mentioned of Nant cwm Dywyll and Blaen Iwrch; and a similar bed is found to the south of the axis, in the valley of the Rhaiadr, just below Pistill Rhaiadr. It is there vertical, and strikes east; and the cleavage dips north-east 5°. It is overlaid by Lower Silurian rocks.

Below the slate is a series of rotten schists, of no very definite character. These run to a great height on both flanks of Cader Berwyn. The summit of Cader Berwyn is a mass of greenstone, having somewhat of columnar cleavage. At the head of the Rhaiadr the schists are altered and disturbed by quartzose rocks, which burst out on the north side of the valley.

The author is not aware of the existence, in these Cambrian schists, of any organic remains. The position of the beds is shown in Section 1.

Anticlinal of Lower Silurian and Cambrian rocks south of the Dee.—The Lower Silurian and Cambrian rocks south of the Dee, considered together, are regarded by the author as forming a great anticlinal, whose axis runs due east through Cader Berwyn. The beds usually strike east and west; but near the Ceiriog there is a tendency to a south-east strike. The cleavage usually strikes east, and dips north, but at so variable an angle as to lead to the inference that the beds have been disturbed since the cleavage took place.

The igneous rocks which break through are mostly felspathic; but some peaks consist of greenstone.

On the north the district is bounded by the Wenlock rocks, along a line the course of which has been already defined. On the east it is bounded by mountain limestone and millstone grit; on the west it is cut off by a great fault which runs along the valley of the Dee from Corwen to Llanderfel, four miles from Bala, and which may be traced beyond Llanderfel southwards, across the moors and up the valley of the Calettwr. The southern boundary of this district has not been examined by the author.

Lower Silurian Rocks on the Holyhead road, from near the Druid Inn west of Corwen to the Conway river.

West of the Druid Inn on the Holyhead road, from the point where the Ludlow rocks already described terminate, to the bridge of Maes mawr fechan, is a narrow anticlinal ridge of hard grey Bala grits. On the east side of this ridge the beds dip E.S.E. 40°, on the west side W.N.W. 50°. The cleavage dip on the east side of the ridge is N. 25°.

At the gorge of Glyn Diffwys is a series of rotten schists, full of Lower Silurian fossils; and between the schists is a bed of dark limestone, which the author considers identical with that of Bala: its position is marked on Mr. Greenough's map. Higher in the series he found some calcareous bands which, he thinks, may represent the Upper Bala or Hirnant limestone. The beds dip in one place

S.S.W. 60°, and in another S.S.E. 60°. A greenstone dyke, running north and south, cuts the beds without disturbing them.

Besides some of the fossils of Glyn Diffwys contained in the list given by Professor Sedgwick, the author found *Orthis radians* (Sil. Syst. pl. 22. fig. 1) and *Favosites fibrosa*.

The rotten schists of Glyn Diffwys rest upon hard blue slaty Bala grits, which contain some Lower Silurian fossils. These are continuous westward from near the sixty-first milestone for nearly twelve miles, across the dreary moors of Cernioge and Pentre Voelas.

In the eastern portion of the district the beds undulate, as will appear from the following table.

Distance from Holyhead.	Dip of the Bala Grits.
m	°
60	E.N.E. 20
58½	N.W. 15
57½	S.E. 30
56½	N.W. 20

In consequence of these undulations they are several times repeated. Their prevailing strike is north-east. They do not extend far to the north of the road, but are covered up, along a line passing nearly east and west, by unconformable Wenlock rocks. The grits found to the east of Cerig-y-druidion split readily along the bedding, and are fossiliferous. The most abundant of the fossils are two unnamed species of *Orthis*, which occur also in the Bala limestone.

Near Yspytty Evan*, a village on the river Conway, the Bala and Hirnant limestones may both be seen, with their attendant upper slate and schists. These beds lie in a sort of trough. About a mile and three-quarters south of the village, on the left bank of the Conway river, the Bala grits are seen, containing an abundance of *Leptæna sericea*. Here they dip N.N.W. 20°. To the north of this point about a quarter of a mile, the Bala limestone appears in a position parallel to that of the grits. Further north, about a quarter of a mile south of the village, the Hirnant limestone, accompanied with fossiliferous schist, crosses the road, its beds dipping north 25°, its cleavage north 60°. North of the village the fossiliferous schist and upper slate abut unconformably against the Bala (?) grits.

Carnarvonshire.

Every traveller on the road to Holyhead, after leaving the forty-seventh milestone, must be struck with the sudden change of scenery. From the dreary moors of Cernioge and Pentre Voelas he passes at once to the picturesque beauty of Bettws-y-Coed, while before him are ranged rugged hills of slate alternating with hornstone and greenstone. This change takes place at a vast dike of greenstone, which forms a high crag on each side of the road. Its course is from S.S.W. to N.N.E. In the latter direction

* In Mr. Greenough's map the occurrence of limestone is marked at Yspytty Evan, and also at Penmachno, a place which the author did not visit.

it passes through Bryn-y-ddinas, and, at the distance of a mile and a half, is lost beneath the Wenlock beds at their junction with the Lower Silurian rocks*. To the S.S.W. it runs along the high hills on the western side of the Penmachno valley, crosses that valley at Moel Machyria, and may be traced in the same direction about two miles further. Throughout the whole of this course, in length about nine miles, it forms a line of abrupt separation between two systems of beds, the system to the east of the dike striking east, the other to the west of it striking north-east.

On the exact line of the direction of the dike, to the further distance of several miles, the beds are in great confusion. The road from Ffestiniog to Bala crosses this line of disturbance at Rhaiadr Cwm, where, at the bottom of the deep and inaccessible chasm formed by the waterfall, the greenstone may perhaps be exposed. On the further prolongation of the same line the greenstone re-appears north of Traws fynydd, and there covers a considerable area. In this, as in the former part of its course, the igneous rock forms the boundary between two systems of beds differing in strike.

The greenstone then bends to the south-west, but its course in that direction cannot be distinctly traced through the intricate number of greenstone rocks belonging to the chain which extends from Barmouth northwards. To the west of this chain the dike is not recovered, but a fault appears, running south-west; and this fault separates the prolongation of the Ffestiniog slates hereafter noticed from the grey slaty flagstones of Harlech. The author endeavoured to connect the bedded rocks of Carnarvonshire with those of Merionethshire, by tracing a section across the line of disturbed beds near Rhaiadr Cwm, where the Bryn-y-ddinas dike does not reach the surface. But he was foiled in this endeavour by a great eruptive mass of felspathic rock, which, a little further to the east, entirely cuts off the beds.

As it appears therefore that Carnarvonshire is completely severed from the rest of Wales, it was from the evidence afforded by the Carnarvonshire rocks themselves, in respect of their position, order of succession, organic remains and internal character, that the author sought to determine their age.

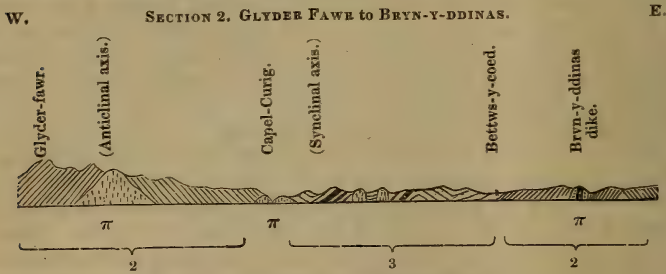
To obtain in the first instance a general section of the position of the beds in Carnarvonshire, he ascertained their dip along two principal lines of section; the first line extending from Bryn-y-ddinas along the course of the Holyhead road to the Menai; the second line passing through Rhaiadr Cwm, Snowdon and Llanberris, to the Menai.

Holyhead Road Section (Section 2).—On approaching the dike of Bryn-y-ddinas from the south-east, the beds of Bala grit are affected by it to the distance of nearly a mile. The dip varies from N.N.E. 15° to N.N.W. 25°, and the cleavage dips N.W. 50°. On the western side of the dike, the beds for $3\frac{1}{2}$ miles dip, at moderate angles rarely exceeding 35°, to the N.W. or N.N.W.: to the north of the Holy-

* The author names it the Bryn-y ddinas dike.

head road the dip is W.N.W. Then for about three miles the dip undergoes frequent changes, owing apparently to the proximity of two dikes of greenstone: then for the distance of more than three

SECTION 2. GLYDER FAWR to BRYN-Y-DDINAS.

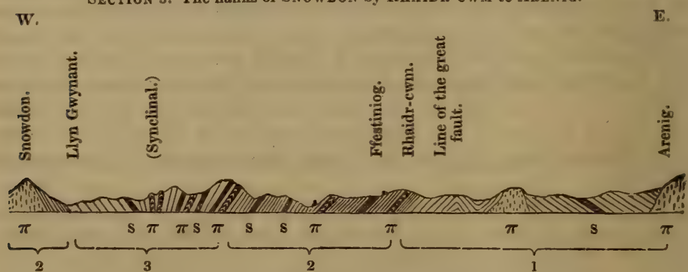


The whole series consists of Lower Silurian rocks.
3. Upper division.
2. Lower division.
π. Greenstone.
This section is the continuation eastward of the section No. 4.

miles the beds dip with great regularity to the N.E., until you arrive at a mass of greenstone in the centre of Glyder-fawr. This greenstone is seen on the Holyhead road in the ridge which separates Cwm Tryfan from Nant-y-gogo. Beyond the greenstone the dip is W., N.W., or N.N.W., for four miles: beyond the thirty-second milestone there are metamorphic rocks and great eruptions of greenstone, and the slates are thrown into great confusion.

Overlooking therefore minor local irregularities, there is a synclinal axis near the forty-first milestone, at the distance of about $5\frac{1}{2}$ miles from the dike, and an anticlinal axis in the centre of Glyder-fawr; and, consequently, the oldest beds in this section will be found on the north-west flank of the Bryn-y-ddinas dike, and also on the sides of the central axis of Glyder-fawr; and the newest beds will be found near the synclinal axis, and again on the north-west flank of Glyder-fawr.

SECTION 3. The flanks of SNOWDON by RHAIDR-CWM to ARENIG.



3. Lower Silurian series. Upper division.
2. Do. Lower division.
1. Cambrian series.
s. Slate.
π. Porphyry and Greenstone.
The section is a continuation eastwards of that marked (5).

Rhaidr-cwm Section (Section 3).—From Rhaiadr-cwm to Cynicht, a distance of about seven miles, the beds dip at considerable angles and with great regularity to the N.W. or N.N.W. On the west of Cynicht, for a short space, they are nearly vertical; and thence to the east flank of Snowdon inclusive, a distance of about four miles, they dip south-east. The centre of Snowdon is much disturbed by greenstone dikes and faults, but its western flank is formed of schists and slate dipping north-west: further westward the section is cut off by great masses of igneous rock.

There is consequently a synclinal axis on the west of Cynicht; and an anticlinal axis in the centre of Snowdon, though on the western side of the anticlinal the beds are very irregularly disposed. In this section therefore the oldest beds will be found at Rhaiadr Cwm on the one side, and in the centre of Snowdon on the other; and the newest beds will be found at the synclinal axis west of Cynicht, and again on the north-west flank of Snowdon at some distance from its centre.

The two sections thus examined in detail give similar results, and establish two principal features in the geology of Carnarvonshire; viz. a great anticlinal axis of elevation along the centre of the Snowdon chain, and a great synclinal axis running parallel to that chain at a distance of about five miles east of the anticlinal axis.

Course of the great Synclinal Axis.—The great synclinal axis of the trough which lies between the Bryn-y-ddinas dike on the one side and the Snowdon chain on the other, may be traced from Trefriw on the Conway, in a S.S.W. direction, to the forty-first milestone on the Holyhead road; and thence, in a south-west direction, to the Traeth mawr, two miles below Aberglaslyn bridge. The course of the axis is generally marked by a band of disturbed beds of unequal width, through which greenstones have forced their way to the surface, either in one great mass or in several minor dikes or ridges. To these belong a dike which runs across the east side of Moel Siabod, Craig-y-llyn-llagi and Yr Arddu, one of the most rugged of the Welsh hills.

Age of the Beds near the Synclinal Axis.—The author has found but few fossils in the beds near the axis of the trough. To the east of the axis in the northern portion of the trough, and to the west of the axis in the southern portion of the trough, he found the fossils hereunder specified at the localities respectively annexed to their names. All the known species in these lists are Lower Silurian species; and the absence of any that are peculiar to the Llandeilo flags renders it probable that the beds near the axis belong to the Caradoc, or upper portion of the Lower Silurian system,—a conclusion which harmonizes with the position of the beds at the top of the series of rocks of the east of Carnarvonshire.

Names of Genera and Species.	East of the Axis, Northern part of the Trough.						West of the Axis, South portion of the Trough.
	Holyhead Road.					Dolwyd-delan Valley.	Cherty bed of Yr Arddu.
	42½ miles.	43 miles.	Bettws-y-Coed.	Water-loo Bridge.	45½ miles.		
Trinucleus Caractaci		+					
Spirifer plicatus			+?				+
Orthis canalis.........		+	+		+	+	
—— basalis? (*Dalm.*)	+						
—— expansa (or O. pecten)							+ +
—— flabellulum		+					+
Leptæna sericea		+		+		+	
Porites pyriformis ...							+

Middle and eastern side of the Carnarvonshire trough.—The beds in the middle and on the eastern side of the Carnarvonshire trough, extending from the synclinal axis to the Bryn-y-ddinas fault, consist of slate and schists, alternating occasionally with hornstone. The author has heard of only two places where limestone has been found; the first to the west of Gwydir Park, on the west side of Nant Gwydir; the other half a mile to the west of Trefriew.

The whole district is intersected by numerous dikes or beds of greenstone, which strike with the beds, and are apparently interstratified with them. They are found however, when minutely examined, to thin out irregularly, and occasionally to cut through the beds: they usually make but little disturbance in the strata; but the greenstones on the lines of the synclinal axis and of the Bryn-y-ddinas fault are exceptions to this rule. The mineral character of the beds however is much altered by these igneous rocks: thus the hornstone is converted, in many instances, into semi-crystalline quartz-rock; and probably the quality of the slates depends very much on the distance or proximity of the greenstones.

The slate-quarries in this district are very numerous, and are only second in importance to those on the western flank of the Snowdon chain; but on the eastern side of that chain scarcely any two quarries are worked on the same bed, and few beds are worked to any great distance: for many a bed, which in one part of its course furnishes excellent slate, in another part, not remote from the former, is found to be so altered in quality as not to be worth working; still, regarded geologically, and without reference to their economical value, the beds of slate are found to be persistent.

Since the direction of the synclinal axis, for the greater part of its course, is north-east and south-west, and that of the Bryn-y-ddinas fault N.N.E. and S.S.W., the breadth of the space included between the axis and the fault increases considerably as you proceed southwards. The prevailing strike of the beds is parallel to the synclinal axis, and consequently, on the eastern side of the trough, the Rhaiadr-cwm section presents a much longer series of beds than the section along the Holyhead road. The synclinal axis near its southern end is formed of a high ridge of greenstone, flanked on both sides by nearly vertical beds of metamorphic quartz-rock, and these form the rugged hill of Yr Arddu. West of this is metamorphic schist of little thickness; and below the schist lies a very hard grey chert or hornstone, faintly affected by cleavage, dipping to the south-east at an angle of 60°. This is the bed of chert already noticed as containing fossils which belong to the upper part of the Lower Silurian system.

The Rhaiadr-cwm section No. 3 passes to the north of Yr Arddu; and on this line the greenstone is divided into two ridges, which are separated by vertical beds of schist. The western of these greenstone ridges forms the very remarkable crag, Craig-llyn-llagi. From this point in the synclinal axis to Rhaidr-cwm, which lies to the south-east, the beds which here constitute the eastern side of the Carnarvonshire trough are traced by the author in the following descending order:—

Upper schists of the Lower Silurian system.

28 Greenstone of Craig-llyn-llagi. Dip of beds N.W. Dip of cleavage 65° N.W.
27 Schist.
26 Greenstone, forming a narrow ridge.
25 Slate which runs up to Cynicht. This perhaps belongs to the same bed as the slate at Llanrhwchwyn, behind Gwydir Park.
24 Semi-crystalline slaty grit.
23 Greenstone.
22 Hard, blue, slaty flagstone.
21 Dark grey slate.
20 Coarse schist.
19 Greenstone, forming a narrow ridge. Strike of beds N.E. by E.
18 Dark slate, of fair quality, near Bryn-gelinnen. It seems identical with one of the beds worked in the great quarries of Dolwyddelan. Dip 45° north-west, of cleavage 65° W.N.W.—Below this point the slates become lighter in colour, and the beds in general become harder than they are above.

Lower division of the Lower Silurian system.

17 Slaty flagstone. Dip of beds 65° N.W. Dip of cleavage 85° N.W.
16 Hard slaty flagstone. Dip of beds 25° N.W. Dip of cleavage 45° N.W.
15 Blue slaty rock.
14 Semi-crystalline chert or hornstone.
13 Blue slate of Moel Wynn. The same bed is worked in the great quarries of Rhiw Brefder, of which see the description, p. 296.
12 Hard schist. Dip 20° N.W.
11 Greenstone interstratified with the schists. To the south it becomes half a mile wide; at the foot of Moel Wynn it thins off; at Rhiw Brefder it is very narrow.
10 Hard schist. Dip 45° to 50° N.W.
9 Thick series of slaty beds alternating with chert or hornstone, seen in the hill above Tan-y-Bwlch. Dip 20° N.N.W.
8 Semi-crystalline quartz-rock, behind Maentwrog.
7 Coarse schist. Dip 30° N.W.
6 Slate of inferior quality, between Ffestiniog and Pant-llwyd. This is the lowest bed of slate worked in this line of section.

Cambrian system.

5 Coarse schist.
4 Greenstone, interstratified, forming a ridge of low crags. Strike of beds N.E.
3 Hard blue schist. Dip 15° N.E.
2 Schist, which continues to Rhaidr-cwm. Dip 40° north-west.
1 Schist, intersected by quartz veins, at Rhaidr-cwm. The beds and cleavage planes are shattered and in great confusion. Dip 20° N., 30° N., and 40° N.E.

In the foregoing section there is no marked change of character in the rocks at those points of the descending series where the author proposes to draw a line of separation between the upper schists and the lower portion of the Lower Silurian on the one hand, or between the Lower Silurian and the Cambrian systems on the other.

On the eastern side of the Carnarvonshire trough, and near the line of the preceding section, are the great slate-quarries which lie to the north-west of Ffestiniog. As these quarries afford great facilities for a minute examination of the beds, the author made a detailed section of these beds, all of which he refers to the lower division of the Lower Silurian formation. The series of slate beds of which the description follows in detail are included in the preceding general account of the strata (see p. 295), in the beds numbered 13 to 7.

Descending order of Beds in the Slate Quarries N.W. of Ffestiniog.

	Bed	Feet.
Mr. Holland's quarry at Rhiw Brefder. The quarry of the Welsh Slate Company is worked in the same beds at a lower part of the same hill.	25 Dark blue slate, not yet worked.	
	24 Blue slate, too hard to work	120
	23 Hard grey chert or hornstone	1
	22 Dark blue slate of good quality	150
	21 Blue slate, too hard to work	120
	20 Hornstone	18
	19 Poor slate	3
	18 Hornstone	6
	17 Dark blue slate, of the best quality	150
	NOTE. All the above beds dip 30° N.W., the dip of the cleavage being 55° N.W.	
	16 A whinstone dyke, which, on the face of the hill, is interstratified with the beds of slate, but, in the quarry, cuts across them.	
	15 Schists	500
	14 Slate, which is quarried	100
	13 Schists	600
Diffws Upper Quarry.	12 Alternations of hornstone and slate, in beds from one to five feet	30
	11 Poor slate	10
	10 Good blue slate	50
	9 Schists, about	100
	8 Whinstone, thinning away towards the top of the quarry.	
Diffws Lower Quarry.	7 Slate, too hard to work	50
	6 Slate, of middling quality	100
	5 Good slate	60
	4 Schist, with some alternations of hornstone; the beds are curved. Dip 10° to 15° N.W.	500
	3 Semi-crystalline quartz-rock	100
	2 Greenstone, interstratified.	
Manod Mawr Quarry.	1 Light grey slate, of indifferent quality. Dip 15° N.W. Dip of cleavage 35° N.W.	150
	Total thickness, exclusive of igneous rocks	2910

NOTE. The beds 14 to 2 inclusive dip 25° N.W., the dip of the cleavage being 45° N.W.

In the Rhiw Brefder quarries the beds are merely intersected by irregular veins of quartz. In the Diffws quarries the rock is soft, and readily splits into slate; and the colour of the slate is lighter and of a more decided blue than in the beds above. Below the beds of the Manod Mawr quarry there are some beds of slate, of inferior quality, and of no economical importance. These lowest beds the author refers, not to the Lower Silurian, but to the Cambrian system.

District between the eastern side of the Carnarvonshire Trough and Arenig.—It has been before stated that the author endeavoured to connect the beds on the east side of the Carnarvonshire trough with those in Merionethshire, by prolonging his line of section across the pass of Rhaidr-cwm in a south-eastern direction; and that he was foiled in this endeavour. The following are the rocks that he met with in that line of section.

The schist that is the lowest rock on the west side of the fault of Rhaiadr-cwm, is found also to the east of the pass, dipping first east 25°, then north-east 30°; and further east it forms a poor slate, dipping north 20°, and resting on the eruptive mass of Moel-llech-wydd-gwyn, which wholly cuts off the stratified series. This igneous mass consists of quartzose felspar-rock and porphyry, and belongs in point of date to the porphyry of Cader Idris. Between this mass and the porphyritic chain of Arenig, schistose rocks occur of variable character; and towards the south-east these rocks are found dipping north-east from 30° to 45°: but on the road to Bala two lines of felspathic rock, proceeding to the N.N.W. from Arenig-fawr, intervene to complicate the section. Between these two lines is a hard blue schist dipping north-east 30°. At Tai-hirim, at the south-west foot of Arenig-bach, is a quarry of poor slate, which dips north-east 30°*. Arenig-bach forms the northern extremity of the porphyritic chain of the Arenigs, which is fourteen miles long, and reaches southward nearly to Cader Idris. On the line of section No. 3, the porphyritic mass of this chain is nearly two miles wide. In the centre it consists of grey and black porphyry; on the flanks the porphyry is usually flesh-coloured, passing into an amorphous quartzose felspathic rock. The beds which lie to the west of Arenig were described by the author in a former paper (see Proc. Geol. Soc. vol. iv. p. 10).

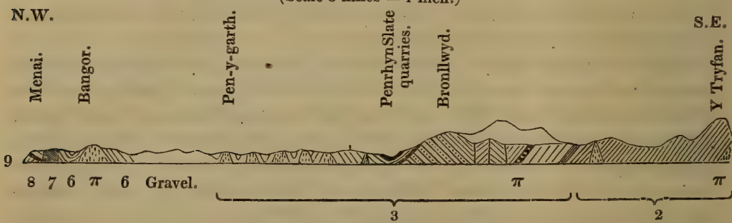
Western side of the Carnarvonshire Trough.—The position of the beds which lie between the synclinal axis and the valley extending from Capel Cerrig to Beddgelert, leads to the inference that these beds are the equivalents of the rotten schists of Merionethshire, which lie above the Bala grits. The beds in question are hard, grey, slaty grits, alternating with slate, grey hornstone or quartz-rock; rocks very different in their mineral character from the schists which they are supposed to represent; but this difference may be attributed to the numerous dikes and interstratified beds of greenstone by which this Carnarvonshire district is traversed; whereas that of Merionethshire is quite free from igneous action. The aggregate thickness of these beds is much greater than that of the rotten schists of Merionethshire.

The valley which reaches from Capel Cerrig to Beddgelert is the line of a considerable fault. To the west of this fault, as far as the eastern sides of Glyder-fawr and Snowdon, are hard grey schists and schistose grits. These the author regards as the equivalents of the

* The bed which is next to the porphyritic rock is so often found to be a true slate, that this character, when it occurs under such circumstances, must be attributed to metamorphic action.

slaty grits of Bala. These are the oldest beds in Glyder-fawr; but the centre of Snowdon consists of older rocks, which are considered by the author to belong partly to the Cambrian system.

SECTION 4. The MENAI to Y TRYFAN, the axis of GLYDER-FAWR.
(Scale 3 miles = 1 inch.)



9. New red sandstone.
8. Carboniferous series.
7. Old red sandstone.
6. Ludlow shale.
3. Lower Silurian. Upper division.
2. Ditto. Lower division.
π. Greenstone.

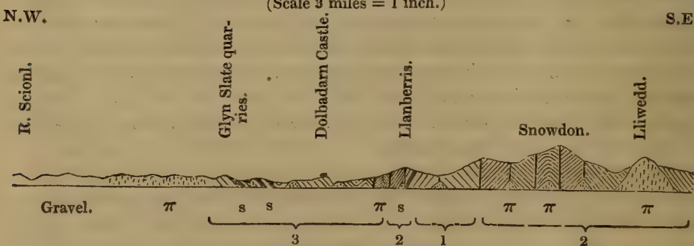
This section is the continuation westward of No. 2.

Western side of the Snowdon Chain (Section 4).—On the line of the Holyhead road the hard slaty grits continue from the central greenstone axis of Glyder-fawr about three miles. At Cwm Perfedd they are overlaid by a series of softer beds, consisting of schists and slate, with occasional alternations of hornstone. These belong to the upper division of the Lower Silurian formation.

Between these beds and the Penhryn slate the section is interrupted by the elevation of the metamorphic rocks of Bronllwyd, which consist of semi-crystalline grits, becoming, in the lower beds, more and more crystalline, until they can hardly be distinguished from greenstone. This grit alternates with thin beds of schist, and the whole mass preserves its bedding and cleavage unaltered. It dips south-east 45°; the cleavage dips north-west 80°.

These rocks are overlaid unconformably by the purple slate of the Penhryn quarry. These slates are of so much importance, that the author describes them under a separate head.

SECTION 5. From near the MENAI to the east flank of SNOWDON through LLANBERRIS PASS.
(Scale 3 miles = 1 inch.)



3. Lower Silurian. Upper division.
2. Ditto. Lower division.
1. Cambrian.
s. Slate.
π. Greenstone.

This section is a continuation westward of No. 3.

On the continuation of the line of section passing through Snowdon, the author regards as Cambrian some of the schists which are seen in the pass of Llanberris, and among these he ranks the bed which is quarried for slate opposite Llanberris Church. Owing to the extreme complication of this part of the section and the altered condition of many of the beds when near to the greenstone dikes, he draws the line of separation between the Silurian and Cambrian rocks with great doubt of its correctness.

A little to the west of the church, on the south side of the Llanberris Pass, the Cambrian rocks are cut off by a great fault, which is remarkable for severing in twain an arch of greenstone. In the metamorphic schists above the greenstone a copper-mine is worked. Westward of the fault are metamorphic slates and slaty grits, which probably belong to the Bala grits. These are followed by softer schists and slates, which, when near the greenstone dikes, are altered and disturbed. This series, as was the case on the Holyhead road, is overlaid by the purple slate. Beyond this is a great mass of igneous rocks, which are covered on the west by gravel.

Purple Slate of the Western side of the Snowdon Chain.—The purple slate-bed of the quarries of Penhryn, Llanberris, &c. is, in an economical point of view, the most important bed in North Wales, supplying, as it does, more than half of all the slates which are raised in the Principality.

The slates that are worked on the west of Snowdon are regarded by the author as all belonging to one bed, which, having been much tossed about by the greenstone, is repeated many times in some localities. On the Holyhead road*, its first appearance towards the west is in the Penhryn quarry. It there lies in a trough between the metamorphic rocks of Bronllwyd on the east, and a ridge of greenstone on the west. The bed being equally upheaved on both sides, dips towards the middle of the quarry at an angle of about 45°.

The effect produced by the doubling up of the bed is shown, at the back of the quarry, by a mass of broken and curved slate which fills the middle of the trough, and is there squeezed up together. The axis of the trough strikes north-east, as do the planes of cleavage in all parts of the quarry, including the crushed portion. These planes dip south-east, from 80° to 85°, with great regularity, showing that the elevating forces had ceased to act before the cleavage took place. The peculiar position of the beds has been taken advantage of in working the quarry, which is disposed in terraces that give it nearly the form of a Roman theatre.

The author estimates the thickness of the bed of good slate at not more than 200 feet, though it appears greater, owing to the filling-up of the trough with crushed portions of its upper part. The slate is of a rich purple colour, with green spots and green lines at the junction of the beds.

Below the fine slate lies another bed of slate of the same colour, but too hard for use; and beneath that is a bed of hard, green slate-rock. Then follow coarser schists, which rest on the igneous rocks.

* See Section 4.

These beds are seen on both sides of the quarry. The trough of slate crosses the Holyhead road, but is not worked to the north of it.

To the west of the Penhryn quarries the same purple slate is repeated three times between ridges of greenstone:

1. On the west of Bethesda, where it dips north-west.

2. At Coet-mor and at Tan-y-Bwlch, where it dips south-east 50°, and is underlaid, as at Penrhyn, by green slate. The quarries at these places are of considerable extent.

3. At Pont-y-Coetmor and Bryn, where it dips south-east 30°.

At all these places the planes of cleavage strike, with the beds, north-east, and dip south-east from 80° to 85°.

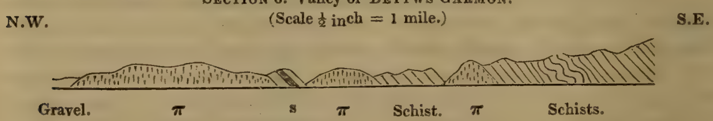
The purple slate is worked on a large scale near Llanberris, but the beds worked on the opposite sides of the valley are in different positions, as a considerable fault runs along the pass*.

On its northern side are the great Dinorwig quarries, which are worked on three apparently different beds, which may be only one bed repeated owing to local disturbance, all dipping W.S.W. 60°; the cleavage dipping E.S.E. 70°. On the same side of the pass, opposite the middle of Lake Padarn, and again below the middle of that lake, the purple slate is seen lying between great eruptive masses of greenstone.

On the south side of the pass, the slate is first seen at the seventh milestone, dipping west 20°. Here it is separated from the Glyn quarries by a narrow dike of greenstone. These quarries are worked upon two beds, which are separated by some irregular masses of greenstone. The beds dip south-east 55°; and the cleavage is vertical, and strikes, with the bedding, north-east. The slate rests on metamorphic rock; and below that are greenstones and other igneous rocks, forming a band two miles wide, the western edge of which is covered by gravel.

Section 6. Valley of Bettws Garmon.

(Scale ½ inch = 1 mile.)



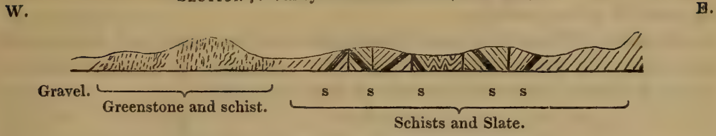
π. Greenstone. s. Slate.

At Bettws Garmon, on the road from Beddgelert to Carnarvon, the purple slate occurs only once; it lies between two beds of greenstone. The beds dip south-east 45°, that is to say, towards the Snowdon chain: the cleavage dips north-west 85°. The slate is of the usual purple colour with green spots, but is of indifferent quality; the workings are on a very trifling scale.

Further south, in the valley of Llanllyfni, the purple slate is thrown up several times, owing to faults and to eruptions of greenstone; in consequence of which it is worked very largely, on no less than six different lines. The colour and quality of the slate are the same as at Penhryn and Llanberris. The beds strike north-east, and dip either north-west or south-east. The cleavage strikes

* See Section 5.

Section 7. Valley of Llanllyfni (north side).



south-east, and does not vary more than 10° on one or the other side of the vertical plane. The most easterly part of this slate dips north-west 65°, and it there rests conformably on the schists of the Snowdon chain.

The purple slate extends about two miles to the south of the valley of Llanllyfni, but it is not worked beyond that valley. The slate, where it terminates, is cut off by a system of rocks striking east and west.

Notwithstanding the repetitions shown in sections 4, 5 and 7, the author considers the purple slate as forming only a single bed, which reaches from Aber on the coast above Bangor to Llanllyfni, and overlies, along that line, the schists of the Snowdon chain. The section of Bettws Garmon might lead one to regard the slate as lying below the schists of Snowdon, but that inference would be at variance with all the other sections; and the beds in that locality are so much displaced by the greenstones, that they cannot afford us any sure guidance. The slate is usually unconformable to the Snowdon schists, and the only exception to this is at Llanllyfni. As from the central axis of the Snowdon chain to the purple slate on its west flank there is an ascending series of beds; as the fossils found on that flank of the chain belong to the Caradoc or upper portion of the Lower Silurian system, and as no other Lower Silurian rocks are found above the purple slate, the author concludes that the purple slate is the uppermost of the Lower Silurian rocks.

This purple slate is probably identical with some one of the beds of slate on the east side of the anticlinal of Snowdon, but there is no bed of slate on that side of the ridge which resembles the purple slate in colour. Throughout the greater part of North Wales the top bed of the Lower Silurian formation is a good roofing-slate, but of a dark grey colour. The purple colour ought therefore to be regarded as a local peculiarity *.

Along the whole line of the purple slate on the west of Snowdon, the cleavage planes are very constant in their direction; for, with the exception of a slight deviation at Llanberris, they uniformly strike north-east, and do not vary from the vertical plane on either side more than 10°.

Northern continuation of the Snowdon Chain.—The author made only a slight examination of the district north of Glyder-fawr. What he saw of it was analogous in structure to that mountain;

* The purple slates with their green spots have much resemblance to the green slates of Cumberland, which are green with purple spots. These are the only slates in North Wales which have any resemblance to the green slates of the Lakes.

but as you advance towards the north, the igneous rocks become more and more prevalent.

To the north and west of Conway there is an extensive district of metamorphic rocks, of which the most abundant is quartz-rock, in various forms, but usually more or less schistose.

South-west part of Carnarvonshire.

1. *Schistose Rocks.*—The strike of the beds, which, in the Carnarvonshire trough, is from N.E. to N.N.E., changes to east a few miles south of Beddgelert, and a little further to the south becomes perpendicular to the strike prevailing in the trough.

At Porth Treweddyn, 4½ miles south of Beddgelert, in extensive quarries of light grey flagstone, the bedding dips north 20°, the cleavage N.N.E. 30°. About a mile west of Porth Treweddyn, in the high crags north of Tremadoc, a remarkable instance occurs of the interstratification of greenstone with the schist.

The schist on which the village of Tremadoc stands is very much altered and broken. It dips N.N.E. 15°, and passes beneath a thick mass of greenstone, running two miles westward. The same dip prevails in several hillocks south-east of Tremadoc, between that village and Porth-madoc; the rocks consisting of a ferruginous grit alternating with beds, four inches thick, of very rich ironstone. Immediately to the south-west of Porth-madoc, near Morfa Lodge, is a light grey flagstone, dipping N.N.E. 10°.

West of Morfa Lodge is the greenstone ridge of Moel-y-gest, which has raised the schists into an anticlinal ridge, and given them an eastern strike. On the line of the axis of this ridge, three miles west of Morfa Lodge, the beds have a north-east strike; and in a metamorphic rock, which dips south-west 30°, a copper-mine is worked.

From Brongader to the south-west as far as Criccieth, a distance of about two miles, schistose rocks extend. They dip south. To the south of Criccieth the schistose beds are much concealed by great accumulations of gravel.

About seven miles west of Criccieth, and four miles north of Pwllheli, is a quarry beside the road from Pwllheli to Carnarvon, in which the beds strike north and south. Here, in a dark slate of indifferent quality, are found obscure traces of organic remains. The bedding dips west 55°, the cleavage west 70°.

The rest of the south-west part of the county, frequently called the heel of Carnarvonshire, is covered by a brown, very rotten and shivery schist, in which the author did not discover any organic remains. The schists are broken up by various porphyritic masses, and their strike and dip are very irregular.

In the proximity of the felspathic rocks, hereafter noticed, these schists are changed into black shale; the resemblance of which to a coal-shale has, in several places, given rise to borings for coal. One of these trials was made between Criccieth and Pwllheli; and, on a common about 2½ miles west of the latter place, the borings were continued until the tools were broken by coming in contact with porphyry.

At the extreme point of the south-west promontory of Carnarvonshire, between Aberdaron and Porth-felin, hard gritty schistose flags are found; and these are overlaid by rotten brown schists, striking north-east or N.N.E., and dipping at a very high angle to the south-east; the cleavage here dips south-east 50°.

The schistose rocks of the south-west of Carnarvonshire (with the exception of the steatitic schist hereafter noticed) are referred by the author, though with much hesitation, to the Cambrian series of rocks.

NOTE, 1846.—From organic remains found in them by Professor Sedgwick, it is now known that they belong to the Lower Silurian series, and they are accordingly coloured as such on the annexed map (see Plate XII.).

2. *Igneous Rocks.*

(*a.*) *Felspathic Porphyry.*—The insulated hill south of Criccieth, a considerable tract round Pwllheli, and the hills which commence on the coast 3½ miles south-west of the latter place, and run north-west from Mynydd-tir-y-Cwmmwd, south of Llanbedrog, through Mynydd-mynytho to Carn Fadryn, consist of an amorphous flesh-coloured rock, composed of compact felspar and quartz, and resembling the rocks of Cader Idris and Arenig. In the ravine of Nant Bodlas, which intersects the last-mentioned felspathic mass, between Mynydd-mynytho and Carn Fadryn, black, grey and flesh-coloured porphyries occur. Felspathic rocks are also found on a line commencing in Mynydd Ystwm north of Aberdaron, and extending, in a north-easterly direction, through Mynydd-cefn-amlwch to the high peaks of Yr Eifls and the hill south of Clynnog-fawr.

These felspathic rocks, when in proximity with the schist, disturb its planes both of bedding and cleavage, and alter its mineral character.

(*b.*) *Greenstone.*—The greenstones of the south-west of Carnarvonshire, not including those of Tremadoc, differ from those of the Snowdon chain in two respects. First, they are of coarser grain; and secondly, they are of posterior date to the cleavage of the schists. Like the felspathic rocks last noticed, they have been upheaved in great masses, causing much confusion in the schistose rocks. Of this description of greenstone consist the hills of Mynydd Rhiw, four miles east of Aberdaron, and of Carn Boduan south of Nevin; also the low rocks of Edeyrn west of Carn Boduan, and of Porthwen on the coast further westward; and to the north-east, the hills of Moel Penllechog and Y-gyrn-ddu, south-west of Clynnog-fawr. To the north of Y-gyrn-ddu, at the points of junction between this greenstone and the porphyry of Y-gyrn-coch, several varieties of igneous rock occur.

(*c.*) *Serpentine and Steatitic Schist.*—Along the western coast of the Carnarvonshire promontory, from the point opposite Bardsey island to Porth Dynllaen, west of Nevin, a band of serpentine and steatitic schists extends.

At Porth-felin, on the south, a narrow ridge of mottled green and red serpentine, associated with green trap, blood-red jasper, and a crystalline flesh-coloured limestone, breaks through between two nearly vertical ridges of greenish-white steatitic schist. The ridge runs N.N.E. and S.S.W. The cleavage of the schist, in the western ridge, dips south-east 50°. At Porth Orion, three miles to the N.N.E., a limestone, similar to that last mentioned, is said to be found.

At Porthwen and at Edeyrn, near Nevin, the serpentine runs between the greenstone, as if ejected at a more recent period. At the northern extremity of the serpentine band, the serpentine is pure, and of a dark green colour.

Merionethshire.

Barmouth chain of Hills.—Barmouth lies at the southern point of a lofty chain, which after running northwards nearly fourteen miles, is cut off by the great Bryn-y-ddinas fault. This chain is chiefly remarkable for the interstratification it exhibits of schistose with igneous rocks.

The axis of the lofty hill immediately north of Barmouth is a mass of compact, highly crystalline, lightish-coloured greenstone. On the west side of the hill are numerous alternations of schist and greenstone. At first the greenstone predominates, and the schistose beds are thin and far apart; but as the distance from the axis increases, they become more frequent, until, at a mile from it, the greenstone wholly disappears.

The schistose beds are of variable thickness; those of greenstone are, many of them, only a few inches thick, and some many feet. The cleavage planes can, in many cases, be traced through the greenstones, but they do not lie close together, and are only faintly marked.

On the east side of the end of the ridge, near Barmouth, the alternations of greenstone are fewer than on the west side. About a quarter of a mile east of Barmouth the greenstone ceases, and the chain is overlaid by a great thickness of hard light blue slaty flagstone, and above this are grey schists.

Towards the southern end of the chain the prevailing strike is north by east. Near Barmouth, on the west side of the chain, the bedding dips south-east 30°, and the cleavage north-west 60°. About a mile north of Barmouth, on the Harlech road, the bedding dips E.N.E. 60°, and the cleavage E.S.E. 80°. East of Hendremynech, which is about a mile north of the town, the cleavage is vertical, and strikes N.N.E. East of Barmouth the bedding dips E.S.E. in a steep arch; the cleavage is vertical, and strikes N.N.E.

Towards the north end of the chain the alternations of igneous with aqueous rocks are on a greater scale. The sides of Cwm-moch, leading from the north-west up to Diphwys, afford a good section of these beds. Greenstone, similar to that of Barmouth, in beds from three to ten feet thick, alternates with thinner beds of sandstone and conglomerate, which are often semi-crystalline, and with beds of schist. The dip is from N.N.E. to N.N.W., at an angle of 15°.

On the west side of Craig-drwg (a ridge commencing about eleven miles north of Barmouth, and $1\frac{1}{2}$ mile long), on the descent towards Harlech, in a similar series of alternations there are nearly 100 beds of greenstone. The bedding dips from south-west to W.S.W. 10°, and the cleavage north-east 60°.

Between these igneous rocks and the sea is a series of light blue slaty flagstones, with some alternations of shale, and a few thick interstratified masses of greenstone. The lowest beds of the series occur near Harlech.

On the hills behind Llanbedr (seven miles north of Barmouth), and in the ravine of Egryn (three miles north of Barmouth), a bed of slate is worked. The bedding of the flagstone and slate dips east, E.S.E., and north-east by north, on the average east, at an angle of 10°; the cleavage dips east 60°.

Since the beds of the Barmouth chain have not been found to contain any fossils, and since they are cut off by the fault of Bryn-y-ddinas from the beds of the Carnarvonshire trough, the author finds it difficult to determine their age with any precision. In mineral character they much resemble the light grey slaty flagstones of Manod-mawr and Ffestiniog, which are placed by the author near the top of the Cambrian series.

From the Greenstone chain of Barmouth to the Porphyritic chain of Cader Idris and Arenig.—The prevailing dip on the east side of the Barmouth chain near Barmouth led the author to seek for an ascending series of beds in the direction of Dolgelly. The lower beds are hard light grey slaty flagstones, the same probably with those of Harlech; and above these are rusty schists with some beds of tolerable slate. The usual dip of the beds is east at a high angle, but it is subject to great irregularity, and to some alternations to the south-west. The cleavage usually dips from east to south-east, at from 50° to 55°; but the angle also is inconstant. All these rocks the author is inclined to refer to the Cambrian series.

The beds in this line of section are much interrupted by extensive igneous dikes. Near the river Mawdach these dikes strike from E.N.E. to N.N.E.; but further northward they strike due north.

The great eruptive mass of Cader Idris, which crosses the Mawdach at Dolgelly, entirely cuts off the last-described series of beds. Between this porphyritic chain and the parallel and similar chain of Arenig, is a narrow tract of slate and schist, which crosses the road to Bala, about three miles from Dolgelly. Between the porphyritic chains of Arenig and Arran Mowddy, the beds belong wholly or in part to the Lower Silurian series.

West side of Carnarvonshire.

1. *Gravel.*—From Clynnog to Penman-mawr, the whole western side of the Snowdon chain is flanked by igneous rocks, forming

either one broad belt, or several narrower bands broken by intervening beds of slate.

This igneous zone is overlaid on the west by a thick bed of gravel, which, for a space of about three miles broad and twenty-four miles long, entirely conceals the beds lying next to the mountain chain*. On the coast near Clynnog, the gravel forms the entire cliffs, nearly 100 feet high; on the east of Carnarvon and Bangor it passes inland, at some distance from the Menai Straits; it terminates northwards on the coast between Aber† and Penman-mawr. It consists of rolled fragments of all sizes, from mere pebbles up to huge boulders, all apparently derived from the rocks of the Snowdon chain. The valley which contains this great drift deposit is the more remarkable when contrasted with the valleys on the east of the chain, which, comparatively, are exempt from gravel. There is however a similar accumulation of gravel in some of the lower parts of the south-west end of Carnarvonshire.

2. *Upper Silurian and more recent formations.*—It was only at intervals that the author examined the rocks on the Carnarvonshire side of the Menai Straits. The strata on the shore rise for the most part into considerable cliffs.

(*a.*) *Carnarvon.*—The hill to the north-east of Carnarvon consists of a light brown or yellowish felspar porphyry; and this mass runs southward more than a mile. On the west the porphyry is overlaid by a brown or liver-coloured shale, which, near the igneous rock, is much contorted and altered. Carnarvon Castle stands on this shale, which may be seen in an unaltered state in the railroad cuttings south-west of the town. The usual dip of the bedding, when undisturbed, is south-east 45°; the cleavage, which is very decided, dips south 70°. Although the author could not discover any fossils in the shale, yet, from its mineral character, he assigns it without hesitation to the Ludlow series.

To the north-east of the porphyritic hills above mentioned, for the distance of some miles, the beds are covered up by gravel.

(*b.*) *Bangor.*—At the Menai Bridge, mountain limestone forms the base of the cliff. Above the limestone are beds of calcareous sandstone alternating with carbonaceous shale. The sandstone contains large Producti; the shale contains vegetable impressions. These beds are overlaid by alternations of ferruginous sandstone and dark shale belonging to the coal-measures. At the top of the cliff is an impure sandy limestone, mixed up irregularly with calcareous conglomerate, and belonging to the magnesian limestone. These three formations are here conformable, and dip S.S.E. 5°. About one-third of a mile from the bridge they are cut off by a fault, which runs north-east, and comes out on the shore about a mile beyond the bridge.

On the east side of the fault is a narrow ridge, running south-west by south, consisting of thick beds of hard, coarse, siliceous conglo-

* Mr. A. Aikin described this enormous deposit of gravel in his 'Tour in North Wales.'

† Three miles south-west of Penman-mawr.

merate, alternating with beds of grey chert. The bedding dips east. This rock the author refers to the old red sandstone. This conglomerate is cut off by a second fault, which also runs north-east, and comes out on the shore at a hollow in the cliff near Gared-gith, about a quarter of a mile beyond the former fault. Between the two faults there is a good section of the conglomerate.

To the east of the second fault, extending along the cliff about a mile, as far as Garth point, and covering the valley of Bangor, lie various brown and liver-coloured shales, referred by the author to the Ludlow series.

The axis of the hill east of Bangor is a greenstone trap. It runs S.S.E., and has disturbed and twisted about the Ludlow rocks, and has given them a high inclination. They dip between the Straits and Bangor E.S.E. 30°; west of the trap, W.N.W. 60°; east of the trap south-east, at a high angle: further to the east they are lost below the drift already described.

Since the beds on both sides of the two faults agree in having a dip eastward, if the faults were overlooked the Ludlow beds around Bangor would appear to lie above the magnesian limestone; and it is from that circumstance probably that Mr. Greenough in his Geological Maps has been led to colour these Ludlow shales as new red sandstone. Unless the thickness of the Wenlock series has been greatly reduced in this part of North Wales, it is impossible that it should lie concealed under the deposit of drift which skirts the Snowdon chain. It is by no means improbable however that in this part of Carnarvonshire the Wenlock series is entirely wanting; that consequently the igneous rock which flanks that chain is overlaid by the Ludlow shales; and therefore that the stratified formation next above the Lower Silurian slates is the Ludlow rock. This cannot be decided owing to the covering of gravel, which completely conceals the stratification.

At the north-east angle of the county, the Wenlock rocks of Denbighshire cross the river Conway above Caer-hun, four miles and a half south of Conway, and, forming a band about two miles wide, they pass along the left bank of the river to the north of Conway town. Along this line they abut unconformably against the Lower Silurian and igneous rocks of the Snowdon chain.

General Remarks on the Upper and Lower Silurian and Cambrian Formations of North Wales.

The principal points of difference which the author has had occasion to observe between the Silurian and Cambrian rocks of North Wales and those of the English border counties, are arranged by him under the three following heads:—

1st. The greater thickness of each formation in North Wales.

2nd. The paucity of organic remains in North Wales, and that even in beds which in the English border counties are crowded with fossils.

3rd. The prevalence of slaty cleavage in North Wales.

First and second Points of Difference.—From the examination which the author and other geologists have made of the several fossiliferous formations of North Wales, described in his paper, and those of the English border counties, he draws the conclusion, that the same formation contains fewer fossils in the one district than in the other, according as its thickness is greater in the one district than in the other; and this conclusion he supports by several examples.

This seeming correspondence between the paucity of fossils in a formation in any given district, and its thickness in that district, the author conceives to be deducible, as a consequence, from the laws which govern the distribution of marine animals in the sea at different depths, which have been derived by Professor E. Forbes from his dredging operations in the Ægean Sea.

The laws to which he more particularly alludes are, 1st, that the number of species, and of the individuals of every such species inhabiting the sea at any given depth, is the less as that depth is greater, and the greater as that depth is less; and, 2ndly, that the range of depth inhabited by any species is the greater as the depth is greater, and the less as the depth is less. Whence it follows, that were an internal sea to be gradually filled up, and were the solid contents of the basin so filled up to be divided into strata, each stratum being determined by the identity of the species therein preserved, the thicker strata, containing the fewest organic remains, would be found towards the bottom, and each successive stratum in ascending order would be thinner and thinner, and more and more replete with fossils.

Among the examples which he gives of an existing correspondence between the thickness of a formation and its comparative deficiency in fossils, is the Wenlock series, as seen in Worcestershire and in North Wales. This series, near Llangollen, is about 3500 feet thick, and is not known to have afforded more than a dozen different fossil species. Of these the most abundant occur in the middle and lower beds, and belong to the genus *Creseis*. The author states, on the authority of Professor E. Forbes, that the remains of the recent species of this genus are found in great abundance in the Mediterranean, in the sediment at the bottom of the sea at great depths; but that in shallow bottoms such remains are rare. The same series near Dudley does not attain, perhaps, a fourth of the above thickness; and it is crowded with organic remains, among which the stony corals abound; and these are specially indicative of a deposit in shallow water. The same may be remarked of the Lower Silurian formations, which in North Wales are far thicker and contain fewer fossils than in Shropshire and the border counties.

The author has not pointed out any criteria by which to distinguish the Cambrian series from the Lower Silurians, unless it be that the former series lies below the latter, and is almost, if not wholly, destitute of organic remains. The law of diminution in the living animals of the sea as the depth increases, points to a total absence of animal life at about 300 fathoms below the surface. The Cambrian series may therefore be regarded, either as a deposit formed in the depths of an ocean below the limit of animal life, or as a formation which preceded the appearance of animals in these parts of the northern hemisphere.

Third Point of Difference.—In North Wales, not only in the Cambrian but also in the Lower Silurian rocks, slaty cleavage is universal: it is very common in the Wenlock series; and in many localities it runs, in a marked degree, through the whole thickness of the Ludlow shales; but in other localities these shales are wholly exempt from it. The principal epoch of slaty cleavage, however, preceded the formation of the Ludlow beds; for these beds are in many instances undisturbed by the faults which have broken up the planes of cleavage in the older rocks. The author was assiduous in measuring the position of the planes of bedding and cleavage in various parts of North Wales, in the hope of making out some general laws respecting cleavage. In measuring the angles, however, he does not pretend to have approximated nearer than within 5° of the truth, as the surface of the beds is rarely flat enough to allow of greater accuracy.

One law respecting slaty cleavage was announced in 1831 by Professor Sedgwick*, and is now well known: that law is, that the cleavage planes maintain their parallelism over extensive areas, irrespective of the varying position of the beds which they cut through, or of the mineral character of the beds. Another law respecting slaty cleavage was detected by the author† in the progress of his tour, and is the following: viz. that the strike of the cleavage coincides with the strike of the bedding, whenever the latter continues uninterruptedly the same for a considerable distance; but when the strike of the beds is inconstant, and shifts at short intervals, then the cleavage planes hold their course right on, irrespective of the varying position of the planes of bedding; in other words, that the strike of the cleavage coincides with the prevailing strike of the beds in each district, and does not vary with the subordinate and local irregularities in the strike of the beds. Whence it follows, that the strike of the cleavage in a district is far more constant and regular than the strike of the beds.

In order to present, in a succinct form, the evidence from which the author has deduced this second law respecting slaty cleavage, the observations he made, in various parts of North Wales, of the positions of the planes of bedding and cleavage, are arranged in the table given at p. 315.

From the author's observations it appears, that the district of

* Geol. Trans. 2nd ser. 3rd vol. p. 68.

† While the author was drawing this conclusion from his observations in Wales, a nearly similar law was announced to the British Association at Cork by Professor Phillips, in the following terms:—"The cleavage planes of the slate rocks of North Wales are always parallel to the main direction of the great anticlinal axes, but are not affected by the small undulations or contortions of these lines. In North Wales they maintain the same direction for fifty miles, not varying more than two or three degrees." [See Athenæum, 2nd Sept. 1843.]

North Wales in which the parallelism between the strike of the bedding and cleavage appears in the most marked degree, is all that part of Carnarvonshire which lies north of Tremadoc. Throughout this area, on the south of the Holyhead road, the beds as well as the cleavage planes strike north-east. On the west side of the Snowdon anticlinal the beds are much tossed about, and dip at various angles either north-west or south-east, and the cleavage planes are nearly vertical. On the east side of the anticlinal the beds dip south-east, and the cleavage dips north-west from 60° to 65°. On the eastern side of the Carnarvonshire synclinal the beds dip north-west, as does also the cleavage, but at an angle which gradually diminishes as you recede from the Snowdon chain. Thus at the Rhiw Brefder quarries the angle is 55°; at the Diffwys quarries it is 45°, and at Manod-mawr 35°. Towards the northern extremity of the county of Carnarvon the strike of the beds changes from north-east to N.N.E., as does also the strike of the cleavage. To the south of Tremadoc the beds change in strike from north-east to east, and the cleavage changes in strike from north-east to E.S.E.

The parallelism in the strike of the planes of bedding and cleavage prevails also, in a marked degree, in the slaty district north of the Dee, and also in the North Berwyns. The common strike of the two planes approaches to east; but it is subject to many local variations; and in such cases the two planes vary in strike together. The cleavage has a northerly dip, at angles varying from 25° to 65°.

In the Barmouth chain the strike of the cleavage is somewhat irregular; but its mean direction is north and south, and its dip is from east 60° to west 60°.

In the district intersected by the great porphyritic eruption of Arenig, Arran Mowddy, &c., the planes of cleavage have lost their original bearings, and are subject to the greatest irregularity both in respect of direction and dip; and the same observation applies to the district of Lower Silurian rocks extending along the Holyhead road between Bryn-y-ddinas and Corwen.

From the circumstance that the position of the planes of cleavage depends, not on the varying position of the beds at each particular spot, but on their main position, the author infers that slaty cleavage cannot have arisen from any power analogous to that of crystallization; and from the almost mathematical regularity with which those planes are arranged, he concludes that they are not the effect of mechanical force or pressure exerted at the moving or upheaving of the rocks.

The author further concludes from his observations, that in those parts of North Wales where the strata are least disturbed, the planes of bedding and cleavage meet at an angle of from 15° to 30°; and hence he infers, that in those cases where, at the time of cleavage, the beds were horizontal, such was also the angle at which the cleavage intersected the bedding (15° to 30°). The author further observed, that in the quarries of North Wales which afford the slate of the best quality, the bedding and cleavage rarely meet at an angle less than 25°, and never less than 20°; and that whenever the angle is less than 20°, the slate is of inferior quality. An increase in the angle at which the planes meet has no injurious effect; for in many instances when the slate is of the best quality, the angle of intersection is 45° and upwards.

The Igneous Rocks of North Wales, arranged according to their age.

The oldest igneous rocks in North Wales are the greenstones of the hills north of Barmouth, which are truly interstratified and contemporaneous with the Cambrian schists of these hills. As these schistose beds could not have been deposited in their present inclined position, they must have been elevated since they were deposited.

The next igneous rocks, in point of age, are the parallel dikes of greenstone, striking north-east and N.N.E., which intersect Carnarvonshire. The whole of these had assumed nearly their present position before the Wenlock rocks were deposited, and also before the Cambrian and Lower Silurian slates were affected by cleavage: for these dikes are never continued into the Wenlock series; nor, if any disturbance in the rocks which the dikes traverse can be traced to the proximity of these dikes, is the Wenlock series ever affected by that disturbance; and in the beds which are broken up and tossed about by the eruption of these greenstones, the cleavage planes preserve their parallelism, as was pointed out in describing the purple slates to the west of Snowdon. Some of the dikes of this period have thrown the strata which they traverse into great confusion; and this is especially the case in the centre and to the west of the Snowdon chain. Those on the east of that chain have for the most part the appearance of interstratification with the bedded rocks. It may be doubted, however, whether they are ever really contemporaneous with the beds. On the surface they seem to dip regularly between the beds of schist; but when laid open in the quarries they are found to swell out, and to thin off irregularly, or even to cut through the strata. These dikes are not all of the same age, but they are all of earlier date than the Wenlock rocks*.

Next in order of time come the eruptive porphyries and felspathic rocks of Cader Idris, Arran Mowddy, the Arenigs, and the igneous plateau of the Ceiriog described by Mr. Bowman. The eruption of these masses, while elevating the rocks in their neighbourhood (including those of the Wenlock series), has broken up the regularity of the planes of cleavage. But the Ludlow rocks lie undisturbed in the hollows between the elevated masses. This eruption must therefore have taken place after the deposition of the Wenlock series, and prior to that of the Ludlow rocks; and to the disturbing forces at work in this interval of time may be attributed the want of conformity between the Wenlock and the Ludlow formations, which is

* The dikes laid down on the accompanying map are such as the author actually observed, but it is probable that there are many more which are still to be discovered.

almost general in North Wales. The great eruptive masses of porphyry in the south-west of Carnarvonshire are probably referable to this period, for they never fail to disturb the regularity of the planes of cleavage.

The greenstones of Rhiw, Boduan, Penllechog, &c. in the south-west of Carnarvonshire, appear to be nearly of the same age with the last-mentioned felspar rocks. The serpentine of Porth-din-llaen seems to be of more modern date than the greenstone in its neighbourhood.

There are some eruptive rocks of less extent and more modern date than any of those before specified. East of Bangor is a mass of trap which has thrown up into a high ridge the Ludlow rocks; and the trap dikes on the shores of the Menai, described by Professor Henslow, are of posterior date to the coal-measures.

The map which accompanies the memoir has been compiled from various sources, with the addition of the author's own observations. The geographical groundwork is copied from Mr. Greenough's Map of England and Wales, and that map and Sir R. I. Murchison's Map of the Silurian district have been freely consulted; Mr. A. Aikin's 'Tour in North Wales,' and his description of Cader Idris in our Transactions, vol. ii. 2nd series, p. 273, supplied some points; but the author is especially desirous of recording his obligations to Mr. William Bowman for the loan of some sheets of the Ordnance Maps, coloured by the late J. E. Bowman, Esq., which were principally used in laying down the boundaries of the Upper Silurian deposits in Denbighshire, as well as for some other points. But the author is the only person who can be considered responsible for any part of the Map, as he has compiled it entirely on his own discretion.

DESCRIPTION OF THE PLATES.

Plate XII.

Map of North Wales *coloured geologically.*

In this map letters of reference have been made use of to denote the different hills and mountains. The following explanation is given of these references arranged according to counties.

Carnarvonshire.

a. Penmaen Mawr.
b. Penmaen Bach.
c. Great Orme's Head.
d. Tal-y-fan.
e. Yr Arrig.
f. Crass.
g. Gyrn Goch.
h. Pen Castell Duon.
i. Y Glelffordd Fawn-Ogder.
j. Benglog.
k. Carnedd Llewelyn.
l. Glyder Fach.
m. Carnedd Ddafydd.
n. Glyder Fawr.
o. Snowdon.
p. Moel Coch.
q. Mynydd Mawr.
r. Yr Arren.
s. Moel Eilio.
t. Craig Goch.
u. Bwlch Mawr.
v. Rivells or Yr Eifls.
w. Carn Boduan.
x. Carn Fadrin.
y. Rhiw.
z. Pen-y-Bryn.

Denbighshire.

a. Moel Morfidd.
b. Pentre Bychan.
c. Bryn Mali.
d. Castell Dinas Bran.
e. Cyrn-y-Brain.
f. Garth Gynnau.
g. Mynydd Llanaermon.
h. Bron Haulog.
i. Bron Banog.
j. Moel Cranaw.
k. Moel Eithin.
l. Cader Danad.
m. Cader Ddimel.
n. Llanellian Mount.
o. Cave Hill.
p. Bryn-y-Pin.
q. Moel-Fre Isa.
r. Moel-Fre Ucha.
s. Moel Fodian.
t. Moel Tywysog.
u. Moel-y-Park.
v. Craig Arthur.
w. Moel Arthur.
x. Moel Fammau.
y. Moel Enlli.
z. Moel Ciw, Cefn Coch.

Flintshire.

a. Gwaunysgaer Down.
b. Garreg Mountain.
c. Pentre Halkin.
d. Moel-y-Gaen.
e. Bryn Yorcin (Fire-Beacon).
f. Fron.

Merionethshire.

a. Llether.
b. Crib-y-Rhiwau.
c. Craig-y-Cae.
d. Llawllech.
e. Rhinog Fawr.
f. Moel-y-Crosau.
g. Moel Llynf Nant.
h. Arenig Fawr.
i. Arenig Fach.
k. Moel-y-fan-y-llan.
l. Rhobell Fawr.
m. Y-Ddualt.
n. Pen-y-Cader.
o. Mynydd Pen-y-Coed.
p. Pen-y-Garn.
q. Craig Coch.
r. Tarren-y-Gessail.
s. Pen-y-Graian.
t. Mynydd Dolgoed.
v. Arran Mowddy.
w. Cader Berwyn.
x. Moel Cerrig Duon.
y. Bwlch-y-Cifno.
z. Moel Ferna.

Plate XIII.

Fossil remains of Pteropodous Shells *from the North Welsh Silurian Rocks.*

Several species belonging to the genus *Creseis* had been confounded with the genus *Orthoceratites*, until Prof. E. Forbes pointed out their true character: these fossils are of great assistance in classifying the middle part of the Silurian system in North Wales, as they are found in rocks otherwise nearly bare of organic remains. The author found the four following species in the Wenlock rocks of Denbighshire and Merionethshire:—

Creseis primæva, E. Forbes, Quarterly Geological Journal, vol. i. p. 146. Plate XIII. fig. 2.—Sheath long and regularly tapering, smooth, with one (or more?) longitudinal grooves. Length two to eight inches; width of the aperture one-twelfth of the length. Very common in the Wenlock rocks of Denbighshire and Merionethshire.

Creseis ventricosa, n.s., Plate XIII. fig. 3.—Sheath straight at the back, slightly ventricose in front, tapering to a point; nearly smooth with faint sloping lines of growth, and a strong longitudinal furrow. Length two and a half inches; width of the aperture half an inch. In Wenlock flagstone, in the Tyn-y-ffridd quarry between Cerrig-y-Druidion and Ruthin.

Creseis obtusa, Plate XIII. fig. 4.—Sheath short and conical, sides slightly curved towards a blunt point, smooth? with a longitudinal furrow. Length two inches; width of the aperture half an inch. Very common in the Wenlock rocks of Denbighshire and Merionethshire.

Creseis gracillima, Plate XIII. fig. 5.—Sheath very long, straight and slender, tapering gently to a point. There is only one broken specimen of this species, four inches long, one-eighth of an inch wide at the upper end. In Wenlock flagstone in Tyn-y-ffridd quarry between Cerrig-y-Druidion and Ruthin.

The following species belonging to the same family is added for the sake of illustration, although found in another district:—

Theca Forbesii, Plate XIII. fig. 1.—Sheath nearly flat behind, rounded in front, conical and tapering to a point; aperture an obtuse-angled triangle, with the angles rounded off; surface covered with fine striæ, arched parallel to the curved edges of the aperture. Length half an inch to one inch; width at the aperture one-third of its length. Common in the middle part of the Ludlow rocks at Underbarrow near Kendal. This species is closely allied to *T. lanceolata* of Morris, found in palæozoic rocks in New South Wales. *a* and *b*, internal casts; the figure above *a* is a section to show the form of the aperture; *c* and *d*, exterior of the sheath. The author names it after Professor E. Forbes, who first pointed out the class of animals to which these fossils belong.

from Nature by G. Scharf

Printed by C. Hullmandel.

1. Theca Forbesii
2. Creseis primæva.
3. Creseis ventricosa.
4. Creseis obtusa.
5. Creseis gracillima.

TAB ne of Bedding in different

Di	Dip.			Angle between planes of cleavage and bedding.
	avage.	Bedding.		
	Angle.	Point of compass.	Angle.	
	80°	S 45 E	45°	65°
	80 to 85	S 45 E	45	35 to 40
	80 to 85	N 45 W	45	55 to 50
	80 to 85	S 45 E	50	30 to 35
	80 to 85	S 45 E	50	30 to 35
West o	80 to 85	S 45 E	30	50 to 55
don A	70	S 68 W	60	65
	90	S 45 E	55	35
	85	S 45 E	45	50
	80	N 45 W	65	15
	80	S 45 E	45	55
	80	N 45 W	65	35
	80	S 45 E	50	30
East s Snow ticlin	60 to 65	S 45 E	40 to 60	55 to 85
	65	N 45 W	45	20
	65	N 45 W	45	28
	85	N 45 W	65	20
East sid	45	N 45 W	25	20
narvo	55	N 45 W	30	25
Syncl	45	N 45 W	25	20
	35	N 45 W	15	20
	50	E 68 N	15	?
East of t y-ddi Holyh road	50	N 22 E	15	125
Ditto ..	50	N 22 W	25	73
Northern mity count narvo	variable	?	?	?
South-w	50	N 45 W	45	90
of Car	70	W	55	15
shire	30	N	20	13
Menai S	70	S 45 E	45	46
Bala tro	65	N 68 W	35	30
	90	S 45 E	90	63
South o	50	N 45 E	30	20
Lake	55	N 45 E	35	34
	75	S 68 E	40	75

TABLE showing the position of the Plane of Cleavage as compared with the position of the Plane of Bedding in different parts of North Wales.

District.	Locality.	Formation.	Strike.			Dip.				Angle between planes of cleavage and bedding.
			Cleavage.	Bedding.	Difference of strike.	Cleavage.		Bedding.		
						Point of compass.	Angle.	Point of compass.	Angle.	
West of Snowdon Anticlinal	Bron-llwyd	Metamorphic rocks	E 45° N	E 45° N	0°	N 45° W	80°	S 45° E	45°	65°
	Penhryn quarry, west side	Lower Silurian slate	E 45 N	E 45 N	0	S 45 E	80 to 85	S 45 E	45	35 to 40
	Ditto, east side	Ditto	E 45 N	E 45 N	0	S 45 E	80 to 85	N 45 W	45	55 to 50
	West of Bethesda	Ditto	E 45 N	E 45 N	0	S 45 E	80 to 85	S 45 E	50	30 to 35
	Coet-mor and Tan-y-bwlch	Ditto	E 45 N	E 45 N	0	S 45 E	80 to 85	S 45 E	50	30 to 35
	Pont-y-Coetmor and Bryn	Ditto	E 45 N	E 45 N	0	S 45 E	80 to 85	S 45 E	30	50 to 55
	Dinorwig quarries, Llanberris	Ditto	E 68 N	E 68 S	S 136	S 68 E	70	S 68 W	60	65
	Glyn quarries, ditto	Ditto	E 45 N	E 45 N	0	vertical	90	S 45 E	55	35
	Bettws Garmon	Ditto	E 45 N	E 45 N	0	N 45 W	85	S 45 E	45	50
	Llanllyfni	Ditto	E 45 N	E 45 N	0	N 45 W	80	N 45 W	65	15
	Ditto	Ditto	E 45 N	E 45 N	0	N 45 W	80	S 45 E	45	55
	Ditto	Ditto	E 45 N	E 45 N	0	S 45 E	80	N 45 W	65	35
	Ditto	Ditto	E 45 N	E 45 N	0	S 45 E	80	S 45 E	50	30
East side of Snowdon Anticlinal	Sundry localities		E 45 N	E 45 N	0	N 45 W	60 to 65	S 45 E	40 to 60	55 to 85
East side of Carnarvonshire Synclinal	South-east side of Craig-llyn-llagi	Lower Silurian	E 45 N	E 45 N	0	N 45 W	65	N 45 W	45	20
	Near Bryn gelynen	Dark Lower Silurian slate	E 68 N	E 45 N	S 23	N 68 W	65	N 45 W	45	28
	Ditto	Lower Silurian slaty flagstone	E 45 N	E 45 N	0	N 45 W	85	N 45 W	65	20
	Ditto	Hard slaty flagstone	E 45 N	E 45 N	0	N 45 W	45	N 45 W	25	20
	Rhiw Brefder quarries, Mr. Holland's	Lower Silurian slate	E 45 N	E 45 N	0	N 45 W	55	N 45 W	30	25
	Diffwys quarries	Ditto	E 45 N	E 45 N	0	N 45 W	45	N 45 W	25	20
	Manod-mawr quarries	Inferior slate at the base of the Lower Silurian rocks	E 45 N	E 45 N	0	N 45 W	35	N 45 W	15	20
	North of Tremadoc	Light grey Lower Silurian flagstone	E 45 N	N 68 W	N 23	S 45 E	50	E 68 N	15	?
East of the Bryn-y-ddinas fault, Holyhead road	Between the 47th and the 48th milestones	Bala grits, Lower Silurian	E 45 N	E 22 S	S 77	N 45 W	50	N 22 E	15	125
Ditto	Ditto	Ditto	E 45 N	E 22 N	S 23	N 45 W	50	N 22 W	25	73
Northern extremity of the county of Carnarvon	....	....	E 68 N	E 68 N	0	?	variable	?	?	?
South-west part of Carnarvonshire	Porth-felin, south of Aberdaron	Schist	E 45 N	E 68 N	N 23	S 45 E	50	N 45 W	45	90
	North of Pwllheli, 3¾ miles	Dark fossiliferous inferior slate	N	N	0	W	70	W	55	15
	Porth Treueddyn, near Tremadoc	....	E 22 S	E	N 22	N 22 E	30	N	20	13
Menai Straits	North of Carnarvon	Ludlow shale	E	E 45 N	N 45	S	70	S 45 E	45	46
Bala trough	Two miles east of Bala	Good slate, Lower Silurian	E 68 N	E 68 N	0	N 68 W	65	N 68 W	35	30
South of Bala Lake	Between Dinas Mawddy and Mallwyd	Good slate, ditto	E 68 N	E 45 N	S 23	vertical	90	S 45 E	90	63
	Taihirion, west of Arenig fawr	Inferior slate	E 45 S	E 45 S	0	N 45 E	50	N 45 E	30	20
	East flank of Arenig fawr	Roofing slate	E 22 S	E 45 S	S 23	N 68 E	55	N 45 E	35	34
	Nine miles south of Bala, on the Twrch River	Lower Silurian slaty grit	E 68 S	E 68 N	N 136	S 68 W	75	S 68 E	40	75

›mpared with the position of the Plane of Bedding
Wales.

Strike.			Dip.				Angle between planes of cleavage and bedding.
			Cleavage.		Bedding.		
Cleavage.	Bedding.	Difference of strike.	Point of compass.	Angle.	Point of compass.	Angle.	
E 45° S	E 45° S	0°	N 45° E	60°	S 45° W	10°	110°
E 68 S	E 45 S	N 23	?	?	S 68 W	10	?
N	N	0	E	60	E	30	30
N	E 68 N	S 22	E	60	S 68 E	30	34
S	E 56 S	N 34	E	60	N 56 E	30	37
E 68 N	E 68 S	S 136	S 68 E	80	N 68 E	60	59
E 68 N	E 68 N	0	vertical	90	?	?	?
E 45 N	E 45 N	0	N 45 W	60	S 45 E	30	90
E 68 N	E 68 N	0	vertical	90	S 68 E	?	?
E 45 N	N	N 45	S 45 E	50 to 55	E	high	?
N	N	0	E	50 to 55	E	high	?
E	E	0	N	60	N	25	35
E	E 68 N	N 68	N	25	S 68 E	40	139
E	E	0	N	65	S	45	70
E	E	0	N	65	N	15	50
E	E	0	N	65	N	25	40
E	E 34 S	S 34	N	65	N 34 E	15	53
E	E	0	N	55	N	30	25
E 45 S	E	N 45	N 45 E	5	vertical	90	86
E 45 S	E 45 S	0	N 45 E	50	N 45 E	5 to 10	45 to 40
E	E	0	N	25	N	10	15
E 22 S	E 22 S	0	N 22 E	45	N 22 E	30	15
E 45 S	E 45 S	0	N 45 E	30	S 45 W	55	95
E	E	0	N	45	S	80	55
E	E	0	N	45	S	40	95
E	E	0	N	45	S	80	55
E	E	0	N	45	S	45	90
E 34 S	E 34 S	0	N 34 E	50	S 34 W	70	60
E 34 S	E 34 S	0	N 34 E	50	S 34 W	70	60

TABLE (*continued*) showing the position of the Plane of Cleavage as compared with the position of the Plane of Bedding in different parts of North Wales.

District.	Locality.	Formation.	Strike. Cleavage.	Strike. Bedding.	Strike. Difference of strike.	Dip. Cleavage. Point of compass.	Dip. Cleavage. Angle.	Dip. Bedding. Point of compass.	Dip. Bedding. Angle.	Angle between planes of cleavage and bedding.
Barmouth chain	North of the ridge of Craig drwg	Cambrian	E 45° S	E 45° S	0°	N 45° E	60°	S 45° W	10°	110°
	Ditto	Ditto	E 68 S	E 45 S	N 23	?	?	S 68 W	10	?
	Llanbedr, seven miles north of Barmouth	Ditto	N	N	0	E	60	E	30	30
	Ditto	Ditto	N	E 68 N	S 22	E	60	S 68 E	30	34
	Ditto	Ditto	S	E 56 S	N 34	E	60	N 56 E	30	37
	One mile north of Barmouth	Ditto	E 68 N	E 68 S	S 136	S 68 E	80	N 68 E	60	59
	East of Hendre mynach, one mile north-west of Barmouth	Ditto	E 68 N	E 68 N	0	vertical	90	?	?	?
	Near Barmouth	Ditto	E 45 N	E 45 N	0	N 45 W	60	S 45 E	30	90
	East of the Barmouth ridge	Ditto	E 68 N	E 68 N	0	vertical	90	S 68 E	?	?
East of the Barmouth chain.	Between Barmouth and Dolgelly	Ditto	E 45 N	N	N 45	S 45 E	50 to 55	E	high	?
	Ditto	Ditto	N	N	0	E	50 to 55	E	high	?
East of Bryn-y-ddinas fault.	South of Yspytty Evan, south of Holyhead road	Lower Silurian fossiliferous schist	E	E	0	N	60	N	25	35
	West of Druid Inn, Holyhead road; west of Corwen, north of the Dee	Lower Silurian grits	E	E 68 N	N 68	N	25	S 68 E	40	139
System of the North Berwyns	Corwen	Ditto	E	E	0	N	65	S	45	70
	1½ mile east of Corwen, north of the Dee	Lower Silurian grits	E	E	0	N	65	N	15	50
	South of Corwen	Ditto	E	E	0	N	65	N	25	40
	Ditto	Ditto	E	E 34 S	S 34	N	65	N 34 E	15	53
	Nant-cwm-dywyll, south of Corwen	Cambrian slate	E	E	0	N	55	N	30	25
	Below Pistill Rhaiadr	Ditto	E 45 S	E	N 45	N 45 E	5	vertical	90	86
South of the Dee	South of the Dee from Corwen to Llangollen	Upper Silurian beds	E 45 S	E 45 S	0	N 45 E	50	N 45 E	5 to 10	45 to 40
	Near Llansaintfraid glyn Ceiriog	Dark Lower Silurian roofing slate	E	E	0	N	25	N	10	15
	Fron frys, south of Ceiriog river	Ditto	E 22 S	E 22 S	0	N 22 E	45	N 22 E	30	15
North of the Dee	Llettywyn, south of Cricor Mawr, west of Nant Morwynion fault	Ludlow rocks	E 45 S	E 45 S	0	N 45 E	30	S 45 W	55	95
	From Corwen to Llangollen	Wenlock beds	E	E	0	N	45	S	80	55
	Ditto	Ditto	E	E	0	N	45	S	40	95
	Glyn and Oirnant quarries, south of Cyrn-y-brain	Wenlock slate	E	E	0	N	45	S	80	55
	Ditto	Ditto	E	E	0	N	45	S	45	90
	Moel-y-faen, south of Cyrn-y-brain	Ditto	E 34 S	E 34 S	0	N 34 E	50	S 34 W	70	60
	Ditto	Dark Lower Silurian roofing slate, conformable to the Wenlock beds	E 34 S	E 34 S	0	N 34 E	50	S 34 W	70	60


Point of Ayre
Blue Head
K. Bride
Point Cranstal
Seafield
Coshnahawin
Derby Haven
Breda Hd.
Mines
Pt. Erin
K. Malew
K. W. College
Kentraugh
Pt. le Murray
Poolvash B
CASTLETOWN
BAY
Kitterland Isle
The Calf of Man
Spanish Hd
& Chasms
Stack of Scarlet
Langness Point
Chickens
Section Map
1. Schist
2. Old red sandstone
3 Carboniferous limestone
3. Lower limestone
3'. Poolvash limestone
3''. Posidona schist
4. Boulder clay
5. Drift gravel
6. Alluvium
Injected Rocks.
A Granite
α Greenstone
β Trap
γ Trap tuff
δ Trap breccia
N.E. of Peel
Sea
High W.
Rock Mount
St. Johns
Foxdale Mines
Granite Boss
S. Barrule
800 ft.
Fault
Ballasalla
Fault
College
Langness Pt.
Sea
SECTION ACROSS THE ISLAND.

On the Geology of the Isle of Man. By the Rev. J. G. Cumming, M.A., F.G.S., Vice-Principal of King William's College, Isle of Man.

Plates XIV. to XVII.

Part I.

The Palæozoic Rocks of the Island.

[Read June 11th, 1845.]

The Geology of the Isle of Man, though possessing much interest, has hitherto scarcely met with the consideration which it really deserves.

The earliest geological notice of the island will be found in an account by Mr. Wood, published in 1811; and this was succeeded by a memoir in the First Series of the Transactions of the Geological Society, published in 1814, by Dr. Berger*. Dr. Berger's memoir was accompanied by a geological map and some sections, and, together with additional remarks, forming a kind of appendix, afterwards published by Professor Henslow†, it forms an interesting and valuable record of what was then known of the district.

Dr. Macculloch, in his 'Account of the Western Isles of Scotland' (vol. ii. p. 516), published in 1819, described (as far as the advance of geological science would then permit) the different characteristic formations.

We have also a paper by Dr. Hibbert, "on the Discovery of the Fossil Elk in the Isle of Man," written for the fifth number of the 'Edinburgh Journal of Science,' in 1826.

The only later notice seems to have been the interesting paper on the Pleistocene deposits in the neighbourhood of Ramsey, by Hugh Strickland, Esq., F.G.S., read before the Geological Society in November 1843‡.

A mere glance at the geological map of the island will show the reason of this neglect, for it will at once be seen that about three-fourths of the whole surface exhibited at high water consists for the most part of grauwacke and clay schist, while almost the whole of the remaining part is covered by diluvium beds of drift and pleistocene sand, and by turf-bogs.

The first appearance of the island, therefore, to the geological student, is extremely unpromising; and even if his attention should be especially directed to the two localities of Peel and Castletown (the only exception to the apparently unattractive sameness) by the patches of red and blue colour upon the geological map, representing the old red sandstone and carboniferous limestone, the apparent

* Mineralogical Account of the Isle of Man, by J. F. Berger, M.D., Geol. Trans. 1st ser. vol. ii. p. 29.

† *Loc. cit.*, 1st ser. vol. v. p. 482 *et seq.*

‡ Proceedings of the Geol. Soc. vol. iv. p. 8.


Geological Map
OF THE
ISLE OF MAN.
Revd. J. G. Cumming
The dotted outline of the Map is the low water mark
Line of Section.
Scale ¼ Inch to a Mile.
Point of Ayre
Blue Head
K. Bride
Point Cranstal
K. Andreas
Jurby Point
Jurby Vicarage
Dog Mills
The Curragh
RAMSEY
Ballaugh
Sulby
Pt. Lewaigue
Maughold Head
North
Barrule
Bishops Court
K. Michael
Glen Willan
Sheudhoo
Snaefell
Slieuue Ffraughane
Kennay
Line of Section
Dhoon
Mines
Garrahan
Sartel
K. Lonan
Laxey
PEEL
Greebah
Rock Mount
St. Johns
Old Church
Baldwin
Contrary Head
Clay Head
K. Patrick
Marown
Mines
Banks How
Mines
DOUGLAS
Mines
Dalby Pt.
South
Barrule
St. Marks
Douglas Head
Pt. Saudric
K. Santon
St. Anns Head
Fleshwick Bay
Seafield
Breda Hd.
Mines
Derby Haven
K. Malew
K. W. College
Pt. Erin
Kentraugh
Pt. le Murray
Poolvash B
CASTLETOWN
BAY
Kitterland Isle
Spanish Hd & Chasms
Stack of Scarlet
Langness Point
The Calf of Man
Chickens
N E of Peel
Sea
High W.
Rock Mount
St. Johns
Foxdale Mines
Granite Boss
S. Barrule
Fault
Ballasalla
Fault
College
Langness Pt.
Sea
SECTION ACROSS THE ISLAND.
TABLE OF SIGNS & COLOURS.
Deposited Rocks.
Marks in Section
Colours in Map
1. Schist
2. Old red sandstone
3. Carboniferous limestone
3. Lower limestone
3'. Poolvash limestone
3''. Posidona schist
4. Boulder clay
5. Drift gravel
6. Alluvium
Injected Rocks.
A Granite
α Greenstone
β Trap
γ Trap tuff
δ Trap breccia

want of any mutual relation, or of any connexion with any other earlier or later palæozoic formation, would lead to the conclusion that as a geologist he might be more profitably employed elsewhere, while the collector of fossils would almost immediately fix upon the limestone of Poolvash as the only spot likely to afford any valuable addition to his cabinet. This, in fact, has been the case; and, from the circumstance of the Poolvash locality being rich in fossils*, and these fossils coinciding for the most part with those of the lower Scar limestone of Yorkshire, it has been at once assumed that the carboniferous series of the Isle of Man was referable to the same geological position.

The object of the present communication is partly to correct so erroneous an impression, by showing that there is in the island the most distinct and perfect sequence from the carboniferous strata into the old red sandstone to be met with in British Geology, and partly to trace out the various circumstances connected with the deposition of the different palæozoic formations, especially in reference to modifications produced upon them by intermitted igneous agency.

The mere statement of the fact of a very extensive development of this agency in the south-eastern basin of the island leads us to expect difficulties in the way of a correct geological history of that district, and the difficulties are further increased by the circumstance that the altered, disturbed, broken, and subsequently denuded beds are almost entirely covered up by the boulder clay, gravel and sand apparently of a very recent geological period.

A residence on the spot for nearly four years has enabled me, by carefully observing, comparing and connecting the different phænomena presented at those points which are most exposed, as well as by an examination and comparison of the fossils, to present the following account with a reasonable conviction of its offering at least an approximation to the truth.

To a person approaching it from the south, the Isle of Man presents the appearance of a broken, mountainous ridge, extending from the Calf of Man to Maughold Head near Ramsey, of which the highest points are Snaefell, in the north (2004 feet), and in the south, South Barrule (1545 feet). Except from the Calf of Man to Port-le-Murray, the descent on the south-eastern side to the coast is gradual, but the coast itself is broken and precipitous wherever the schists are exposed, and the cliffs in some places rise to the height of 300 feet. Douglas Bay and the limestone district in the neighbourhood of Castletown exhibit different geological and physical conditions.

On the western side of the island, the descent from the mountain ridge is generally very rapid from the Calf of Man to Dalby Point, and excepting the inlet of Port Erin and Fleswick Bay, the whole may be regarded as a continuous precipice from 400 to 1000 feet in height.

From Dalby to Kirk Michael the coast corresponds with that on

* Mr. Gilbertson once observed to me that it was by far the most productive place he had ever seen.

the south-eastern side of the island, and thence round by Jurby and Point-of-Ayre to Ramsey, there extends a wide expanse of fifty square miles of Pleistocene deposits, presenting cliffs both in the eastern and western sides of the island, whose height is from 50 to 200 feet, and which are subject to very rapid encroachments from the rake of the tide, which sweeps up and down the channel.

The northern shore, in the neighbourhood of Kirk-Bride, is low and flat, and is very rapidly extending.

A ridge of sand hills occupies a line running from Blue Head to about four miles north of Ramsey, between which and the mountain-chain lies the swampy plain of the Curragh, once occupied by a number of small lakes, which have been gradually filled up or drained, but which were laid down in Chaloner's Map of the Isle of Man, published in 1656. The mountain-chain of the schists along its northern boundary sinks as precipitately into the Curragh as it does into the sea at the south-western extremity of the island. With respect to the general arrangement of these schists, they dip off S.E. by S. and N.W. by N. from the before-mentioned ridge. A close examination shows that they mantle round a series of nuclei forming a rather irregular curved line from the Calf to Maughold Head*.

There is good reason for believing that these nuclei may be granitic bosses; and in two cases there is no doubt of it, the granite itself appearing at the surface in a characteristic dome-shape. The first of these occurs in the neighbourhood of Laxey, near the head of the Dhoon river; and the second is on a grander scale on the south-eastern side of South Barrule, where it has also protruded itself into the schist, having been reached in the workings of the Foxdale mine†. Of the probable age of these granitic domes I shall have hereafter to speak, and at present I would only mention that they do not appear to have been older at any rate than the carboniferous limestone. The boulders of the Barrule granitic boss occur in the tertiary formations of the south of the island, but I have not as yet seen any indications of them in the Old red conglomerate.

Along the mountain-chain in various places we meet with gneiss and other metamorphic rock, greenstone, and massive quartz-rock, with abundance of mica. And generally reposing upon these, though occasionally interstratified, we have the series of clay schists with interposed beds of grauwacke, which constitute the body of the island.

These schists are highly ferruginous, and in lithological character somewhat softer than the generality of the rocks of the Snowdonian range: I have anxiously sought for fossils to determine their age,

* Slieudhoo, Sartel, Rock Mount and Contrary Head may perhaps be regarded as prominent points of a secondary ridge on the north-western side, in which porphyritic greenstone is developed at Rock Mount and Cronck-y-Voddy.

† See Section across the island, Pl. XIV. It is worthy of notice that both in this case and at Laxey the intrusion of granite has improved the produce of the mine.

but hitherto without success; the only indication of organic existence consisting of the fucoids which occur in some of the upper beds.

I have seen nothing in any of these schists which I could recognize as true slate, or as exhibiting cleavage distinct from stratification, the stratification seeming pretty clear, as well from the evidence of the fucoids as from ripple-marks and various coloured layers. I have observed at the northern extremity of Langness, in some particular lights, an appearance which is not unlike a contorted bedding, in a direction entirely differing from the fissile planes of the schists at this point; yet it is here that the fucoids are most abundant, and they lie in the plane of cleavage. All the schists are greatly traversed with joints, and there is a general tendency to an imperfect rhomboidal structure, especially in the neighbourhood of the greenstones.

The schists immediately under the Old red conglomerate are deeply claret-coloured, and at the southern extremity of Langness contain as much as fifteen per cent. of pure iron.

At Spanish Head there is a series of light blue beds, which at a distance may be mistaken for limestone. This rock is used largely for lintels and gate-posts, and is slightly elastic. It appears to be nearly horizontal, but has been rent into deep chasms in consequence of a land-slip.

Between the schists and the Old red conglomerate there are no formations visible; and we have several sections both on the north-west and south-east sides of the island where the unconformity of the Old red sandstone to the schists is clearly exhibited. Perhaps the most beautiful is that on the eastern side of Castletown Bay in the Peninsula of Langness, where the conglomerate forms the crown of a fine natural arch, and the unconformable claret-coloured schists (the layers of which are distinct and variegated) form the abutments.

The Old red sandstone appears in two districts; first, on the north-western side of the mountainous chain in the neighbourhood of Peel, where it is of moderate thickness (not more than 300 feet), and covers from one to two square miles*. It is here in the character of a fine sandstone, used extensively for building purposes, flags and tombstones. Its dip is north-west and at a high angle. The same rock appears again in the south of the island in the neighbourhood of Castletown, where it lines the whole of the limestone basin, and may be observed at the basset edge, almost continuously from the southern extremity of Langness, in a curved line by Ronaldsway, Coshnahawin (at the Santon river mouth), Ballasalla, Ballahot, buried under diluvio-glacial and pleistocene deposits in the neighbourhood of Ballahick and Arbory, and overlapped by the limestone at Port-le-Murray. In this southern basin the Old red exhibits for the most part the character of a conglomerate, and in no place where it can be observed is it more than fifty feet in thickness, being often not more than four or five feet, and giving plain indi-

* The greater portion is covered up by the tertiary clays and gravels.

cation of the ancient shore. I have not as yet succeeded in obtaining any fossils from the Old red sandstone of any portion of the island. As far as I have observed, there does not appear to have been any disturbance of the Old red sandstone prior to the deposition of the overlying limestone.

The overlying limestone is always conformable to the subjacent conglomerate; and indeed the passage of the latter into the former is often so regular, that it is difficult for a few feet to say to which formations the beds belong. There appears to be a gradual abstraction of the larger quartz pebbles and we obtain a brown arenaceous and pebbly limestone for a few feet containing organic remains; these beds soon pass into the regular series of dark limestone and shales, to which I am more particularly anxious to direct attention.

The small patch of limestone which once existed to the north of Peel on the surface of the Old red sandstone as it dips rapidly seaward, has some time since been wrought out, and it is difficult now to determine absolutely whether it belonged to the mountain limestone, or was merely a thin band of cornstone; but there are strong indications of the mountain limestone existing not far out at sea, as the shore to the north abounds with boulders not much rounded, and with pebbles containing fossils similar to those of the southern limestone basin of the island.

I have before observed, that the limestone of the south of the island has generally been regarded as of the same age as the lower Scar limestone of Yorkshire. It will however I think become a question whether the greater portion should not be considered as of a more ancient date, and whether, if not merging into the Devonian period, it is not at least of the same antiquity as the lowest Northumberland shales and the oldest carboniferous beds of the south of Ireland.

As the different beds of limestone crop out very regularly on all sides of this southern basin, the order of succession in the lower portion is made out without difficulty, especially as each bed has some characteristic fossil. Thus we find in the lower beds, and within a few feet of the old red conglomerate, *Cirrus rotundatus*, *Bellerophon apertus*, *Creseis Forbesii*, *Productus hemisphæricus*, *Orthis Sharpei* (the *O. umbraculum* of Portlock's Survey), a species of *Posidonia*, *Cyathophyllum megastoma*, *Calamopora ramosa*, and *Phillipsia Kelli* (of Portlock's Survey). Above these are very large specimens of *Turbinolia fungites*, and a large coral apparently very similar, but recognised by Count Keyserling as *Caninia gigantea* of Michelin. We have also the *Leptæna papilionacea*, and lastly, amidst a great dearth of organic remains, the few specimens of *Goniatites Henslowi* and *Nautilus complanatus* which have hitherto been discovered. By the assistance of a fault in the centre of the basin we can arrive at a fair estimate of the general thickness of this lower series of dark limestone and shales, which does not thus appear to be more than 160 feet at the deepest accessible part. The passage however from these beds into the superior light-coloured and highly fossiliferous limestones of Poolvash is not very distinct, the basset edge of the junction being either covered up by the boulder clay and pleistocene deposits, or where uncovered on the sea-shore, so greatly changed by igneous action as to have lost entirely the distinctive characters of the two series. The best place for tracing the connexion seems to be at the edge of the fault at Poolvash, about 300 yards westward of the road running from Balladoole to the sea-shore, where some dark beds, which look like the commencement of the lower limestone, are brought up; but as not more than four or five feet appear, the few fossils contained in them are hardly sufficient to establish their identity. There can however be little doubt that a great and almost sudden change took place in the physical condition of the basin in the midst of the period of the deposition of the limestone strata, almost every species of mountain limestone fossils being crowded within a thickness of not more than sixty feet of limestone, and in an area of scarcely a mile across. Even here however we may remark, that the various beds of the series have individually their own more characteristic fossils. Thus I have found *Nautilus oxystoma* in the lower Poolvash beds alone, and the same species (but of much larger size) in the lowest dark limestone of Ballahot. The beds next above seem characterized by a *Natica* and by *Cyathophyllum basaltiforme*. In the next we have *Orthis resupinata* and *Goniatites crenistria*, extremely common; and later still, *Nautilus sulcatus*. Some of these fossils range more or less through the whole series. The Orthoceratites in general are more common in the middle period, and so also is *Terebratula excavata*. Somewhat earlier we have *Producta anomala*, and a little Crustacean, named by De Koninck *Cytherina Phillipsiana*, pervades both the earlier and middle beds. In the upper portion the larger corals disappear and give place to *Fenestella*, while in that part even the Encrinites are not abundant in proportion to other fossils.

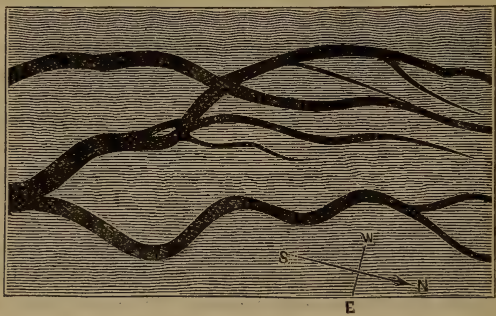
Another sudden change however seems to have taken place in the physical condition of the basin in the midst of the early carboniferous period. A violent convulsion running along an axis from the Stack of Scarlet, in a direction nearly N.W. by W. (see Map, Pl. XV.), would appear to have produced an extensive crack or chasm in that direction, accompanied by an eruption of trappean matter and producing a breaking-up of the strata into a series of troughs, causing at the same time a general elevation of the limestone basin. In the troughs thus formed a highly interesting series of deposits then took place. It would seem that from this period there existed for a long time a subaqueous volcano, acting with more or less intensity, at no great distance from this basin, and probably connected also with the before-mentioned crack or chasm. By this means the basin was constantly being filled up with a series of volcanic products, consisting chiefly of volcanic ashes forming a tuff. But a deposition of limestone beds and shales, similar in their general character to the earlier beds of the basin, was going on at the same time; and these deposits became more or less mixed with volcanic strata, thus forming trappacean limestones and shales, the proportion of the respective ingredients depending in great part upon the relative distance of their respective sources and the intensity of the volcanic action. Occasionally there seem to have been periods of quiescence, allowing larger depositions of limestones unmixed with volcanic tuff. One of the beds so formed is interesting, as having supplied the material for the steps of St. Paul's Cathedral, presented by Bishop Wilson. It is a schist or plate, in some places ten feet thick, in others not so many inches. It is characterized by an abundance of very beautiful and perfect Posidoniæ, by several cephalopodous shells, not occurring elsewhere in the basin, and in one place by several varieties of Ferns, the nearest approach here to the coal-measures. All the shales abound in iron pyrites; and in one spot we find, a little to the east of a stream running from Balladoole into the sea, and parallel with a trap-dike, several extremely beautiful fossils of this material, consisting mostly of *Goniatites* and *Orthoceratites*. I have fossils also from the trap-tuff.

After the deposition of a considerable portion of these trappacean limestones and shale beds and a large accumulation of trap-tuff upon them, a second violent convulsion along the same axis as before seems to have taken place, accompanied by a discharge of heated gaseous vapours. The beds formed during the previous eruptions were broken up, and fragments of trappacean limestone and shale rolled along and mixed in indiscriminate confusion, the consequence being a kind of trap-breccia enveloping the broken strata. The trappacean limestone boulders are metamorphic and amygdaloidal, and the shale has become cherty. In some places, where the igneous action may have been more intense, the mass in cooling has assumed a crystalline character, well exhibited at the Stack of Scarlet, where the trap has become columnar basalt, and the adjoining limestones have a similar disposition to columnar structure. There seems afterwards to have been a continuation of the tufaceous deposits, but for how long is altogether uncertain, as there are no carboniferous or secondary strata which can be determined above them. They are however all intersected by the more modern trap-dikes which stretch in numerous places across the area of the basin.

The date of the eruption of these dikes may range through the whole interval betwixt the carboniferous and tertiary periods, as they are only covered up by the boulder clay and pleistocene deposits, which occupy the greater portion of the area where they occur. On this account the tracing the same dike continuously for any distance with certainty is impracticable, and our observations must be made betwixt the high and lower water marks, and the lines filled up by conjecture. The task would not indeed be very difficult did the dikes preserve in general their direction and appearance; but they are frequently curved, sometimes branching and thinning out, and ultimately disappearing, especially where they happen to intersect the Old red conglomerate. An extremely interesting section of this kind is laid bare on the western shore of Langness, and is figured in the accompanying woodcut.

These dikes have more or less altered the intersected beds; and

Ground plan of a Dike on the N.W. shore of Langness.
Scale 30 yards to 1 inch.



Note.—The shaded parts are Old red sandstone.

they vary also themselves in general character according to the nature of the strata with which they are in contact. We have also extensive traces of igneous action where the trap itself is not immediately developed, and this is particularly the case along axes of elevation and lines of fault. All these appearances may perhaps suggest the idea of heated gases charged with acids escaping through the cracks formed during some of the periods of convulsion. But I would observe, that in several instances the crystalline character of the limestone, and its tendency to break up into regular geometrical figures, are distinctly attributable to the continued action of the cooling of a fluid mass of trap, forced in between the Old red conglomerate and the limestone, or rather, perhaps, forced in under great pressure amongst the looser and separable beds of the conglomerate. We may almost suppose that the entire district must have been floating upon a molten sea of igneous rocks, subject to many convulsions, frequently exerting an upward pressure at many points, but at the same time held down by a tough mass of limestone resting upon moveable and permeable beds of conglomerate of very moderate thickness. A reference to the Map denuded of the tertiary deposits will show that it is crossed by a series of undulations and studded with bosses (see Map, Pl. XV.).

As the general strike of the more important of these undulations is nearly coincident with that of the great mountain-chain of the island, which is about 80° west of magnetic south, it appeared to me at one time that they must have been produced by lateral pressure at the time of the elevation of the central axis of the island, and that the bosses were caused by the intersection of the more prominent cross-undulations created at the same time as the axis of disturbance which runs from Ballasalla about 10° west of magnetic north. And this solution may perhaps hold good in whole or in part, so far as the main features of the district are concerned; but my attention having been especially directed to the examination of the very singular bosses at Skillicore, between Ronaldsway and Coshnahawin Head (Plate XVI.), and another series at Poolvash, I am rather inclined to believe that the former intrusion of trap amongst the Old red conglomerate exerted an upward pressure at various points. It will be seen that both these series are in the immediate neighbourhood of trap-dikes, the latter being included between two dikes not more than thirty feet apart and parallel to one another, while the former is actually cut through by a dike which ramifies just at the summit of the boss. The direct evidence however of tabular masses of trap underlying altered limestone bosses has only very lately been afforded me. It is exhibited just above low-water mark on the shore betwixt the north end of Derby Haven Pier and the little bay of Ronaldsway; and it may be best seen about fifty yards to the east of a limekiln formerly used near that spot. And as we have an anticlinal axis or saddle running from this very spot through the Skillicore bosses to the great fault at Coshnahawin, the chain of evidence appears to be complete as to the origin of the bosses in question.

I now proceed to describe *seriatim* those points of interest and importance in the southern basin which may best lead to accurate conclusions respecting its geological history.

Starting from the south-western point of Langness, we find ourselves upon the schists, whose general strike runs a few degrees north of east (magnetic). A dike of greenstone is here seen at first running along the northern edge of the ridge, and nearly in the same direction; and six yards further to the north there is a second dike parallel to the former. The schist is contorted, and thrown into a synclinal axis in the intermediate space. These greenstone dikes run into the sea in a direction north-east by east; and I believe that one of them, or perhaps the two united, reappear on the top of the hill 200 yards to the north of the land-mark. At this point, at any rate, we find a corresponding dike running into the sea on the south-eastern side of Langness. The whole promontory of Langness is rent by a series of chasms parallel to each other, and having a north-east direction. A mass of greenstone is also seen, which seems to form the nucleus or support of the ridge, and this is connected with the first of these chasms, commencing at the extremity of the promontory (see Map, Pl. XV.).

The second chasm exhibits a trap-dike running across the ridge, and intersecting the former greenstone dike at an angle of 50°. I consider this trap as newer than the greenstone; and the difference between them, both here and elsewhere, is easily traceable, the former (greenstone) being of a lighter colour, extremely hard, not so readily weathering, and prismatic in structure; the trap, on the other hand (corresponding with the Derbyshire toadstone), containing a larger proportion of iron, easily weathering, often rotten, becoming converted into clay exhibiting columnar structure, and ultimately breaking up into spherical masses. The former would appear more nearly allied to the granitic, and the latter to the basaltic family of plutonic rocks; and we may imagine the greenstone to have been thrust up in a solid state, contorting the strata but not altering them, and occasionally running so constantly along the line of strike as to appear like a contemporaneous formation poured forth upon the sea-bottom at the time of the deposition of the schists, while the trap was erupted in a more fluid state and under great pressure, and mixed with the limestone formations of the same basin, having insinuated itself, like a fine mud, into very small crevices in the limestone, adapting itself to the crevices between boulders of the Old red conglomerate, and having often greatly altered all the beds, including the schists. Though there are many spots where the greenstone and trap must intersect, these are always either covered up with recent deposits, or too much confused to be readily made out. The intersection at this extremity of Langness is the best developed, and even here they are so much buried in sand, that it becomes doubtful whether they cross or merge into each other.

Proceeding onwards, we meet with the drift capping the highest portion of the ridge; and as we proceed more to the east, it forms an extended platform at the height of thirty feet above the sea. At the bend or hollow of the promontory we find under the drift the Old red conglomerate, which lies in a depression of the schist, but dips north on the north side of the ridge, and south on the south side, thus giving evidence that the slight elevation of these schists along the line running nearly east and west is of a more recent date than the formation of the conglomerate and the older dark limestone. My present impression is, that this elevation cannot be looked upon as older than that convulsion of the Stack of Scarlet in a north-western direction which contorted all the beds prior to the last eruption of trap-tuff, as I think that otherwise this ridge would have formed a basin to the north of which we should have some indication in the thinning out of the limestone. But so far from this being the case, the different beds of limestone at the Stack on the opposite side of Castletown Bay are the thickest anywhere developed.

As we pass up the north-western side of Langness, we still keep on the Old red conglomerate, which here attains the greatest thickness noticed in the basin. The base of it appears resting on the schist at the water-worn caves and excavations, and the uppermost beds of it can be readily traced down as they pass under the neighbouring limestone.

A remarkable fault or line of disturbance, which runs from the southern extremity of Langness through Derby Haven, Ronaldsway, Coshnahawin, and up the Santon river, begins to show itself near the caves just alluded to. At this point the Old red sandstone, dipping at an angle of 5° in a direction N. 65° W. mag., is suddenly broken off on the south-western side by the upheaval of the promontory of Langness: the broken and upheaved beds of the Old red sandstone and limestone, which were once continuous over Langness, have since suffered entire denudation, most likely from the north-east, the remaining beds lying in hollows on the south-western side, protected by the ridge of schists from any action upon them to the north-east.

At the same caves we find a dike of amygdaloidal trap running 70° west of magnetic south, which cuts through the Old red conglomerates, and probably also through the limestone series (see Map, Pl. XV.). This dike seems to have been affected by the dislocation before noticed. A series of parallel dikes occurs, penetrating the schist a little further to the north, generally conforming to the strike of the schist, and not intersecting the Old red conglomerate. These might be taken for grauwacke beds in the plane of the schists, but the wall of one of them is very well exhibited, and shows the well-known tessellated appearance marking the surface of trap-rocks. Proceeding still northwards, we find coming out from under the drift a trap-dike, which winds about and ramifies amongst the Old red conglomerate with a general northerly direction, till it meets and merges into the great dike intersecting the middle of Langness in a direction N. 15° W. mag. It will be seen that this dike presents on the ground-plan numerous branches, several of which terminate in a north-westerly direction. If we now cross over to the south-eastern side of Langness, we find the same dike running out into the sea, having the same general direction (S. 15° E. mag.), and including altered masses of the schist. The total width of this dike, with its included masses, is here forty-five feet.

On the summit of the ridge of Langness, about 200 yards to the north of the land-mark, we find the greenstone dike before described running here N. 65° W. mag. This dike is intersected by the trap we have just noticed, but the intersection is covered up by the drift. It is afterwards seen running out in a mass into the sea on the north-eastern side of Langness, where its structure may be well examined. In passing up the same side of the peninsula northwards from this point, we fall in with several masses of greenstone amongst the schists (see Map, Pl. XV.).

About 500 yards north-eastward of the former trap-dike, a second is seen, thirteen feet wide, running in a direction N. 25° W., and this re-appears on the western side of Langness, with the same direction, but soon divides into two main branches, one of which runs at right angles to this direction along the saddle where the Old red sandstone is brought up, and then returns to that former course for a short distance and terminates; the other turns a few degrees westward, and is shortly lost sight of under the sea-weed.

If we cross over the narrow neck uniting Langness with the main island into Derby Haven, a continuation of the before-named saddle again brings the Old red conglomerate for a short distance to the surface; but crossing a synclinal to the southern corner of the bay, we find this rock coming up again regularly from under the limestone and resting unconformably upon the schists, which are here contorted by a mass of greenstone, apparently continued in a somewhat irregular dike to the northern extremity of the little island upon which stands the fort and ruined church. At the southern extremity of the bridge uniting this island with Langness, we meet with another trap-dike, three feet wide, running N. 20° W. magnetic; and at the northern end of the bridge near the church, another running N. 15° W.: these dikes are continued, in directions generally parallel to each other, across the bay to the north-westward, and appear at low-water in the ridge upon which the Derby Haven Breakwater is built. The intersection of these dikes with the greenstone is also obscure, being either built over as at the bridge connecting Fort Island with Langness, or covered up by sea-weed and shingles.

Before leaving Langness, we must notice the remarkable mass of greenstone on the summit of the hill at its northern extremity. This mass appears pushed up amongst the schists which mantle round it, and into which it sends forth arms in every direction. It is most extensively though irregularly developed in a westerly direction along the ridge. Starting again from the southern end of the Derby Haven Breakwater in a north-easterly direction, we follow an anticlinal upon which the breakwater is built, and which is intersected nearly at right angles by the two trap-dikes which have just been mentioned. At the northern end of the breakwater the first observable boss occurs, and a little further north-eastward, near the old limekiln, amongst divided and broken beds, we may make out another. The limestones here are sometimes greatly altered, especially along cracks, and the sequence into the Old red conglomerate may be observed, although it is interrupted in one place by the interesting tabular mass of trap before mentioned. At that spot (see Map, Pl. XVI.) the trap has so mixed itself with the Old red conglomerate as to appear a substitute for the ordinary matrix of the quartz pebbles. The strike of the beds is here S. 50° W. mag. At the southern extremity of the little bay of Ronaldsway, there may be traced the effects of a disturbance crossing the general strike of the beds, and forming troughs on the northern and southern sides. This line of disturbance runs from under the drift in a direction N. 80° E. mag. for a distance of sixty yards, and then gradually disappears. Along the ridge of this anticlinal the limestone is raised vertically, but the steeper beds are on the northern side. Very unequivocal tokens are here given of igneous action, the limestones are crystalline and corroded, and we even have patches of the overlying boulder-clay formation so hardened and cemented together as to have resisted the denuding action of the sea. This may have been caused by heated gaseous vapours ascending through the cracks formed by a previous disturbance, but it tends to support the opinion which I shall have occasion to put forth in the second part of this communication, that the series of disturbances thus noticed and the phænomena connected with them are of a date posterior to the formation of the boulder-clay, whenever that might be. It will be observed that we have several cracks and slight faults running in directions parallel to this, and traceable hence to Coshnahawin at the mouth of the Santon river, but I can only at present direct attention to the fact, which is well-worthy of careful consideration. This little bay of Ronaldsway will be found the most fossiliferous of all the localities in which the lower dark-coloured limestones are accessible. There is one bed of mudstone enormously loaded with fucoids, another (a shaly bed) abounds with encrinital stems, and in a third *Orthis Sharpei* is found. Two more of these bosses occur in Ronaldsway Bay, and as we proceed north-eastward towards Skillicore, beyond the limekilns, two others, situated upon that line of disturbance which runs from the Brough in a direction S. 40° W. mag., and which is evidently connected with the great fault at Coshnahawin. The beds here are greatly altered and disturbed, especially along the eastern side of the fault, where we have a mass brought up from below, which I have little doubt is an altered Old red conglomerate. On account of its beautiful colour, some attempts have been made to work this rock for marble, but the quartz occurring in it appears to have been the cause of the failure that was experienced. Proceeding still to the north-east, we again cross a trap-dike running S. 15° W., and branching much amongst the outcropping shales: one of these branches apparently connects itself with the series of dikes intersecting the Skillicore boss, which is perhaps the most distinct and remarkable of these appearances, in consequence of its being so intersected. It will be seen that whilst we have here a dike running in a direction generally parallel to the disturbance at Ronaldsway, it divides itself nearly at the centre of the boss, and that those branches which run at right angles to the line of fault, separate again into mere cracks only partly filled with trap, and ultimately disappearing. From this boss to Coshnahawin, the shore between high and low water mark has a gentle dip inland, and is occupied by beds of limestone and shale, which are broken up into rhomboidal blocks by cracks running generally towards the south-west. The line of high-water is formed by a continuous mass of the altered Old red conglomerate which has been brought up very rapidly; the limestones, which are almost horizontal to the very edge of the fault, being there suddenly broken off.

A small bay is here formed apparently by a transverse disturbance, which has completely shattered and confused the beds, and the broken masses are so enveloped in sand and shingle as to preclude examination. We have however two parallel cracks with slight faults running nearly south-east on the north-eastern side of this little bay, and the beds then rise rapidly to the edge of the great fault in that direction, at the mouth of the Santon river. At this point also is another boss, through the centre of which runs a crack or chasm, and there is also a crack and fault on one side of it. It will be seen that, advancing from the south-western extremity of Langness in a direction nearly north-east, we have been gradually approaching the point of principal disturbance, which seems to be under the hill called the Brough, where the Old red conglomerate, which appears at low-water at the mouth of the Santon river, conformably underlying the limestone of Coshnahawin Head, has been brought up on the rise side of the fault to the height of 110 feet. As far as I can judge at present, this elevation was however connected with the formation of two faults crossing each other, and occurring at different periods. The valley along which the Santon river runs is one of elevation, running for the most part nearly north and south, and at the mouth of the little stream the effects of another disturbing force may be traced, running in a nearly transverse direction, or from east to west, greatly contorting the schists and reversing their dip. Nearly parallel with this axis we have several bands of greenstone. We may suppose then that a portion of the country on the north side of this latter east and west line was elevated at the time of the formation of the valley, along which the river runs to a somewhat greater extent than that portion lying on the south side of the line, and this was one stage of the uplifting of the Old red conglomerate.

Another disturbance of a different date is however conspicuous at the mouth of the river, between high and low water; and a very distinct line is drawn by the difference between the blue and claret-coloured schists, which always immediately (though unconformably) underlie the Old red conglomerate. There is then exhibited a line of principal fault running S. 40° W. magnetic, the rise being on the north-western side; and a small ridge of limestone runs out to sea in a direction S. 50° E., marking another fault at right angles.

It will be seen that these directions coincide with those which we have been continually noticing in connexion with the series of bosses; and by the disturbance last alluded to, it will be clear that the Old red conglomerate on the north-west or upcast side of the fault received another elevation.

I have not stated distinctly which series of disturbances happened first, and this may perhaps be a matter for further consideration. My own impression is, that the first elevation caused the fault running S. 40° W., since the line of demarcation between the blue and claret-coloured schists, which were formed by the fault running nearly south-west, appears to be broken by the other which crosses it. A large quantity of sand and shingle unfortunately covers up a portion of this line, and prevents a conclusive determination on this point.

Crossing the country now in a north-westerly direction, we may trace conjecturally the line of outcrop of the Old red conglomerate, although it is entirely covered up by diluvial drift or boulder clay from the Brough to beyond Ballasalla, where it appears in the little stream which runs from St. Mark's and joins the Silverburn a little above Crossag Bridge. It is also seen in the road above the umber works.

In this neighbourhood the conglomerate has entirely lost its red colour in the upper beds, and is very thin, the quartz pebbles being merely a white gravel in a limestone paste. Further on, at Crag Mill, an elevation of the schist in a line crossing the Silverburn in a direction S. 80° W. has cut off the continuation of the outcrop of the Old red conglomerate; but following the stream upwards for 300 yards across the bridge we come upon it again, forming the ridge of a small semicircular basin in which the beds are nearly horizontal. There is here an indication of our having attained the original limit, in this direction, of the southern limestone basin of the island.

In passing up the Silverburn we have however been following a line of fault running in a direction N. 10° W. magnetic. This fault, combined with the axis, already mentioned as having elevated the schists, has raised the Old red conglomerate to the surface on the hill to the south-west above Athol Bridge (sometimes called Silverburn Bridge). It appears here in considerable force on the Peel road, which has in part been cut through it, and forms an interesting section.

A little above Athol Bridge, near the mill, there is some evidence of a disturbance and fault at right angles to that which I have mentioned, which is continued apparently quite into the mountain range of South Barrule. The rise side of this fault appears to be to the north.

I have never seen or heard of any indication of limestone to the north of a line drawn hence to Port-le-Murray. The whole distance however to the sea is covered up by diluvium and estuary deposits, and if the beds are not cut off by a fault, we must conclude that a line nearly in this direction formed the ancient limit to the basin on the north-west (see Map, Pl. XV.).

Directing our course again southward along the Peel road, we come upon the large development of limestone forming the Ballahot quarries and supplying the limekilns of this neighbourhood. The beds dip gently, but on a saddle, towards Poolvash and the Carrig, and soon attain a considerable thickness. The base of these beds is not seen in the quarries. On the road however which crosses from the Peel road to Rushen Abbey, just by Ballahot farmhouse, we find ourselves upon the underlying Old red conglomerate, which is here observable in its upper beds as white quartz gravel in a limestone paste. The dip is here 10° west of south. Following this road down to the Abbey, we find this same bed of the Old red conglomerate on the side of the road which leads by the west wall of the Abbey gardens, and the north Abbey cottage to Crossag Bridge. The fault however along the course of which the Silverburn runs, and which may be observed in the river at Crossag Bridge, must have turned the direction of the basset edge of the Old red conglomerate to the southward, and it is covered up by the diluvial gravel in the low ground in the neighbourhood of the Abbey.

If we follow the Silverburn towards Castletown from Ballasalla, we find it presently passing through some broken limestone ground, but the nature and extent of the disturbances are not well-developed. My impression is, that the river runs along the line of a crack on the ridge of the limestone in a direction 40° west of south; and there is a cross fault at right angles, perhaps connected with that which runs in this direction from Coshnahawin. It is only in a few places that we can obtain an angle of dip, and the beds have suffered considerably by denudation.

At the mouth of the river in Castletown harbour we find the limestone again presented in an anticlinal axis running 70° west of south from under Government House towards Scarlet Head. This axis is cut through nearly at right angles by a trap-dike which makes its appearance on the south side of the old pier in the new harbour. This dike has greatly altered the limestone, and more particularly in those places where it encloses a mass of limestone betwixt two of its branches. In this crystallized and altered limestone we meet with thin strings of galena. I may also mention, that along the side of the dike cutting the southern point of Langness, and in a narrow gully, I have met with fine veins of copper in the schist. In the dike at the caves in Langness, we have sulphuret of iron.

From Castletown pier-head to Scarlet House several trap-dikes occur, generally at right angles to the anticlinal just alluded to, and following its slight curvatures. There is however one remarkable exception in the dike which runs from under Knockrushen in the direction of the southern end of Derby Haven in a direction S. 70° E. This dike seems to be more compact than any of the others, and its width in solid trap is twenty-one feet. I think it possible that this dike is identical with that running in the same direction from Copenhagen. If it should continue north-eastward in the same direction, it will cut the isthmus of Langness at a point which is buried under sand; but it is not altogether improbable that, making a slight curve, it may also be the same as the more southerly branching dike on Langness, and that the dike at Castletown pier is the more northerly of the two which cut through the promontory. Thirty yards to the south-west of this is a small dike one foot wide running parallel to that which branches from the great Knockrushen dike; and sixty yards still further south-west, a dike one and a half foot wide, running S. 25° E. mag.; and again very near to it, under the limekiln, is a smaller one running S. 20° W., and soon terminating.

All these last three dikes appear to be mere branches of the greater Knockrushen dike, shooting out from it at a point a little above the limekiln at the centre of a semicircular boss. The limestone is here traversed by a number of joints and intersecting cracks, and has been considerably altered.

Passing by Scarlet House we find another boss where the shore turns westward, and continuing in that direction towards the Stack, very sudden and repeated contortions of the strata appear; the strike of the beds, which has hitherto been pretty uniformly W.S.W., trending round towards the south. The cause of this very soon appears in the protrusion of the basaltic mass of the Stack, and the great fault or disturbance running about N. 30° W. mag. from this point (Pl. XVII. fig. 3).

At this point there is a series of plutonic rocks of every character and description, containing commingled masses of altered or trappaceous limestone, whose original order of deposition it is almost impossible to speak of with confidence. The passage from the most decided trap-rock into the most decided limestone is so gradual that it seems hopeless to attempt a classification; and we are forced to the conclusion, that either under great pressure and under the action of great heat, some of the elements of trap-rocks were made to incorporate themselves with the proximate limestone, or as I have rather concluded, that a deposition of carbonaceous sediment at the bottom of the ancient sea in this locality was going on contemporaneously with the deposition of volcanic ashes; and that subsequently the whole series so formed has been subjected, under pressure, to the action of considerable heat.

The sections which I have made are based on this supposition, and offer the nearest and simplest approximation to order which I could discover, amidst so much contortion and breaking up of the strata and intrusion of volcanic products. The older dark limestones of the basin (which we are here enabled to measure to the thickness of 130 feet) are suddenly thrown downwards towards the line of disturbance running north-westward from the Stack, and are intersected by several trap-dikes also running north-west (see Pl. XV. and section, Pl. XVI.). Above them we have the Poolvash limestones nearer the Stack, greatly altered and crystalline; then a series of trap-tuff, trappaceous limestone, &c.; and overlying and unconformable to all these are other broken and twisted beds, and an outpouring of trap-tuff with mingled fragments of the broken strata. The breaking up of the beds appears to have been occasioned by the eruption of the trap, which forms the basaltic pile of the Stack, and which may perhaps be only the more prominent portion of the largest trap-dike, assuming that columnar structure in consequence of some peculiar condition of cooling.

The whole distance hence to Poolvash Bay, wherever the beds are uncovered from the drift, exhibits this remarkable trappaceous formation; and as we proceed onward in that direction, the order of the formations appears to come out with greater regularity, and the different beds attain a greater thickness. In some of the deeper chasms which the action of the sea has worn in the tuff, the Posidonia schist is seen; and where we come upon the bay itself, the shore turning suddenly to the northward and north-eastward, we find that large development of it which is worked as a marble quarry. In many places the schist rests directly on the limestone, and thins out around masses of the limestone in such a manner as to indicate that it was deposited after some disturbance of the limestone had taken place, and that the sea-coast was in this immediate neighbourhood. We may indeed almost fancy we can trace the ancient outline of the land; and the presence of the fossil ferns found in one of these recesses appears to indicate the same fact.

Westward of Poolvash the trappaceous deposits do not appear, and the shore is so much intersected with trap-dikes and the rocks are so much altered, as to prevent all description of that neighbourhood. The hill above Balladoole appears to have been raised in a dome, and it is not unlikely that there may be caverns formed in that neighbourhood, as there is close alongside the great fault (which has before been mentioned as bringing up the dark beds of the lower series of limestone), a strong spring of salt water which continues to run several hours after ebb-tide, apparently from an underground pool which is filled at high-water. At the mouth of the stream beyond the farm called Copenhagen, where the high road comes upon the shore, we find ourselves upon the lower series of limestone, the newer or Poolvash series having suffered denudation to the north-west of the stream.

The Carrig rock in the midst of Port-le-Murray Bay appears to be a boss of the older limestone, of the same age as the patch of limestone which is quarried at Port-le-Murray itself. How far inland the Poolvash limestones extend I have not as yet seen; the outcrop is seen at Knockrushen at the south-eastern side of the basin, and they must have been denuded from the whole of Castletown Bay, if indeed they ever extended in that direction.

On the whole then, it appears that we have evidence in proof of the existence of some portion of the Isle of Man as an island about the commencement of the newer Palæozoic period, the Old red conglomerate forming a thin fringe, and occurring at the edge of the southern basin as a mass of small white quartz pebbles in a carbonaceous paste not more than three or four feet thick. This thin fringe does not appear however to have suffered denudation, but passes regularly into the overlying dark-coloured limestones and shales. It is worthy of notice that no granite boulders are found in the Old red conglomerate; and the probable inference is, that the granitic nucleus had not yet been brought to the surface. The accumulation of beds reposing on the Old red indicate by their fossils the presence of a fauna not unlike that of the lower Scar limestone of Yorkshire.

This early condition of the beds was soon affected by disturbances, marks of several of which can be traced in the southern basin.

And first, we find the lower beds contorted and partially broken up, while volcanic ash, &c. has become mixed with carbonaceous matter, and passes into the black schistose Posidonian limestone, this bed containing ferns, and forming the nearest approach to the true coal-measures that the island affords. After this a second eruption of volcanic matter took place; and we may trace the formation of a trap-breccia containing fragments of the Posidonia schist and limestone and of the older trap-tuff. Lastly, there is evidence of at least one disturbance posterior to this, in the intersection of the entire area of the southern basin by a series of trap-dikes having a general direction E.S.E. and W.N.W.

The whole district under discussion exhibits what may be termed an undulating structure, the ridges of the anticlinals running generally S.S.W. and N.N.E.: and it has been shown that the trap dikes exhibit certain relations with these ridges, being compact and broad on the ridges of the anticlinals, and branching out or ramifying in the corresponding synclinals. The trap also does not seem to have merely penetrated into old crevices; but if we may judge from the appearance of the bosses, must have forced itself in between the schist and the tough beds of limestone, perhaps amongst the boulders of the Old red conglomerate.

There is, besides those already mentioned, a fourth system of disturbances, whose direction is nearly N.E. by N.; and these are connected with the outburst of porphyries at a period later than that of the deposition of the carboniferous strata. I have ventured to conjecture that the date of this disturbance may be even more recent than the deposit of the boulder clay.

Part II.

On the Tertiary Formations of the Island.

[Read February 4th, 1846.]

I have already stated the nature and extent of the difficulty that exists in the way of obtaining a correct geological history of the older rocks in the Isle of Man; and I have alluded to the fact that the beds in general, especially those which are most instructive, and which appear on the southern side of the island, are covered up by tertiary sands and clays. I propose now to describe these deposits.

Although the existence of a large marine formation in the north of the island, containing shells which have been referred to the post-pliocene or pleistocene age, has already been made known through the labours of Professor E. Forbes and Mr. Strickland*, the occurrence of similar beds in other parts of the island appears hitherto to have been overlooked. It is however only by a close connexion and comparison of the phænomena presented at these other localities that the real character of the deposit and its relation to the older rocks can be determined, the base of the formation not being exposed in the north; whilst on the other hand, the superior thickness of the strata there developed and the fossils contained, supply evidence rarely to be obtained in the other district.

The deposits which I have now to describe may be classed under the four heads:—1. boulder clay and erratic blocks; 2. diluvium; 3. drift gravel, and 4. alluvium; and I propose to describe in detail the position and relations as well as the nature and contents of each of these.

1. *Boulder Clay.*—This deposit consists for the most part of a mass of unstratified, or very irregularly stratified loam and sand, including boulders of local and foreign rocks, of which the former (those from the neighbourhood) are generally the most remarkable in point of size, and are not much rounded, although scratched and polished on their flat surfaces. These boulders are frequently pushed over one upon another, and this is especially the case with the fragments of limestone in the south. The lower part of the deposit is the most loamy, and in the upper part the sands are scattered in irregular patches, and often exhibit a waved appearance.

Throughout the whole, fragments of shells are diffused sparingly and in an extremely broken and comminuted state; they are chiefly abundant in the sands, but are generally too friable to be removed without injury. Those that have been examined seem to belong to the pleistocene or newest pliocene period of Mr. Lyell; but in the lower portion of the deposit some species have been found identical with those hitherto considered as confined to the Crag; so that the date of the formation may perhaps extend so far back as the older pliocene†.

There is yet greater difficulty in determining the superior limit

* Proc. Geol. Soc. vol. iv. p. 8.

† See List of Fossils, p. 346.

of age of this deposit, since the beds pass upwards into the diluvial drift or *till*, especially in the northern part of the island. This difficulty arises partly from the want of any regular stratification and the presence throughout of transported blocks, and partly from the partial denudation and removal of the boulder clay and its re-arrangement amongst the drift; whilst it seems probable that causes resembling those which produced the true diluvium, though not perhaps of equal intensity in the same direction, may have operated during the whole period of the boulder clay formation*.

In the northern district of the island, the rake of the tide in the channel, assisted no doubt by the ordinary atmospheric action and by violent wind and rains, is constantly removing large masses of the cliff on the eastern and western coast, and exposing the whole series to view. It may be usefully studied a few hundred yards south of the town of Ramsey, where it abuts against the schist, which is seen dipping rapidly to the north (see section, Plate XVII. fig. 4). The more loamy lower portion is not there discovered in the cliff, which is hardly more than thirty feet high, but it appears to form the good holding ground in the south of Ramsey Bay; and a stick thrust down into the sand between high and low water reaches a hard clay, which no doubt belongs to this part of the formation. As we proceed northwards from Ramsey, we obtain in the cliffs between the Dog Mills and Point Cranstal a finer development of the series and access to the more loamy portion.

The boulders are described by Mr. Strickland† as consisting of slate-rock, quartz, old red sandstone, carboniferous limestone, granites, porphyries and chalk flints; and he mentions that all the rocks except the two latter occur *in situ* on the island. The granites however of the northern deposit of the boulder clay, as far as I have yet seen, are not the insular granite, nor have I discovered any chalk flints in that part of the series which I consider really belonging to the pleistocene series. In consequence of the diluvium overlying the boulder clay formation, it frequently happens that when the cliff is undermined, the boulders of the two separate series become mixed together on the sea-shore, and even on the slope of the cliff; and much caution is requisite before deciding to which formation an individual boulder may belong‡. The boulders of red syenite and porphyry agree very well with hand specimens from Cumberland, and one of them with the Skiddaw granite. As porphyritic greenstone occurs largely both in the south and centre of the island, the blocks of it in the boulder clay seem of uncertain origin; but most probably those in the northern boulder formation are foreign, and those in

* At Cranstal Head, in the north of the island, there is an appearance of alternations of larger masses of gravel and transported matter associated with the finer clays and sands.

† Proc. Geol. Soc. vol. iv. p. 8.

‡ Since writing the above I have found a chalk flint in the boulder clay of Hango Hill, at the head of Castletown Bay, in a position which seems to render it almost certain that it belongs to the formation we are now considering. See woodcut, p. 338.

the southern partly foreign and partly insular, but there are evidently two or three varieties of it. In the south of the island near the Stack of Scarlet, there are also rolled fragments of a gritty sandstone probably belonging to the coal-measures of Cumberland. We seem therefore on the whole warranted in concluding, that the transport has taken place for the most part from the E.N.E., or thence round to N.N.E.; and this view would hardly be invalidated by finding occasionally rocks from other points of the compass (as for instance, if such should be the case, chalk flints from the north of Ireland*); since supposing the general contour of the surrounding countries not to have been greatly different from the present, we can imagine a current from the N.N.W. drifting materials into this area, and mixing them with the products of more powerful currents from a direction between east and north.

Mr. Strickland has noticed certain remarkable concretionary masses occurring at Point Cranstal, four miles north of Ramsey, consisting of the fine sands (which have been mentioned as occurring in patches in the boulder deposit), "cemented together by carbonate of lime, extremely hard and even sonorous, presenting sometimes a stalactitic appearance with a pebble attached to the larger end of the concretion, at others the form of flat tabular masses, mammillated on their surfaces or perforated obliquely by tubular cavities†." He suggests that currents of water (or possibly of wind operating during ebb-tide) setting in a certain direction may have disposed the sand in ridges parallel to that direction, and that the carbonate of lime may have been afterwards attracted into these ridges in preference to the intermediate portions. I am however of opinion, that the formation is for the most part of a recent character and of the nature of a true stalactite. Having visited the spot in the spring of 1845 after copious rains, I observed that nearly similar stalactitic masses were being formed in the gullies and at the base of the cliff, by the percolation of the waters amongst the alternating beds of sand, gravel and loam. But a difficulty presented itself in the circumstance that these masses occur in nearly horizontal positions at various heights in the cliff. On the western coast also, in the neighbourhood of Ballaugh, we meet with similar formations; and on the south coast, at the mouth of the Strandhall brook which runs into the sea between Poolvash and Kentraugh near the lime-kilns, we have a bed of sand of the pleistocene age resting upon a layer of the loam of the boulder formation. It has been observed by Dr. Macculloch, that the loam of this island is so largely charged with lime as to render it for the most part unsuited to brick-making. It seems reasonable to conclude that it was formed by the grinding up of the subjacent beds of limestone and shale. Underground currents of water permeating the sands which are interposed between the beds of loam, carrying along with them particles thence derived, and becoming mixed with the finer sand and minute fragments of shells, have a tendency to deposit the same, and

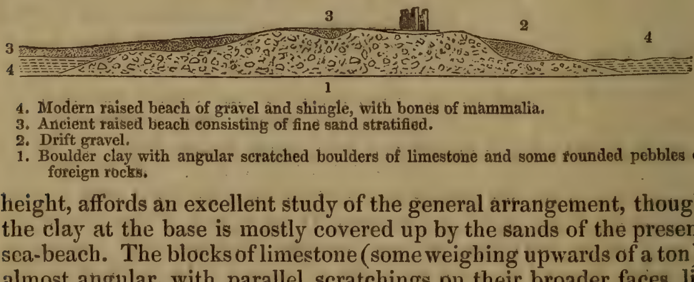
* See the previous note with reference to this point.

† Proceedings, *ante cit.* p. 9.

form a concretionary mass on the lee side of any obstruction, (as, for instance, of a pebble bedded in the sand,) the action of the water forming elongated cavities or pipes in other portions. In the instance occurring in the south of the island, not only is this seen with respect to the pleistocene sands, but a raised beach of more modern date, resting on a partially denuded bed of the boulder clay, has acquired a similar consolidation and concretionary structure; and still further, a quantity of moss growing on the cliff is now being gradually converted into travertine. If this explanation should be accepted for the phænomena occurring in the north of the island, it will remove any difficulty which might arise from considering the concretionary structure as necessarily coincident in time with the pleistocene deposit.

In the central valley of the island running from Douglas to Peel, and also in the Baldwin valley, it appears difficult to determine what portion of the water-moved mass belongs to the boulder clay formation. There is no exposure in the sea-cliffs and in the interior, but the superficial gravel and alluvium conceal everything*, and in the south of the island we have evidence of its existence through the whole of the limestone basin. All along the coast it appears as a loamy clay resting immediately on the older rocks, and occasionally we find thicker patches of it containing, in the greatest abundance, scratched fragments of the limestones, &c. of this basin, with a few rounded pebbles of the foreign rocks before mentioned. The mass of it forming Hango Hill, at the head of Castletown Bay, exhibited in the annexed sketch, and presenting a cliff to the south twenty-four feet in

The cliff at HANGO HILL, near CASTLETOWN.



4. Modern raised beach of gravel and shingle, with bones of mammalia.
3. Ancient raised beach consisting of fine sand stratified.
2. Drift gravel.
1. Boulder clay with angular scratched boulders of limestone and some rounded pebbles of foreign rocks.

height, affords an excellent study of the general arrangement, though the clay at the base is mostly covered up by the sands of the present sea-beach. The blocks of limestone (some weighing upwards of a ton), almost angular, with parallel scratchings on their broader faces, lie piled one over the other in the utmost disorder, like masses of ice drifted down a stream after a thaw. They all have the appearance of having come from Skillicore, near Coshnahawin, a mile and a half to the north-eastward, where the beds, having been altered by heat and traversed by deep intersecting cracks, break up naturally into rhomboidal blocks, which are largely used for building purposes.

But the best evidence of the direction in which the drifting current has most powerfully acted is seen near the Stack of Scarlet, on

* Two road cuttings made in the spring of the present year (1846), the one at Douglas and the other at Peel, exhibit the stratified drift gravel resting upon masses of the boulder formation from twenty to thirty feet thick.

the west side of Castletown Bay, under the lime-kilns. The limestone rising there on a steep inclination is most distinctly grooved and scratched in parallel lines, the direction being magnetic east and west*. We have similar groovings, and with the same bearings, on the surface of the Posidonia schist, in the east of Poolvash Bay, near the marble quarry†. Now had the drifting current come from the W.S.W., it would almost necessarily have carried along with it, in passing over Scarlet Head, some of the trap-tuff and fragments of the Posidonia schist; but at the before-mentioned locality near the Stack, where the scratchings and the boulder clay are well seen, and which is only a few hundred feet to the eastward of the trap-tuff, I have not yet found a single fragment of this rock, though there occur in it pebbles of the Old red conglomerate, and some of the foreign rocks to which we have already assigned a Lower Silurian origin. The same conviction as to the direction of the drift arises from an examination of the colour of the boulder clay where it is in contact with the subjacent rock. In Poolvash Bay, to the westward of the trap-tuff, it is of a yellowish brown colour, and very ochreous. Near the Stack of Scarlet it is dark blue, having obtained its materials from the dark limestones and shales of Castletown Bay. Further to the eastward we find it on the Brough, of a reddish brown tinge, which it seems to have derived from the beating of denuding waves upon the escarpment of the Old red conglomerate above Coshnahawin Head. At Port-le-Murray again, near the lime-kilns, it is of a dingy dark blue colour, possibly obtained from the older dark limestones and shales of Poolvash Bay.

The best development of the boulder formation inland is in the valley westward of the Creggins, where it is laid bare by the continued erosion of the Castletown river. The difficulty before mentioned, of distinguishing the more gravelly portions of the boulder clay from the drift, renders it uncertain whether the rounded hill above Rushen Abbey ‡, to the north-east of Ballahot (115 feet above the level of the sea), should be considered as belonging to the former deposit; but it appears in every respect similar to the Brough, and, like it, rests upon a sudden elevation of the Old red conglomerate. There has probably been large denudation of the more sandy upper portions of this deposit, which has been partly re-arranged in the lower level of the southern basin. It is not clearly exhibited in any eminence westward of Malew Church; but as there is some appearance of it on the banks of the stream near Colby, and it is distinct along the sea-shore to the south of Kentraugh and Mount Gawne, and so round to Port-le-Murray, we may safely regard it as forming, either in its original or re-arranged condition, the substratum next above the older rocks in most parts of this basin; it appears also to form

* It is perhaps well to observe that this direction is not the dip of the subjacent scratched limestone, which is more to the south, though varying.

† The limestone at Perwick Bay is scratched and grooved with nearly the same bearings, but directed rather more to the south, as we should expect, the current being turned in that direction by the coast. See Map of the Island, Plate XIV.

‡ All the hills in this neighbourhood have greatly the character of the Scandinavian trainées or osar, the longer axis running from N.E. by E.

the anchorage of tough clay in Castletown and Port-le-Murray Bays, for which reason it is inserted conjecturally in the sections made across the basin over those areas (see Plate XVII. fig. 3).

There are certain appearances in the boulder clay formation in the neighbourhood of Ronaldsway, which may lead to the conclusion that the disturbance which has produced the cracks and faults running N. 80° E. mag., and nearly at right angles to that direction, did not take place till after some deposit of the boulder clay. Whenever that disturbance did take place, it appears to have been accompanied with a discharge of heated gaseous vapours with acids, since the limestone along the cracks and upheaved portions has become burnt, crystalline and metamorphic. But what is most remarkable is, that the boulder formation is also in some way affected in the same spots, parts of it having become a hard and burnt-looking mass, which has resisted the action of the sea, whilst the rest has been denuded from the unaltered limestone in the immediate neighbourhood. It may be possible to explain this phænomenon by supposing that a cementing matter has in some way been obtained from the subjacent altered limestone, by long-continued contact and the action of water. If however the former hypothesis be adopted, it will also enable us to account for the elevated position of the boulder deposit on the Brough above Coshnahawin, and may assist in determining that the second of the disturbances which effected the elevation of that hill, was that which passed in a direction nearly compass east and west, producing also faults which run nearly compass north and south*.

Upon a general review of the boulder clay, or pleistocene formation of this island, it seems not unreasonable to conclude that there was a more arctic climate at the period of its deposit than now exists in this latitude. If we examine carefully the striations upon the subjacent rocks, we shall perceive that many of them are not continuous, but have the appearance of being struck out by a sharp blow of some hard object brought suddenly in contact and then passing over the surface. I have examined very closely the action of the waves of the present sea driving boulders over the surface of the limestone where it is exposed in many places to the action of the breakers, and can perceive no similar effect now produced; and I am rather inclined to believe in the action of ice drifting from the E.N.E., conveying fragments of the rocks from the north-west of England and south of Scotland, scratching, grinding down and polishing all the more prominent surfaces in the different channels through which it might be compelled to pass. We can readily conceive that in such a sea the action of the breakers driving forward frozen masses of gravel and boulders would have a powerful effect in the degradation of the shores; and also that large accumulations of detritus from the clay schists of the higher portions of the island (reaching to a height of between 1500 and 2000 feet) would be brought down by the

* I had long sought for some fragment of the Barrule granite in the boulder clay, and very lately I have succeeded in obtaining two rounded boulders of this rock, which however have set at rest the question as to whether that granitic boss had been upheaved before the boulder clay was deposited.

melting of snow and ice, and spread out quietly in the surrounding waters. There appears no necessity for supposing any extraordinary rush of water or more powerful waves or currents than there are at present*, but simply a difference of climate.

2. *Diluvium.*—To this series of deposits I refer certain beds of yellow sandy loam with patches of gravel and rounded masses of insular rock. It is developed on the mountain sides and filling up the valleys, being cut through by the mountain torrents, which thus leave flat terraces from thirty to forty feet above the present level of the streams. This remarkable formation was noticed by Dr. Macculloch, who gives it as his opinion that "its origin cannot apparently be traced either to the present or former action of rivers, since it is equally deep and predominant even where water could never have flowed, but that it is due to a general diluvial action from the south towards the north." I think it however more probable that the transporting action has come in nearly the opposite direction, namely from north to south, or perhaps from the north-east†. In the south of the island the deposit contains boulders of the Barrule granite, and masses of quartz-rock and metamorphic schist, derived apparently from the same locality, and does not contain, so far as I have hitherto observed, any masses of the limestone of the southern basin, even where overlying the limestone, being remarkably deficient in this respect.

It is possible to account for a large portion of these accumulations in the inland valleys and on the slopes of the mountains, on the simple hypothesis before suggested, of an arctic climate existing at the period of the formation of the boulder clay.

The whole of the south-eastern side of the chain of South Barrule, as far south as Perwick Bay, is however scattered over with blocks of the insular granite‡. Now it is easy to imagine a transporting action from the north-east sufficiently powerful to drive these boulders along the slope of the mountain range from the granitic boss on the eastern side of South Barrule. But the most remarkable circumstance is, that these boulders are found not only on the *south-eastern* side of the ridge, but on the very top of it, and driven over to the *western* side; they are even plentiful on Irey-na-Laa, and may be seen on its very summit, and occur on the western slope down to Dalby Head. Further than this, there is one large boulder, weighing apparently more than two tons, on the western side of South Barrule, within a hundred feet of the summit, and several a few hundred yards to south-west, at a little lower level. To reach this point from the granitic boss on the eastern side of South Barrule, the boulders must have been driven 600 feet in perpendicular height up

* The current now runs at the rate of eight or nine miles an hour in some states of the tide, between the Calf of Man and the main island.

† From observations recently made on South Barrule, I am now inclined to consider that the diluvial action was directed from a more easterly point.—June 1846.

‡ They occur near Arrogan-beg in Santon parish, on the Brough, on the Douglas road near Ballasalla, and on the peninsula of Langness, which are points varying from S.E. to S. by E. from the granitic boss on South Barrule. See Plates XIV. and XV.

the steep face of the eastern side of the mountain, and rolled down on the other side. The granite blocks appear quite distinct from any Irish granite, and in no respect differ from the insular kind wherever that is seen *in situ**.

3. *Drift Gravel.*—It would seem that a deposit of this kind has at one time been extensively distributed, but has suffered greatly during the partial upheavals of the whole island, and the constant beating of the sea into the insular valleys. It is generally found capping the lower hills, and sometimes spreading out in extended platforms, as in the parishes of Andreas and Jurby, and in the Vale of St. John's. This deposit exhibits all the appearances of an ordinary sea-beach, consisting of beds of pebbles, shingle, gravel and sand irregularly stratified, and it contains (in addition to the insular rocks) chalk flints. These are not uncommon even in the south of the island, and have been found in digging the foundations of houses in the higher part of Castletown. The sifted gravel is the great material for road-making in the northern parishes, and is found reaching to a height of more than sixty feet above the present high-water mark. It caps the old red sandstone and the boulder formation at Peel, and occurs on the western side of the Calf of Man. I consider it to be a drift from the north-west†, and deposited when the level of the land was from sixty to eighty feet lower than at present. Its occurrence in the Castletown basin is easily accounted for by remembering that a channel would then exist from Port-le-Murray to Port Erin; and in the same way, by the central valley from Douglas to Peel, we may account for the patch of this gravel near the Douglas Light-house and in the upper part of the town of Douglas.

The denudations of this drift during the subsequent upheaval of the island are extremely interesting. The extensive swamp of the Curragh, in the north of the island, seems to repose in a hollow scooped out in it, so that in proceeding northward from the Curragh you ascend at once upon the platform of gravel and sand, which appears to form a kind of fringe, like the banks of some large inland lake. The same is the case in the Vale of St. John's, where the turf bogs lie in hollows formed in a similar way. But the most remarkable appearances are in the southern basin of the island, and give the impression that the great denuding action has come from the south-west by south, or up the Irish Channel, as this is the direction of the long valleys which run down to the sea and form the river-courses. Doubtless this form has been aided by the circumstance that the strike of the undulations of the subjacent limestone runs in general in this same direction; and it is highly

* I believe there is no point north or north-west of Barrule at which the granite is developed, as I have crossed Slieuhallin (the most likely point for its development) and inquired for it in vain amongst the miners in that neighbourhood. The existence of granite in this district would indeed relieve us from a considerable difficulty, as we can hardly otherwise understand the phænomena presented in the distribution of the boulders.

† There is however no necessity for supposing any other currents than those at present existing in the Irish Sea, and the materials of this drift gravel are evidently derived in great part from the boulder formation.

interesting to observe how the axis formed by the eruption of trap-rocks at right angles to this direction from the Stack of Scarlet to Poolvash, and, again, the elevation of the mass of limestone forming the Balladoole Hill, has acted as a barrier against this south-west-by-south denudation. The effects of the denuding action when the sea was at a higher relative level, and flowed over the low barrier extending from the Stack of Scarlet to Poolvash, are somewhat singular.

We observe a series of rounded hills (Pl. XVII. fig. 1) situated on a line from the Brough towards Kirk Arbory, the most remarkable being that above the Creggins, and at Skybright near Malew Church. They present the appearance of bosses of an oblate-hemispheroidal shape, and consist of masses of drift gravel and sand. They have perhaps formed (when the land was at a lower level) a continuous line of sea-beach since broken through by a rush of water from the N.E. by E., or they are the relics of the former highest level of the drift, and were produced by the beating about of different currents during a period of elevation. And we may observe (as in some respects connected with this last view) a similar conformation in the chain of low hills (reaching to about the same height) running from Point Cranstal to Blue Head. This chain exhibits an appearance of having been a sand-bank extending in a line parallel to the ancient northern coast of the island, at the distance of four miles from it.

The neighbourhood of the Creggins, and the valley down which the Castletown river runs, are well-worthy of study, as presenting some of the most striking features of a country denuded by water at different levels. I have, however, no new facts to offer with regard to the age of these formations, as I cannot with certainty refer to them a few shells of recent species, with bones of mammalia, obtained near the surface; since in these places it is doubtful whether they may not belong to a more modern raised beach, of which notice will be presently taken, and which, partly covering up the older alluvium, is of considerable interest as indicating an oscillatory movement of the land.

4. *Alluvial Beds.*—It has just been stated that the alluvial deposits of the island rest for the most part in large hollows formed by the denudation of the drift gravel and sand down to the boulder clay, and in some instances, in the south of the island, down to the fundamental limestone. The numerous mountain torrents flowing into these hollows have afforded abundant material for sedimentary deposits wherever the imperfect drainage of the country has given opportunity for the spreading out of tranquil waters into inland lakes or sheltered estuaries.

The existence of such lakes to a large extent, even within the historical period, is attested by ancient records, and by the names of several places on the island*, while four of them are inserted in a map of the island published in 1595. Those in the north were

* Thus we have Ballaugh (Balla lough—the place of the lake) in the north, and Balla-lough, near Castletown, in the south. Also Ellan-vane (White-island), near Lezayre.

drained by a deep cutting towards the close of the seventeenth century. I cannot help thinking, however, that these lakes, and their resulting deposits of shell marl, were of recent date compared with another alluvium which originally occupied the entire basin of the Curragh from sea to sea, and was widely spread over the low grounds of the southern basin of the island.

The marl, which is used largely in the northern districts for agricultural purposes, is of three kinds, a reddish-brown marl being obtained in the parishes of Kirk Bride and Andreas, a bluish-brown marl generally raised in Jurby parish, while a light-coloured shell marl chiefly prevails in Ballaugh. The first evidently belongs to the boulder clay formation, the second is perhaps the older alluvium, and the third is the deposit of the lakes drained in the seventeenth century.

It has been stated that the remains of the Irish Elk (*Megaceros hibernicus*) have only been found in this last deposit, the shell marl; but I have myself discovered them in the blue marl of the south of the island, which I believe to be identical with the blue marl of the north or Jurby marl. The bog timber is generally procured from the turf, which is in many places from ten to twelve feet thick. It is stated in Sacheverell's 'History of the Isle of Man,' published in 1702, that trees of very large dimensions had been found in the Curragh, twenty feet below the surface, with their roots firm in the ground and their trunks laid over in a north-easterly direction*. Dr. Macculloch also mentions, and living witnesses have confirmed the statement, that twenty years ago, after a violent storm, lasting three days, the sands in Poolvash Bay being denuded in front of Mount Gawne, trunks of trees were discovered lying prostrate towards the north, as if overthrown by the force of waves coming in upon them from the south. In the autumn of 1845 I discovered, about a mile to the east of Mount Gawne, at the mouth of Strandhall brook, betwixt high and low water, a bed of turf one foot thick, and the trunks of trees (oak, ash and fir), of which I counted eight in an erect position, and traced the roots of one (an oak) several feet in the stiff alluvial blue loam, which was evidently the subsoil upon which the trees grew†. The alluvium (which is here not more than three feet thick) rests in part upon the nearly horizontal limestone and in part on a denuded bed of the boulder clay, and is situated at the opening towards the sea of one of the valleys of denudation. A few yards to the east and west of this submerged forest we have a raised beach of a recent period. It is possible at this particular spot to explain the phænomenon by supposing the bank driven back upon the land, and that formerly it intervened between this forest and the sea, and by a partial damming up of the water of the stream formed a swamp, and the alluvial deposit in which the turf and trees grew. However this may be, it is certain that this same alluvial

* Bishop Wilson, in his 'History of the Isle of Man,' notices the remarkable occurrence of a layer of peat for some miles together, under a layer of gravel, clay, or earth, two or three, or even four feet thick.

† It is singular that the trunk of an oak-tree which has been removed from the submerged forest at Strandhall exhibits upon its surface the marks of a hatchet.

marl is covered up in the neighbourhood by a recent marine formation. The greater part of the almost flat country extending from near Castletown to Kirk Christ's Rushen has evidently been submerged after the deposit of blue marl. From this blue marl on the Balladoole estate, at a depth of six feet, I recently obtained the portion of the right pelvis of a *Megaceros*, and at the same place, reposing on the blue marl, we have two feet of marine sand, in which, at the distance of a few hundred yards, at a spot lying between Balladoole and Scarlet House, there is a complete bed of recent marine shells. I consider that the submergence which buried the blue alluvial marl was to the amount of at least twenty feet, as the recent beds are seen at that elevation on Hango Hill, and the before-mentioned spot near Scarlet, where the marine shells occur, is not less.

Should the evidence of the overthrown trees, both in the Curragh and in Poolvash Bay, and the occurrence of beds of gravel in the latter place (to the northwards), suggest the idea of a sudden depression of the land, perhaps the occurrence in the south of the island of beds of recent marine shells at different levels, and the appearance of terraces in some of the southern valleys, may be looked upon as evidence that the subsequent emergence was gradual, or occurred at intervals. Whether the human race inhabited the island at the time of the older alluvium will admit of question; but the Elk, which at any rate was then existing, may have continued as an inhabitant of the hills at the time of the submergence of the lowlands, of which he resumed the occupancy when the final emergence subsequently took place, and those insular lakes were formed, in which (imbedded in the clay marl) we find the remains of this singular animal associated with the implements of human art and industry, though of an uncouth and ancient character.

Concluding Remarks.—Upon a general review of the facts which have been adduced, I have now in conclusion to offer the following summary.

At the period of the deposition of the boulder formation, the present Isle of Man, with the Calf of Man, must have existed as a chain of certainly four, probably more than four, small islands. These were, first, the Calf of Man, nearly as at present; then to the north of this an island lying between the Kitterland Strait and a line running from Port-le-Murray to Port Erin; and another or third island betwixt a channel in this last direction and another channel running from Douglas to Peel. A fourth island also probably extended to the north, as far as a curved line drawn from Ramsey to Kirk Michael, the sea at that time flowing over an entire area of nearly fifty square miles which now constitutes the northern tertiary district of the present Isle of Man.

Presuming, from the character of the fossils, that there existed a climate much more excessive than that which is now met with in the island, and which we may call Arctic, we have the conditions necessary for the origin of the boulder clay formation in the drifting of icebergs through various channels, and the thrusting forwards masses of frozen gravel along and upon the coasts, the general drifting current coming from E.N.E. At a subsequent period, and during convulsion and general disturbance (possibly not unconnected with the latest upheaval of the insular mountain chain *), enormous waves appear to have swept the island from the N.E., or N.E. by E., depositing erratics on the highest points, and filling up the valleys with an accumulation of diluvium. The drift gravel may be considered as merely the subsequent spreading out, with greater uniformity, of the same material over the then sea-bottom; and it is not unreasonable to conclude also, that there had been through the whole of this period a filling up of the area of the Irish Sea, so that on its subsequent elevation the present Isle of Man was connected with the surrounding countries. The preservation of the tertiary beds of this island from the continued destruction, which enabled the sea to recover so large a portion of its ancient area, is evidently due to the configuration and position of the island; whilst the formation of the valleys of denudation, and the hollows in which the ancient alluvia repose, seem to indicate that there was at first a gradual rise terminating in a sudden elevation of this area. But further facts have been adduced pointing to its subsequent submergence, followed again by a second partial emergence, and this latter movement has left the Isle of Man as a nucleus of palæozoic rocks, fringed with tertiary marine and freshwater formations belonging to the most recent geological period.

APPENDIX.—*List of Fossils from the Pleistocene Marine Formation of the Isle of Man, collected by the Rev. J. G. Cumming and named by Prof. E. Forbes.*

Pectunculus pilosus.
Cyprina islandica.
Astarte gairensis ?
Artemis exoleta ? (fragments).
Astarte damnoniensis.
—— pisiformis ? †
Venus casina.
Pullustra decussata ?
Nucula rostrata (oblonga of authors).
—— minuta.
Cardium edule ?
—— lævigatum.
Tellina solidula.
Dentalium entalis.

* It may be useful to observe, that the direction of the great fault lifting South Barrule, and producing cracks at right angles, coincides exactly with the line of those disturbances and cracks in the neighbourhood of Ronaldsway and Coshnahawin, the occurrence of which after the deposition of some portion of the boulder formation, I have before shown as not altogether improbable.

† Named by Mr. G. B. Sowerby.

Patella vulgata.
Turritella terebra.
Fusus Bamfius.
—— scalariformis.
—— antiquus.
—— cinereus*, *Say*. (An American species, according to Mr. G. B. Sowerby.)
A variety of the same, or possibly a distinct species.
Pleurotoma turricula.
Murex erinaceus.
Buccinum undatum, var. tenerum.
A variety of Buccinum undatum? resembling Nassa reticosa.
Purpura lapillus.

DESCRIPTION OF THE PLATES.

Plate XIV.

1. General Map of the Isle of Man, corrected by the Author, and geologically coloured.

[In this map the beds are coloured to the outer line, which represents the coast at low water.]

2. General Section across the south-western part of the island from Lhergydoo, north-east of Peel, to Langness Point, south-east of Castletown.

Plate XV.

Geological Map of the limestone basin, and other parts of the southern district of the island, as it is supposed they would be seen if denuded of the tertiary formations. This map exhibits the relations of the Carboniferous series to the older Palæozoic formations, together with the undulations caused by the intrusion of igneous rocks and the principal axes of disturbance.

Plate XVI.

1. Ground plan (geologically coloured) exhibiting the details of the coast from Ronaldsway near Derby Haven to Coshnahawin at the mouth of the Santon River, and marking the position of the faults, cracks and axes of disturbance connected with the elevation of the Brough and the formation of a series of bosses along one of the lines of disturbance.

2. Section exhibiting the contorted limestones and trap at Scarlet Stack near Castletown.

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* This is Mr. Strickland's *Fusus Forbesii*.

Plate XVII.

Sections in the Isle of Man, exhibiting the arrangement of the Southern Basin and of the Tertiary Deposits in the neighbourhood of Ramsey.

Section 1. From Balla Gawne, near Kirk Christ's Rushen, to Coshnahawin at the mouth of Santon River, exhibiting the effects of denudation on the tertiary beds, and illustrating the formation of alluvial basins.

Section 2. From Scarlet Head to Umber Hill near Ballasalla.

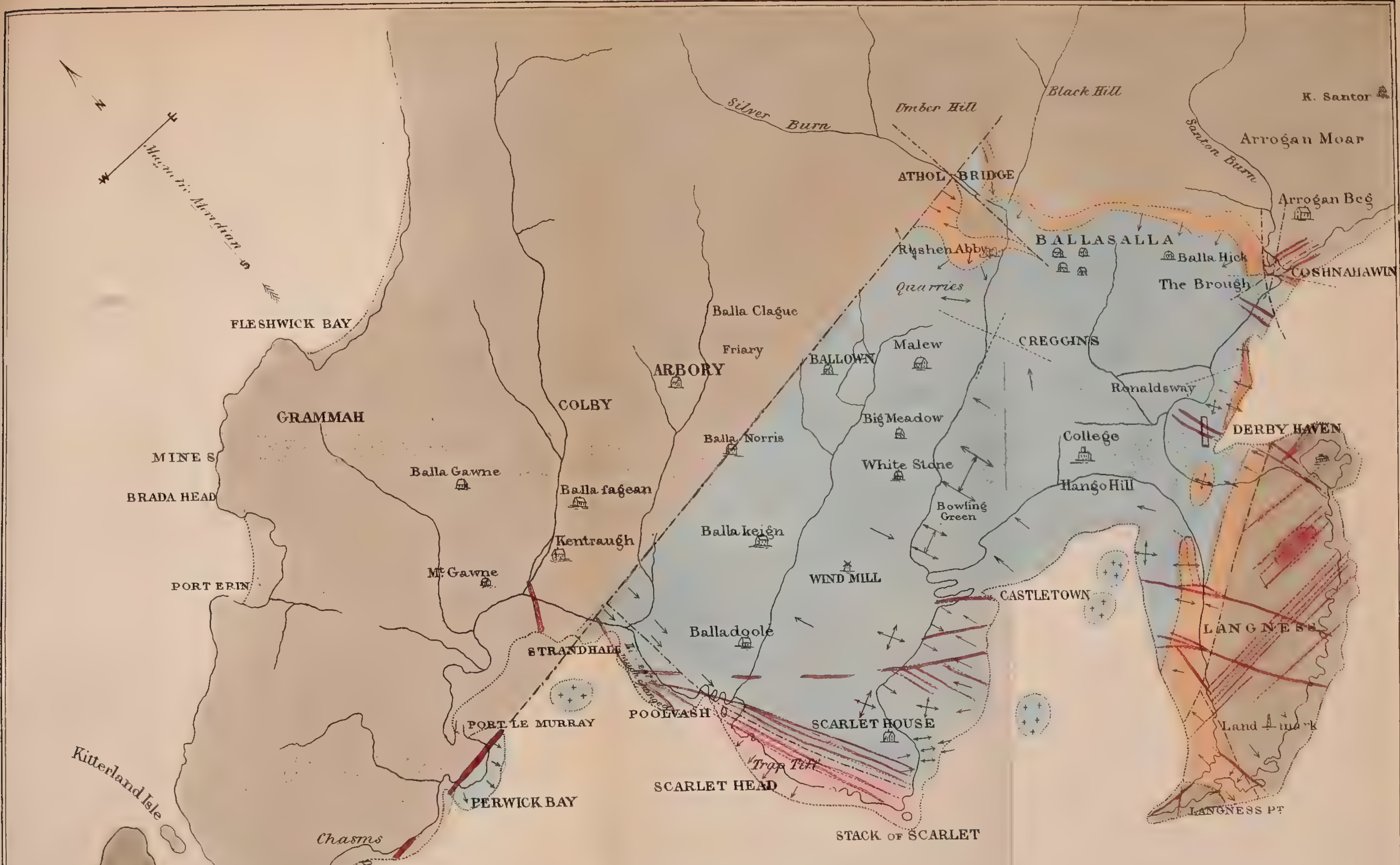
Section 3. From Perwick Bay near Port-le-Murray through Poolvash and Castletown Bays to the sea-coast at Langness Farm, illustrating the formation of the stratified trap-tuff with the included Posidonia schist.

N.B. These three sections are not seen continuously on the coast line, and are in some parts theoretical as respects the palæozoic formations.

Section 4. Coast section exhibited south of Ramsey, showing the boulder clay formation partly denuded and overspread by drift gravel, boulders and sand, the latter much waved.

Sections 5, 6. These sections are intended to illustrate the elevation of the Brough at the mouth of the Santon River. The letters of reference, O P, R S, refer to the ground plan, Plate XVI., and the Sections are exhibited in the cliffs, the observer being supposed to look towards the south-west in the diagram marked (5) and north-east in that marked (6).

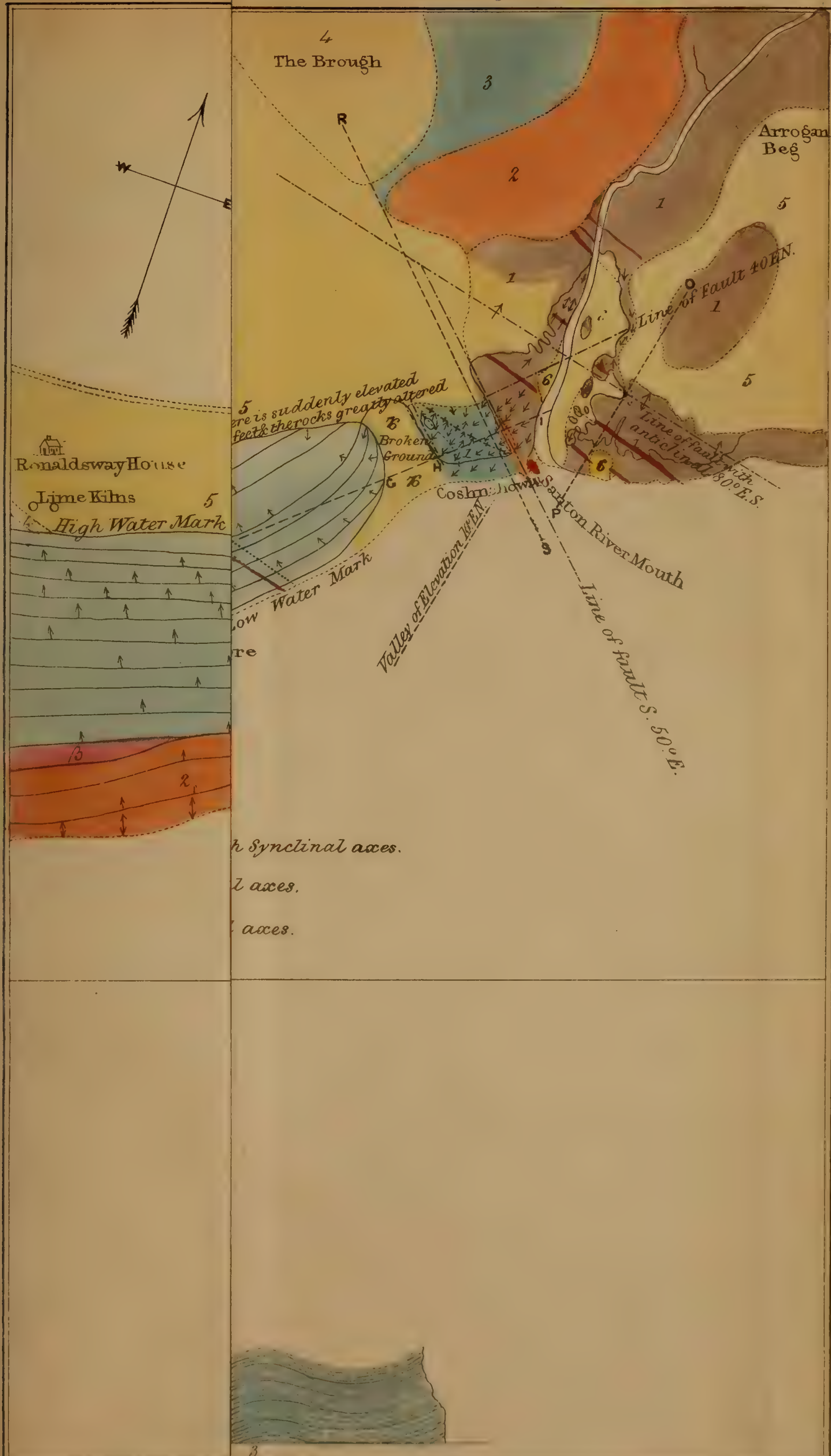
Reeve Bro lith King William St



SOUTHERN LIMESTONE BASIN of the ISLE OF MAN, Denuded of the Tertiary Formations.

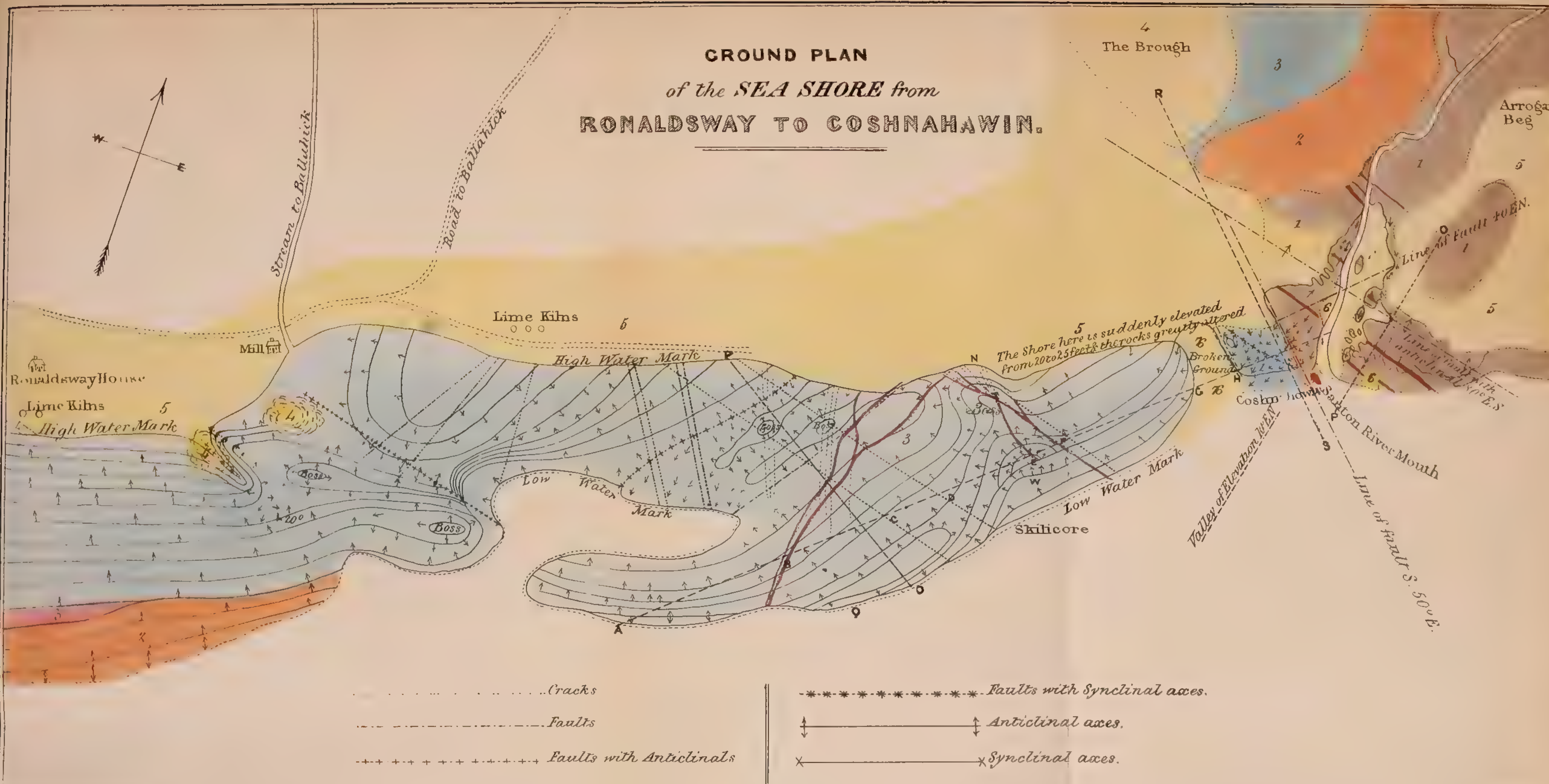
Revd. J. G. Cumming.

Reeve Bro. lith. King William St. Strand.

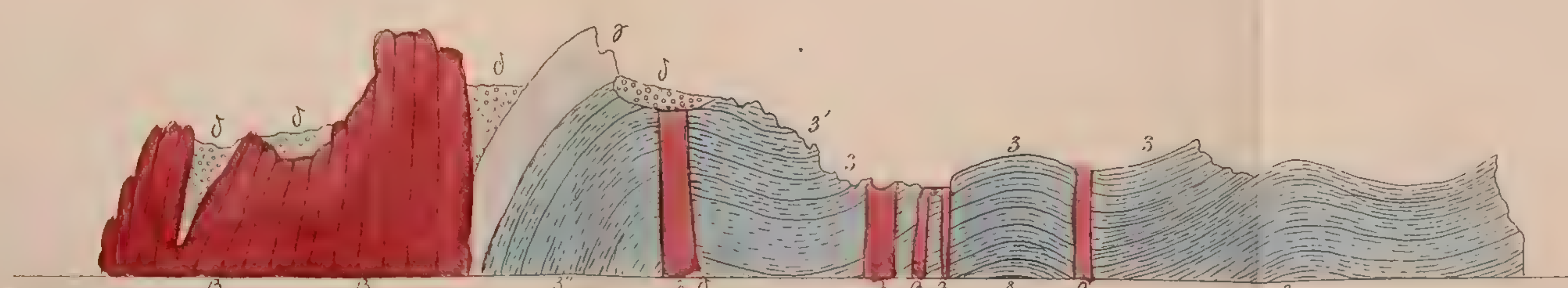


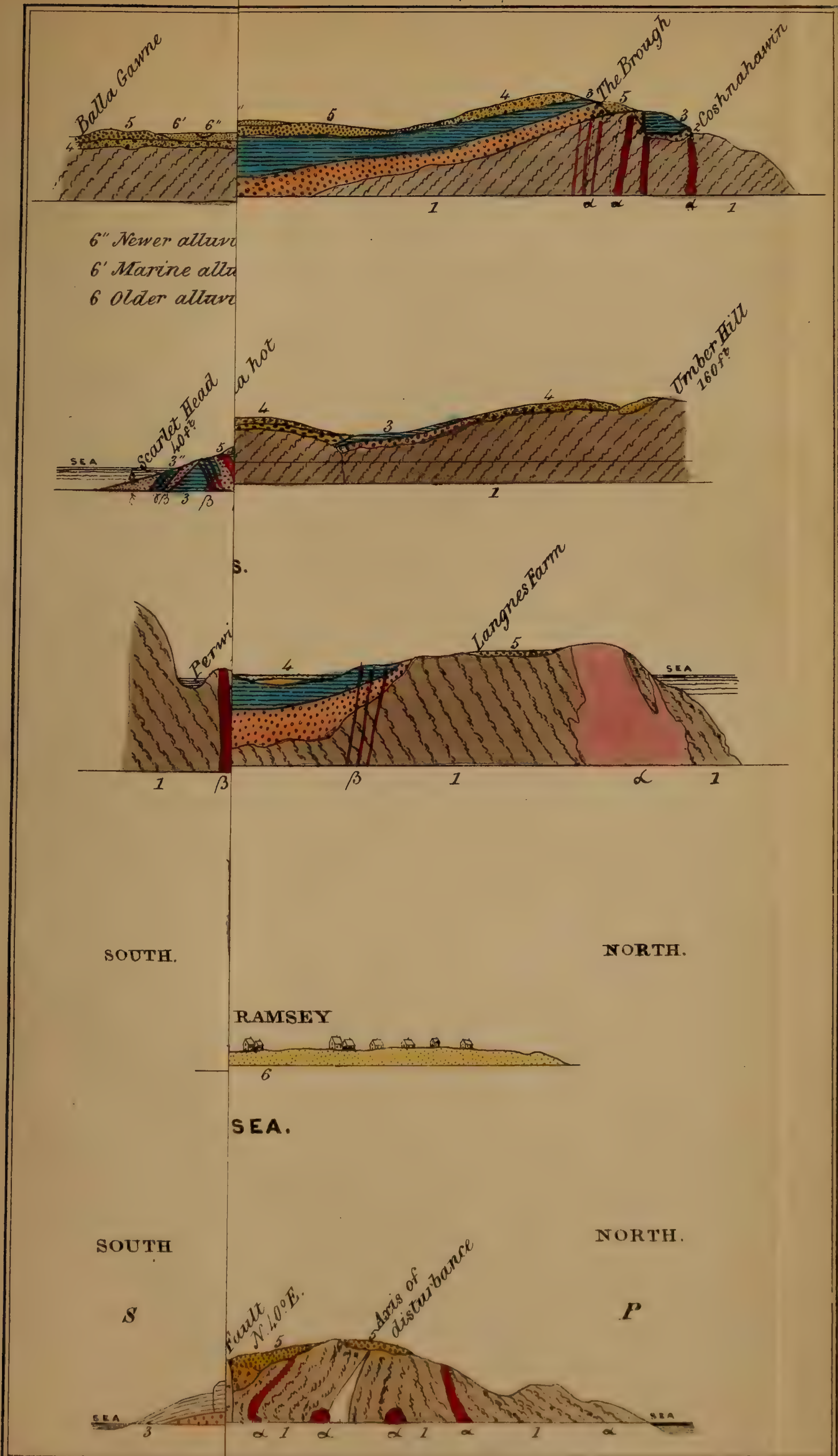
Reeve Brothers, lith.

GROUND PLAN of the SEA SHORE from RONALDSWAY TO COSHNAHAWIN.

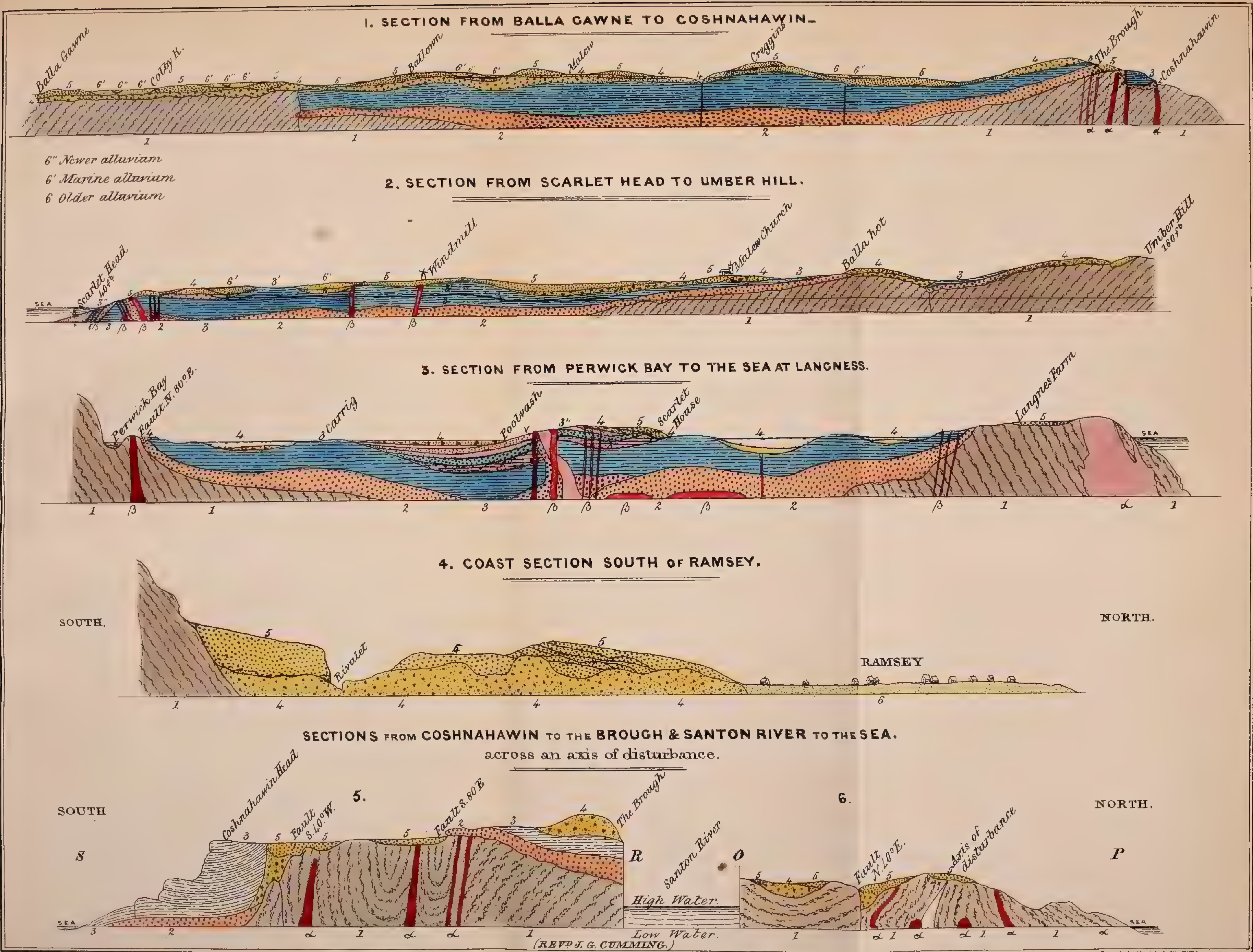


7. CONTORTED LIMESTONES & TRAP, *at Scarlet,* ISLE OF MAN.





Reeve Brothers, lith.



1. SECTION FROM BALLA GAWNE TO COSHNAHAWIN.
Balla Gawne
Colby R.
Ballown
Malew
Creggins
The Brough
Coshnahawin
6″ Newer alluvium
6′ Marine alluvium
6 Older alluvium
2. SECTION FROM SCARLET HEAD TO UMBER HILL.
SEA
Scarlet Head 40 ft
Windmill
Malew Church
Balla hot
Umber Hill 160 ft
3. SECTION FROM PERWICK BAY TO THE SEA AT LANGNESS.
Perwick Bay
Fault N. 80° E.
Carrig
Poolwash
Scarlet House
Langnes Farm
SEA
4. COAST SECTION SOUTH of RAMSEY.
SOUTH.
NORTH.
Rivulet
RAMSEY
SECTIONS FROM COSHNAHAWIN TO THE BROUGH & SANTON RIVER TO THE SEA.
across an axis of disturbance.
SOUTH
NORTH.
5.
6.
S
R
O
P
Coshnahawin Head
Fault S. 40° W.
Fault S. 80 E.
The Brough
Santon River
High Water
Low Water
Fault N. 40° E.
Axis of disturbance
SEA
(REVD J. G. CUMMING.)

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

April 8, 1846.

James Matheson, Esq., M.P., F.R.S., and Joshua Richardson, Esq., were elected Fellows of the Society.

The following communication was read :—

On the Superficial Detritus of Sweden, *and on the Probable Causes which have affected the Surface of the Rocks in the Central and Southern portions of that kingdom.* By Sir Roderick Impey Murchison, G.C.S., F.R.S., V.P.G.S., Memb. of the Imp. Ac. Sc. St. Petersburg, and Corr. Memb. of the Royal Institute of France.

In the work on Russia and the adjoining countries published by M. de Verneuil, Count Keyserling and myself, the subject of the erratic and superficial phænomena of Scandinavia and the northern regions has been discussed at some length, the facts being derived from our joint observations in Russia, and also from personal researches of my own in Poland, Norway and Sweden during the summers of 1843 and 1844. Having since revisited Sweden, and having examined certain districts of that country in company with M. de Verneuil, I beg to lay before the Geological Society some additional data which we there collected, confirming and enlarging the views at which I had previously arrived, and still further elucidating the subject.

The superficial phænomena of Sweden are so remarkable, that, to say nothing of native authors, few foreign geologists have visited that kingdom without recording the impression which their inspection produced. M. Alex. Brongniart published in the year 1828 a memoir* on the erratic blocks of Sweden, in which, referring to De Luc, De Saussure, and others who had treated generally of the distribution of coarse detritus, he cites MM. Escher and von Buch (particularly the latter) as having well considered the northern examples. In this memoir M. Brongniart, after describing the linear form of the Osar†, and the size, form and nature of their materials, specially calls attention to the fact, that their chief mass is composed of completely rounded water-worn gravel, often very coarse and containing boulders of some magnitude; and states, with perfect accuracy, that the largest blocks invariably overlie the great heaps of detritus. But although he also truly says that some of them are angular, he does not convey to his readers the important fact, the result of my own investigations and those of my friend, *that such large blocks as are on the surface are invariably more or less angular, and are quite distinct from and never intermixed with the rounded and highly triturated debris on which they rest.*

At the period when M. Brongniart wrote, geologists had no mode of explaining the transport of all sorts of detritus, except by assuming the powerful action of water in the manner supposed by De Saussure, De Luc, Sir James Hall, and numerous other authorities, among whom M. Brongniart cites our distinguished countrymen Buckland and Sedgwick, both of whom, with the rest, then attributed such transport to a more powerful agent than any now known in nature.

Another superficial phænomenon dwelt upon by M. Brongniart was the mechanical striation of the Swedish rocks in lines from north to south, or as he thought, generally from N.N.E. to S.S.W.; in reference to which he quotes De Lasteyrie, who not only remarked the same fact thirty years before, but also observed, what indeed M. Brongniart did not remark, that the northern ends of certain rocks and promontories were rounded and worn, and their southern sides left rough. The observation of De Lasteyrie is that which M. Sefström at a subsequent period so extended as to render it probable that the phænomenon might be considered general in respect to all those parts of Sweden which he visited, and in memoirs communicated to the Academy of Stockholm he showed that long ridges of detritus of northern origin were almost invariably to be seen extending from the southern or abrupt side of each rocky promontory whose northern face was worn down and striated, and observed that such results had probably been produced by a powerful deluge pro-

* Ann. des Sciences Naturelles.

† "Osar" in Swedish is the plural of "Os," a heap or ridge of water-worn detrital matter.

ceeding from the north, which, conveying coarse materials along with it, had worn away and ground down all natural asperities forming the "Stoss Seite" or weather side of the rock, such materials (the impetus of their transport being checked) having been deposited under the lee or "south" side of the elevation. But neither in these, nor in other collateral observations, was it supposed that the operation had taken place when the rocks of Sweden so affected were beneath the sea, nor was any clear distinction drawn between the greatly water-worn rounded materials (which with sands form the mass of the Osar) and the angular erratic blocks on the surface. It was only when the subject of terrestrial glacial action was brought prominently before the scientific public by the researches of Venetz, Charpentier and Agassiz in the Western Alps, that geologists and naturalists began clearly to see, that although water may have been the agent by which great masses of drift and sand have been spread over the low countries of Europe, there might be many mountain localities where glaciers formerly existed, to the advance of which, as well as to their melting and dispersion, many of the superficial phænomena in question, particularly the "*blocs perchés*," might be due.

Dwelling upon the great truths which his contemporaries and himself had worked out in the Alps, Professor Agassiz pursued his favourite hypothesis with an ardour which has always seemed to me unsupported by reason, and endeavoured to show that true terrestrial glacial action once extended over nearly the whole of northern Europe, covering all those tracts, whether in the British Isles or on the Continent, where the surfaces of rocks are worn down, polished and striated in a manner resembling that observed in the Alps. This bold but hasty generalization was however soon restricted to what is apparently its legitimate range by the publication of Professor James Forbes's work on the Alps, in which it is clearly demonstrated, from actual experiments on the motion of the glaciers themselves, that such bodies never do and never can advance except in tracts where they are backed by lofty mountains, so that the accumulated and condensed snow may be pressed forward by constantly increasing masses, and moved by its own gravitation on an inclined surface*.

Without here entering further into the question of what tracts now exempt from them may formerly have been subjected to the advance of true terrestrial glaciers, and not now discussing the case of Snowdon and other elevated points of Britain to which Dr. Buckland has called attention, since each case must be rigorously determined on its own merits, I now call the attention of my brother geologists to the superficial phænomena of those parts of Scandinavia, in which, at all events, it will, I trust, be made quite manifest that no land glaciers have ever acted.

In all the central and southern portions of that district, and over

* The same author has shown how ancient glaciers must have produced the superficial appearances in the lofty Cuchullin hills of Skye.

many degrees of latitude, there is, it seems to me, more distinct proof than in any other part of the globe yet examined, that however glaciers may have once prevailed (as I believe they did in ancient times) in the higher tracts which form the northern axis of that country, its lower portions, and with them, the greater part of Russia and Germany, were beneath the sea during the whole of the period when the detritus to which I am now alluding was accumulated. This inference has been sustained by much independent evidence already recorded, and chiefly by the existence of sea shells in sandy and argillaceous detritus beneath the erratic blocks both on the east and west coasts of Sweden. To illustrate this point, I formerly cited proofs, that post-pliocene marine shells occur in the north-eastern extremity of European Russia under the sand and detritus on the banks of the Dwina; and in my last tour I found that Colonel Osersky had discovered marine shells of the same age and character in the gravel and sand and under the great erratic blocks which cover the Silurian plateaux of Esthonia on the southern side of the Gulf of Finland*.

Referring to the published views of my friends and myself respecting the vast distances to which the northern detritus has been carried southwards over Russia and Poland (usually in long *trainées* which proceed in divergent directions from Scandinavia and Lapland as a common centre), I will now very briefly allude to some observations of our French contemporaries in Norway, and afterwards treat of those superficial appearances in Sweden, including Gothland and Dalecarlia, which have recently fallen under my notice, tracing the phænomena from south to north.

Both Spitzbergen and the region of Norway now occupied by glaciers have been recently illustrated by different French naturalists attached to the "Expédition Scientifique du Nord." I need, indeed, scarcely allude here to the memoirs of M. Martins, since they have little bearing on the broad geological phænomena to which I now advert. M. Durocher, however, not only visited Spitzbergen and the Alps, but has since travelled over North Sweden and also those parts of Norway which are still occupied by glaciers; and as his chief object, in a memoir recently read before the Geological Society of France, has been to point out the real distinctions between true glacial phænomena and those resulting from aqueous transport or drift, I would refer to his writings as bearing distinctly upon the present question.

It is almost needless to revert to M. Durocher's former opinions respecting Scandinavian drift, as they were clearly placed before the public by M. Elie de Beaumont in a report to the French Institute. At that time M. Durocher believed (and I am not aware how far he has yet changed his opinion) that the whole or the chief mass of the drift had traversed Scandinavia from some more northern or polar region. The subsequent observations however of Böhtlingk

* I had indeed anticipated that such would be found. See 'Russia in Europe and the Ural Mountains,' &c., vol. i. p. 327.

in Russian Lapland, as well as of Siljeström in Finmark (if not those of M. Durocher himself), appear to me to negative such a view; for it has been clearly shown, that the axis of the Scandinavian chain being once passed, the drift has been transported north-westwards, northwards, and even north-eastwards. Nay more: as in reference to the central and southern portions of Sweden, including Finland, &c., all the northern faces of the promontories are worn down where the drift has travelled southwards, so in North Lapland, Finmark, &c., where the drift has been moved northwards (as is proved by the materials), it is the southern faces of the headlands which have been abraded. These facts sufficiently indicate that the drift, however produced, has radiated from the Scandinavian as from other mountain chains. Such being the case, it would be useless to seek for an exact parallelism in the numerous striæ which cover any one great portion of this part of the continent. In the region of the present glaciers, the striæ, according to M. Durocher, proceed in divergent radii from small centres, just as they do in the Alps or other countries where glaciers exist; and I am far from wishing to deny, that in certain portions of those high tracts, other striæ which are visible where no glaciers now exist may have also resulted from former larger glaciers.

But even granting this to an extent which M. Durocher, who has examined the localities, does not admit, the survey of Sweden has convinced M. de Verneuil and myself, and M. Durocher entertains the same views, that glaciers cannot by any possibility have caused the phænomena to which I now wish to direct special attention. A much more extended view must be taken of the operations of nature by those who would expound in a rational way these phænomena. When carefully observed and duly considered, I feel, however, persuaded that even the most determined glacialists must admit, that other agents besides solid ice moving over the surface of the earth may have produced some results exactly analogous to those which glaciers now effect; whilst in developing the facts which have come under my notice in Sweden, I shall be able to show, that, associated with certain features quite undistinguishable from those which are left by the advance of glaciers, the rocks there offer other superficial appearances which are perfectly incompatible with the movement of such bodies. I do not believe, that because it may not be possible to find in existing nature any other agent than ice which leaves behind it these markings, that geologists, whose investigations involve inquiries into the former energies of nature at periods when most of our present continents were under water, are to be debarred from reasoning on ancient evidences, or from appealing to what we firmly believe must have been true ancient causes, which, however they may at first sight appear difficult to imagine, are not to be left, as Pliny thought of old, "concealed in the majesty of Nature."

Referring then to various memoirs of M. Durocher relating to the higher tracts of Norway and the northern parts of Finland not visited by me, and to a note by that author in reply to certain criticisms of Messrs. Agassiz and Schimper on his views of the Scandinavian phænomena, published in the Comptes Rendus of January 19, I will here simply state, that in his description of the deep and sinuous furrows so frequent in Norway, M. Durocher most clearly establishes, that such furrows could only have been produced by violent currents of water transporting drifted materials. Most thoroughly, indeed, do I agree with Durocher, as will be seen in the sequel, that the accumulations of gravel and sand spread over the low plateaux and plains of Dalecarlia can never by any possibility be explained in the way insisted on by Agassiz and Schimper, namely by alternations of glacial moraines and sandy beds formed by the dissolution of glaciers *.

Viewed as a whole, the detritus of southern Norway and the adjacent portions of Sweden may be considered to have swept over Denmark and Holstein to Brabant and the northern provinces of

* In M. Durocher's memoir read before the Geological Society of France in November last (Bull. vol. iii. p. 65), after describing the different forms of erosion, striation and polish to which the rocks of many varieties of composition have been subjected, that author dwells much on certain deep and narrow gullies (often only one to three feet wide), which, even when tortuous, sinuous and branching, have their sides polished and also scratched in the prevailing direction of the transport of the drift. Arguing that glaciers never could have produced such results, particularly on the upper or overhanging faces of some of the narrow cavities which are so polished and striated, he comes to the same conclusion as that already published by my friends and myself, " that the erosive apparatus or instruments must have been to a certain extent not only fluid, but also partly solid and composed of blocks of gravel and sand, the same materials, as is well known, which etch and polish the rocks subjacent to glaciers." While repudiating, as we do, the possible application of the Alpine glacier theory to the chief phænomena of Scandinavia, M. Durocher rests to some extent on the value of proofs of aqueous action which we have only partially and imperfectly seen (the long sinuous and deep channels), and his conclusions are therefore of additional value in the argument. The reader who will consult what we had printed (Russia, &c., *ante cit.*, vol. i. p. 540, *et seq.*) before the communication of M. Durocher appeared, and will also compare what he has enunciated with the observations which I now offer, will perceive, however, that besides the distinctions in the phænomena cited by him and by ourselves (all equally subversive of the application of the glacier theory to Scandinavia), M. Durocher has adopted theoretical views of diluvial action essentially differing from those which I have advocated and still adhere to. He clings, for example, to the ancient idea of water passing over pre-existing continents, and appeals to the former action of seas standing at higher levels; whilst I consider the level of the ocean to have been unchangeable, and refer nearly all the phænomena treated of in this memoir to action produced under the present level of the sea before certain vibrations of the surface had elevated the great mass of northern Europe from beneath it. Again, the extensive sands (all evidently formed under water) which he describes as chiefly existing towards the frontier of Sweden and Norway, are quite as striking in Scania, the very southern point of Sweden. There are, besides, two essential matters of fact in this memoir to which M. Durocher does not advert; 1st, that the great angular blocks are superposed on the rolled detritus throughout Scandinavia; and 2ndly, that large districts north of Upsala are invariably occupied by these angular blocks *in situ*. These essential distinctions, with a description of the drift and its relations in Gothland, constitute the chief claims of this notice to the attention of geologists; for I quite coincide with M. Durocher, that much as has been written on them, " the study of these facts is only commencing, and that as yet we have only a part of the materials required to construct a durable theory."

Holland, where it forms the "polder" of that country. In Denmark these materials have been shown by Professor Forchhammer to have been aggregated at different periods, the earliest of which he believes to be contemporaneous with the sub-apennine formations, and from that comparatively ancient date has worked out a succession of block and erratic operations at two other epochs, and has shown how such operations are to a certain extent proceeding even at the present day.

Believing that Russia in Europe and the north of Germany were, like Denmark and Holstein, beneath the sea during long periods, as well from the fact that the fossils of the earlier tertiary epochs there occur, though at wide intervals, as from knowing that the shells of the post-pliocene period have there been associated with the uppermost drifts, we are led to conclude, that with the progress of research the details of the succession of aqueous deposits may, in the sequel, be worked out in some of these low countries as they have been by Professor Forchhammer in Denmark and Holstein, as laid down in the geological map of those countries.

Passing however to Sweden itself, where the phænomena of drift are more simple, and referring to the published work on Russia for an account of the detritus which has been transported into Prussia and Poland, I will commence with an account of the superficial phænomena in Scania, the most southern province of Sweden, and therefore the furthest distant from the great source of all the erratics. The southern and south-western portions of Scania are flat, and the fundamental rocks chiefly cretaceous, with two detached masses of oolitic age at Höganaes and Hör, covered with detritus of sand, mud and rolled northern boulders*. In this tract, however, few large distinct and angular superficial blocks are seen, and the whole has still the Danish type. With this external coincidence it is further remarkable as being the only portion of Sweden in which remains of great land quadrupeds have been found; thus proving, that whilst all the other parts of the country (to be alluded to in the sequel) may have remained under the sea, the lands of Scania, like those of the continent to the south, must at all events have been raised above the waters, and inhabited at an æra immediately before, if not contemporaneous with, the existence of man. This inference has been chiefly arrived at by the researches of Professor Nilsson of the University of Lund, who has discovered in bogs the remains, and even the entire skeletons, of the *Bos Urus* or *B. primigenius*, and also of the bison, or *Bos Aurochs*, the one a species now extinct, the other living in the forests of Lithuania. In both cases, these are associated with the remains of deer and other land animals; and a skeleton of the *Bos Urus* was extracted by Nilsson himself, from beneath ten feet of peat near Ystadt, the horns of the animal having been found deeply buried in the subjacent blue clay on which the bog has accumulated. This specimen is not only most remarkable as being the only entire skeleton yet found of an animal

* See the General Map in the work on Russia and the Ural Mountains.

whose detached bones occur in the ancient drift or diluvium of many countries of Europe as well as in Siberia (where it is the associate of the mammoth and the *Rhinoceros tichorhinus*), but also as exhibiting upon the vertebral column a perforation, which Nilsson has no doubt was inflicted by the stone head of a javelin thrown by one of the aboriginal human inhabitants of Scania. By whatever instrument inflicted, this wound has its largest orifice on the anterior face of the first lumbar vertebra, and, diminishing gradually in size, has penetrated the second lumbar vertebra, and has even slightly injured the third. Occupying himself for many years in collecting all the utensils of the aborigines of his country and in studying their uses, Professor Nilsson shows, that the orifice in the vertebræ of the specimen of *Bos primigenius* in question is so exactly fitted by one of the stone-headed javelins found in the neighbourhood, that no reasonable doubt can be entertained that the wound was inflicted by a human being. He does not think that this wound was mortal, but, on the contrary, he indicates (from the manner in which the bone seems to have afterwards cemented) that the creature lived two or three years after the infliction of a wound produced by the hurling of a javelin horizontally in the direction of the head, but that missing the head it passed between the horns and impinged on this projecting portion of the back.

It is not my intention to enter further at present upon the subject of the terrestrial remains of Scania, and I will only say that Professor Nilsson thinks he has discovered good proof of the existence of bogs, containing these land animals and also affording independent proofs of the co-existence of man, which have since been submerged and covered by gravel and sand, and also that the present land is there still undergoing subsidence*. On the other hand, Professor Forchhammer contends that there is no proof whatever of this progressive subsidence in Scania, not even in the celebrated case of the town of Trälleborg, cited by various authorities from the time of Linnæus to our own days, and seen and referred to by Mr. Lyell. I have alluded to this fact of the occurrence of great land animals, some of which are now extinct, in the bogs of Scania (presenting a parallel case with our *Cervus megaceros* now buried in the bogs of Ireland), because the phænomenon is of great importance in reference to the superficial deposits of Sweden generally, in no other part of which has a trace of such remains been found, and where, as we shall see, all the evidences indicate a continuous submarine condition, from periods of very remote antiquity to the existing epoch.

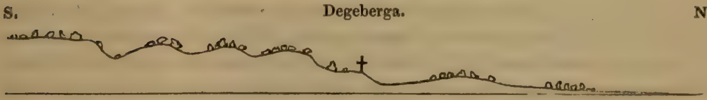
Advancing to the north and east from the lower grounds of Scania, the surface of the more elevated portions of this province affords convincing proof, that the drift of materials from the north has taken linear directions, or has been arranged in great trainées. The Osar or gravelly longitudinal zones which occupy such large parts of the centre and north of Sweden, are not however typi-

* See Lyell, Phil. Trans. 1835, p. 5.

cally displayed in Scania; but in traversing the country from Lund on the west to Christianstad on the east, the traveller first passes over a ridge of gneiss and crystalline rocks on which a few large erratics have been lodged, and then over sands of nine or ten English miles in width, throughout which tract not a single block can be detected. Passing however the lake of Womb-sjön (whose eastern shores are occupied by Silurian strata and porphyry), numberless blocks are again found on the surface of the argillaceous soil, and are seen at intervals and in separate trainées overspreading the plateau between Kloster Öfved and Andrarum. It is only however on nearing Christianstad on the north that the phænomena begin to assume the distinct division which is so clearly indicated in many other parts of Sweden, and on which I shall mainly dwell in this memoir. The village of Degeberga, for example, which is situated at the northern limit of this plateau or high ground, may be cited as a spot, the inspection of which at once explains relations which are constantly repeated towards the north. Sandy hills covered with clusters of large blocks there rise to the north to heights of about 300 feet above the great plain of Christianstad, this plain however being for the most part devoid of such great erratics. In some of these hills where subsidences have occurred, vertical thicknesses of sand layers are seen, forty to fifty feet thick, beneath the great blocks, all of which are more or less angular, and some of them eight to ten feet in diameter.

Here then we have sandy accumulations, which from their form and siliceous texture have all the appearance of having been fashioned by currents of water, and these are at once surmounted by isolated groups of angular blocks, which from their composition must have been derived from the countries in the north (the substrata to the south being of an entirely different character), and which must have been transported across the wide low tracts which lie around Christianstad. Such blocks, and all traces of coarse superficial detritus, are gradually lost as the ground declines in altitude towards the marshy and muddy soil in the neighbourhood of the city. (The diagram fig. 1 will sufficiently explain these relations.)

Fig. 1.



This diagram represents siliceous sands covered with angular blocks, extending from some distance south of Degeberga to the plains of clay which reach to Christianstad on the north.

In the western portion of the province of Bleking which ranges down to the Baltic, the ground being flat with much argillaceous covering, there is little to be observed, except a pretty general distribution of rounded boulders of no great size, and an occasional hillock covered with larger blocks; but in traversing the higher lands (which however are never more than 300 or 400 feet above the sea, and where, especially between Runaby and Carlscrona, the crystalline rocks protrude), the surface begins to assume many of the Swedish and Scandinavian peculiarities. The road there runs through numerous bosses and promontories of granite or granitic gneiss, often beautifully wooded with beech and oak trees, and each of these bosses, whether its altitude be 100 feet or only twelve or twenty feet above the road level, exposes a northern face not only worn down, but also polished and striated from north to south, whilst each southern face is natural, rugged and step-like.

At Carlscrona again, the naval arsenal of Sweden, nearly all the headlands exhibit similar phænomena. Between Carlscrona and Calmar, the Osar or longitudinal ridges of gravel, sand and rounded blocks show themselves with more distinctness than in any tract further south, and whilst the rocks are worn down in undulating surfaces*, and are completely "moutonnés," they do not present so marked a distinction between the north and south ends of the usually ellipsoidal masses as is seen in those to the south of Carlscrona. The worn north side (having eastern or western flanks which are also affected, as will be explained hereafter) and the abrupt south side are invariably best seen where the rocks consist of gneiss or any hard crystalline rock, whether bedded or not, which is not prone to exfoliation by atmospheric influence. Now in the district between Carlscrona and Calmar there are many examples of a granite† which thus exfoliates, and consequently the diurnal weathering of ages has, by peeling off concentric coats of the rock, reduced the southern faces to nearly the same convex form as the northern. Even in these exceptions, however, a close survey will detect the difference between the southern and northern faces.

To the north of Calmar, as well as on the western shores of the long adjacent island of Öland, the Lower Silurian sandstone is present, and the fragments of this rock are abundantly distributed, extending to some distance south of the tract itself; and in this low tract, so full of local debris, there is little else to notice. Fine Osar, however, are seen between Monsteras and Norby, and thence to Jemserum, some of them being quite as coarse as those of the north of Sweden. Here, as in the north, they constitute long linear ridges, and often form a watershed separating lakes and streams. The crystalline rocks of Smoland which appear in the vicinity of these coarse Osar, particularly all those which lie to the north of them, have been most powerfully denuded and "moutonnées," and being ornamented with noble oak-trees help to form one of the most picturesque tracts of Sweden. The marine promontories of quartz rock to the south of Westervik exhibit also some good examples of rounded northern and southern abrupt sides, but near that place the rock (a quartz rock) is for the most part too full of small joints and

* I now speak of hillocks not 200 feet above the sea, and even extending down to the sea level.

† I observed the same frequently in my journey across Sweden in the country between the Wenern and Wettern Lakes.

too easily affected by the atmosphere to have retained the outline impressed upon it by the great mechanical forces which have swept over this low tract and left so many of their traces upon it.

Island of Gothland.

Intending on a future occasion to give an account of the geological structure of Gothland, I shall now only mention that the island is from one end to the other * a mass of coralline and shelly limestone, with some shale and limestone of most unequivocal Upper Silurian age. Its surface, which is nowhere more than 200 feet above the sea level, is covered with coarse northern gravel and boulders, and overlying these are occasionally seen large erratic blocks, the whole of this material being derived from the north, or from points east and west of that direction. Notwithstanding this accumulation of transported matter, the limestone is not only seen in the coast cliffs, but in numerous ridges and points, where it rises through the drift to the surface; but in no place does it exhibit proof of having been specially affected by powerful erosion so much as on the north-eastern face of the island near Slite, where the limestone of the rocks of Lanna has been probably worn by the powerful action of water into those grotesque forms of which Linnæus has left rude sketches in his description of Gothland. That these currents have acted from N.E. to S.W. in the northern part of Gothland is, indeed, proved, not only by the detritus having been swept in that direction, great quantities of it having been accumulated to the south of Wisby (where it is both lodged on the surface of the rocks and has been precipitated over the lofty cliffs, to form at their base the bottom of the actual sea), but also by exhibiting in many places where the gravel has been cleared away from the surface of the subjacent rock, decisive marks of having grooved and striated the limestone on which it rested. This is particularly well seen to the south of Wisby, where gravel pits have been opened to procure the hard granite and porphyry pebbles for the use of the roads. The surface of the limestone thus exposed presents parallel grooves or flutings from one to three inches wide at intervals of from six to nine inches from each other, the whole of the rock having been smoothed down by powerful friction, and marked by innumerable scratches, which, deviating slightly from the absolute parallelism of the larger grooves, yet preserve the same general direction. These markings on the Upper Silurian limestone, which would have been long ago effaced from this comparatively soft rock if it had been exposed to the weather, do, I venture to say, so perfectly resemble the flutings and striæ produced in the Alps by the actual movement of glaciers, that neither M. Agassiz nor any one of his supporters could detect a difference. Yet where is the glacialist who will contend that terrestrial glaciers passing over the Baltic Sea can have traversed this low

* The length of the island is about eighty-four English miles.

island in the middle of the Baltic, which is at least 400 miles distant from any elevation to which the term of mountain can be applied*?

Referring to my published views concerning the manner in which the drift itself has produced such appearances in these flat regions, I will, before I quit the consideration of Gothland, say a few words on the strong evidences which this island affords of having been elevated from beneath the waters at a comparatively modern date. In many ancient bays where the coasts do not present bluff cliffs washed by the Baltic, like Hög-Klint on the east coast and Mount Hoburg on the south†, terraces of water-worn and flattened shingle are exhibited at heights of twenty or thirty feet above each other, of which four or five may in some places be counted between a low interior (or ancient) cliff or scar of limestone and the present sea, to which there is usually a long slope from the lowest of these terraces. The inland cliffs or scars present in many places the aspect of having been washed by the waves, and the different terraces of shingle (each having a level surface, and each exactly like that which the sea washes at its present level) bespeak as many distinct upheavals, and are evidently quite unlike anything which could have resulted from the gradual upraising of the island. As the nature and relative position of numerous raised sea-beaches or shingle-banks in different parts of Norway and Sweden lead to the same conclusion, the bearing of this view upon our subject consists, not merely in establishing a submarine condition of things totally irreconcileable with the application of former glaciers to such tracts, but is, as will be seen, of some theoretical value, in accounting for the motive causes of those waves of translation to which I have elsewhere referred, and which, independent of all glacial action, may by sudden upcasts have produced the violent transport and consequent rounding and rolling onwards of much gravel and detritus. Now, it is important to observe, that these terraces in Gothland simply consist of the limestone locally rolled and flattened into shingle, such as is actually formed on the sea-beach; and it is only after having passed over them, and when we have reached to the height of 100 feet or more, that we meet with the "Osar" drift of foreign coarse boulders mixed with limestone debris, and surmounted here and there by great angular blocks. All these facts seem to render it highly probable that Gothland was entirely beneath the sea when the northern or north-eastern drift was being carried over it. This drift, however, violently affected its surface, after which the blocks were irregularly wafted in such manner as not to destroy their angularity, and therefore, as we sup-

* I may here mention also, that the Lower Silurian limestones forty miles to the south of St. Petersburg were observed by M. de Verneuil last year to exhibit exactly similar phænomena in a region also entirely void of all mountains, the direction of the markings being the same, or from N.N.E. to S.S.W. The limestone of the low island of Dago has also, according to Professor Eichwald, been in the same way affected, and that of Esthonia has presented similar phænomena according to Colonel Osersky.

† This latter, though described as a lofty mountain by Linnæus, is really only a fine bold cliff, less than 200 feet above the sea.

pose, in icebergs or ice-floes, in the manner already explained in the work on Russia and the Ural Mountains.

In speaking of the erratics of Gothland, it is well to indicate the marked distinction between the ancient and powerfully rolled drift and any materials which are now wafted to its shores. The former is composed of crystalline materials all derived from the north *, and these crystalline and rounded fragments, together with much hard quartzose red sandstone, also only known in the north, are mixed with limestone of the island and a good deal of sand. In corroboration of this, we see that the subjacent limestone has been furrowed and scratched, I believe by the weight and friction of those very masses which have lain upon it until removed by the hands of man; and in the north of Gothland, where I principally observed them, these markings are directed from N.N.E. to S.S.W. Now, whether the foreign materials may have been derived from the northern parts of Finland or from the north of Sweden (and the latter supposition might be inferred from the character of the porphyry and hard red sandstone) is immaterial for the present argument. Doubtless, under the extensive submarine area in which I consider that this drift was transported, the powerful currents of translation referred to (caused, as I imagine, by sudden heaves of the Scandinavian continent), may, by the form of the bottom of the sea and other causes, have been in some tracts directed to the east, and in others to the west of north; for throughout all the mainland of Sweden, the linear direction of the gravel-banks or Osar and the wearing and striation of the subjacent rocks vary from east to west of north in different districts and according to the general outline of the land. But that to which I wish now to call attention is, that in no instance is a fragment of chalk or chalk-flint to be found in such ancient detritus, though these rocks exist abundantly in the countries to the south and S.W. of Gothland; whilst, on the other hand, the devious and uncertain tides of the present sea, differing entirely from the ancient currents, and acting quite as much from the south as from the north, do occasionally waft to the shores of this island (probably in fragments of ice) lumps of chalk and flint, derived from the cliffs of Rugen, Bornholm or Denmark.

Lastly, in reference to Gothland, I annex a series of diagrams which sufficiently explain my hypothetical views respecting the condition of the island at different periods after the first consolidation of the limestone floor of which it is composed.

The first of these (fig. 2) represents a portion of the Upper Silurian limestone, of which the island is composed, when it laid beneath the sea, long after the consolidation of the rock, and when its surface had been partially eroded by ordinary submarine action.

Fig. 3 exhibits the same mass of limestone exposed to a powerful denudation on its northern flank (N.W. or N.E., as the case may be) and also along its upper surface, by the passage of great heaps

* This is proved by the character of the granites and porphyries therein contained, none of which occur to the south of Gothland.

of crystalline materials drifted from the north and impelled onwards by powerful waves of translation, which rushing onwards above the usual level of the sea, propelled and rolled on the subjacent detritus in the manner suggested by Mr. Scott Russell, and under the geological conditions suggested by Mr. Hopkins in reference to such agency during former periods in our own country. By this operation the exposed northern face as well as summit of the rock was, it is supposed, worn down, polished, grooved and striated; and the force of the shock having been partially arrested, the drifted rollers were then, it is imagined, shot over the natural escarpment at the south end of the rock and lodged at its foot, there forming a bank of gravel without wearing away the lee or protected face of the submarine hillock.

Fig. 4 marks the period, when the waves of translation having subsided, the sea has resumed its ordinary level and a glacial or ice-floating epoch has supervened, during which icebergs and ice-floes transported large angular blocks, and deposited them, sometimes on the surface of the denuded limestone and sometimes on the water-worn gravel or Osar.

Fig. 5 represents the Silurian limestone after it has been raised above the level of the sea; its surface (with the exception of having parted with some of its loose materials) having preserved the same general outline and covering which it had when beneath the sea.

Fig. 6 exhibits the chief mass of the rock with the same terrestrial features as in the preceding stage, but raised higher above the sea level; such elevation, it is supposed, having been brought about by vibratory upheavals, the periods of tranquillity between which are indicated by the successive terraces of horizontal shingle, in which some crystalline materials of former Osar are mixed up with a great proportion of local Silurian limestone.

Fig. 7 shows the terrestrial mass in its present relations to the sea, or raised to a still greater elevation during the modern period, the shore terraces of former days being at some height above the waters; whilst the ground between the lowest of these terraces and the sea is seen to consist of a long gradually sloping delta, which seems to indicate a gradual uprising of the land.

That this last operation has been going on in recent times is indeed borne out by tradition and local history. Between the calcareous ridges there are depressions, which, whether occupied by water, marsh or bog, may still in some instances be traced almost transversely across the isle, and of these the low grounds proceeding from the north of Klinte on the west to Skärnsvik and Hellesvik on the east are among the most remarkable; others have all the aspect of having been fiords, which if they did not traverse, at all events penetrated deeply into the island. Not only, indeed, do the inhabitants currently believe, that such depressions were occupied by the sea during the early abode of man (when the famous sea-kings of the North exerted their piratical sway), but Bishop Wallin of Wisby, giving full credence to this tradition, copies it into his learned work (*Gothlandiska Samlingar*, Stockholm, 1747), and cites

Fig. 7.

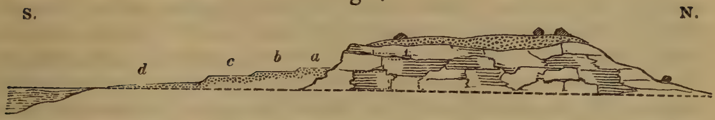


Fig. 6.

Fig. 5.

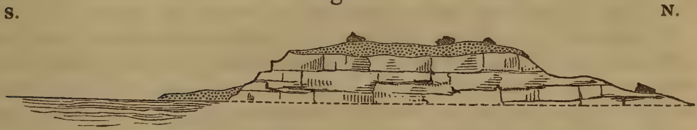


Fig. 4.

Fig. 3.

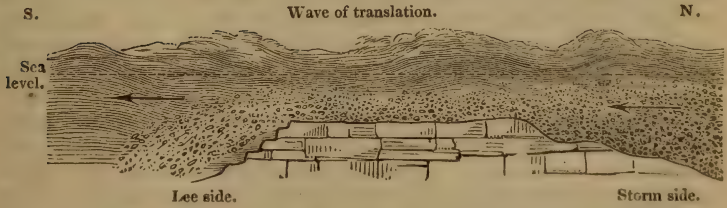


Fig. 2.

an old Danish map of so late a date as 1676, in which such fiords and arms of the sea are laid down to a much greater extent than at present; and connecting these by dotted lines, the learned prelate brings Gothland before his reader's eye as a group of islets which have since been united; not, as geologists would now very generally suppose, by the elevation of the land, but, as is the belief of the natives, by the depression of the waters. I may further add, that though prevented during my stay of ten days in the island from visiting the spot, I was informed on very credible authority, that large iron rings for the attachment of vessels are still to be seen on the sides of inland rocks facing these marshy depressions, a circumstance I am well disposed to believe, knowing that such proofs of the ancient ingress of the sea are not unfrequent in parts of Sweden far inland of Gottenburg, and in other situations widely removed from the present sea, but to which a very small change of the relative level of land and water would afford access by boats.

In framing the above hypothesis respecting the former condition and changes of the surface of Gothland from remote times to our own period, I must beg it to be understood, that the terraces to which I have alluded are not to be seen at or near the bluff and rocky shores and under the steep cliffs north or south of Wisby, where travellers usually reconnoitre the island, but that they occur in several parts of the island to the north of Klinte, and to the north of Bursvik on the west coast, and particularly near Lansberg on the south-eastern coast, where the physical features and the shelving nature of the shore have combined to favour the accumulation of ancient shingle beaches, and to expose a long modern talus beneath them*."

Whilst Gothland, from the nature of its subsoil, can only afford traces of striation and grinding down of the limestone in those places where that destructible rock has been covered by superincumbent gravel, the great cluster of islets, the Aland Isles, which lie between Abo and Stockholm, offer the most surprising evidences of hard crystalline gneissose rocks having been worn down and striated on their northern sides, and presenting abrupt escarpments on their southern faces. The traveller who simply passes by the steam-boat between Stockholm and Abo, and from the latter place to Helsingfors, traverses hundreds, and indeed, including small rocky islets, I may say thousands of isles, throughout which he can observe no exception to this remarkable phænomenon, the more strikingly confirmative of the views I entertain respecting the cause of such results, since none of these isles rise much more than 100 feet above the water, and all are very widely remote from any mountain chain.

* My chief object in Gothland being the identification of its calcareous rocks with the Upper Silurian of our own country, I could not devote much time to visiting all the spots where the surface is striated and grooved; but I was informed by Dr. Colmarden that he had observed grooves and striæ similar to those I have described in various parts of the island, wherever, in short, the superincumbent gravel had been removed for the repairing of the roads.

Similar appearances, although by no means so clearly defined, are to be seen in the groups of islands between Westervik in the parallel of North Gothland and Nykoping, which I merely passed near in a steam-boat, without having an opportunity of closely observing the facts, and I therefore pass on to the district extending from Nykoping to Stockholm. By inspecting the map of Forsell, it will be seen that most of the numerous cavities occupied by water in this tract, with the exception of the great Mälar Lake, trend from N. by W. to S. by E., and such is the chief direction in which the linear accumulations of gravel and sand, or 'osar,' have been formed. Such also is the direction in which the subjacent rocks have been ground down and striated. Many of these osar are well-seen, indeed, between Nykoping and the sea, where the great Stockholm canal has been cut through them, and where shells of the Baltic Sea, as previously mentioned by Mr. Lyell, are seen in blue clay beneath the great mass of the osar drift, again indicating in the clearest manner a submarine condition when such drift was transported. Passing from Södertelge through the southern arm of the Mälar Lake, the traveller is then conducted to Stockholm in one of the chief arms of that sheet of water, which as it is on the whole directed from W.S.W. to E.N.E., is transverse to the main direction which the drift has taken in this part of the country. To one who has explored by land and in detail those phænomena, to many of which I shall afterwards have to direct attention, the south and north sides of this arm of water, extending even up to the gates of Stockholm, offer the most striking confirmation of the agency of a great force which has ground down the one and left the other comparatively unaltered. The scarped, picturesque and broken rocks on the north side and the side facing the south offer indeed a most striking contrast to the abraded, sloped and polished surfaces on the other side of the lake which faces to the north. The environs of Stockholm abound also in such examples, and exhibit admirable instances of osar; that of Bronkeberg, to which one district of the city extends, affording as clear evidence as can possibly be given, since the rounded materials are there piled up to the height of 100 feet or more, and many of them exceed the size of the largest man's head. Polished and scratched surfaces abound, and no example is more remarkable than one, to which Baron Berzelius directed my attention in 1844, a little to the N.W. of Stockholm, where a buttress of hard and highly crystalline gneiss with veins of grey granite had been laid bare in improving the roads, and exhibited numerous striæ having a general direction from N. by W. to S. by E., though there occurred between the different markings just those deviations from parallelism which we might expect to result in the case of a rush of broken drifted materials, however solid the whole mass and however determinate its general line of transport. The same rock, equally polished and ground down, has been since laid bare and freed from its coating of gravel and sand to the N.W. of the Park of Haghe, on the other side of which it forms abrupt and picturesque cliffs. Passing in a direction a little west of north over a considerable tract on the road to Upsala, which is covered by osar, surmounted at intervals by the larger blocks, the whole region is found admirably calculated to exhibit the results which such drift has produced. Slightly covered over with angular blocks and coarse detritus, usually on the south side of the hills, each promontory is seen entirely cleared of wood; and in travelling through this district I observed many hillocks, the northern faces of which were invariably rounded, polished and scratched, but which assumed different curvilinear forms, some being very nearly vertical, others quite planed away into a gradual slope, and others again of intermediate shapes, as represented in the annexed sketches. Of these

Fig. 8.

N. S.

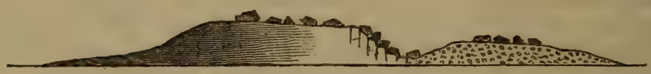


Fig. 9.

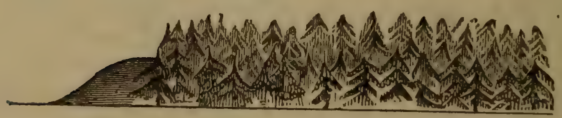
N. S.

Fig. 10.

N. S.

Fig. 11.

N. S.



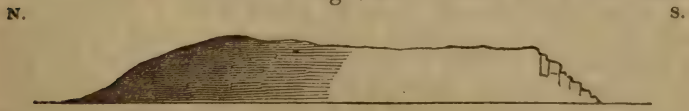
diagrams fig. 8 exhibits a sloping rounded surface to the north and a flattened summit covered at once by erratic angular blocks, some of which are seen also at the ragged or southern scarped side, whilst an os of gravel and sand to the south of the hillock is partially surmounted by angular erratics. Fig. 9 shows the northern face much more abraded and flattened, and the surface of the summit to some extent covered by the drift and also by the angular erratics.

In the next diagram (fig. 10) the vertical '*bombé*,' northern face, so common in the worn rocks of Sweden, and its southern scarp, are followed by a very coarse os, whilst, as in fig. 11, some of the ridges are nearly covered with wood (the exception in this denuded tract), the northern face only being entirely free from vegetation, since no shrub or plant can there find root in the smoothed spherical and polished surface of a crystalline rock where it is void of vertical fissures.

In Wassunde parish, which we crossed in making a lateral excursion to the north-western arm of the Mälar Lake, the gneiss and the hard granite veins in it are beautifully exposed, the striæ traversing them in this case from S. 15° E. to S. 15° W. This is the direction which Sefström believed to prevail in Sweden, but my own observations would lead me to think that the markings in many other districts are as often from the west as from the east of north.

Since I am now treating of a tract abounding in isolated hummocks or promontories of rock, the direction of each of which trends on the whole from north to south, I will here mention a fact which seems to have escaped former observers, viz. that not merely is the northern end of each hillock worn and abraded, or in Alpine language, '*moutonné*,' but also to a certain extent the east and west sides of each,—its southern face alone remaining in a natural and unaltered state. But in the amount of degradation and polish, and above all in the striation, there is a marked difference between these east and west sides and the northern face of the rocks. The latter is not only extremely *moutonné*, and when its nature admits of it, or when it has been recently uncovered, finely polished, but is powerfully striated and sometimes grooved, whilst the longer or east and west sides only exhibit such features along a certain distance, seldom exceeding more than one-third of the length of the face in question, the remainder of which gradually loses all traces of denudation and exhibits no more striæ towards the rough and wholly unaltered southern extremity (see fig. 12). I mention

Fig. 12.



In this diagram is seen, as indeed in those preceding, the gradual disappearance of the striation and wear of the lateral surfaces of the rocks from their northern to their southern ends.

this fact, because it seems to coincide very well with the hypothesis, that powerful currents from the north, carrying vast masses of detritus and sand with them, impinged with great violence and exercised a powerful friction on the northern or weather face of each hummock which exposed a resisting front, whilst such resistance would naturally diminish as the opposing promontory trended off into a flattened side, the drift and materials simply rushing through the often wide depressions between the low and isolated rocks and producing little or no lateral effect, except indeed in the case of narrow mountain gorges, wherein the lateral pressure of a mass of drift and the increased velocity of the current may have acted with much energy on the enclosing sides. Without however too much insisting on the value of my own hypothesis, I specially dwell on this feature of the Swedish phænomenon to prove, that even supposing it were possible that terrestrial glaciers could have advanced over these flat regions, they never could have left such effects behind them; for it is quite certain, that if by any possible combination such bodies could have moved over so level a region*, they must, according to all the Alpine analogies offered by Professor Agassiz, have left decisive striæ all along the sides of the parallel or flanking rocks through which they advanced. A comparison of the diagrams of Professor Agassiz, exhibiting such lateral effects of the walls of glaciers, with our Swedish examples, at once indicates the important distinction; and in the sequel, other and still more cogent reasons will be given to show the utter impossibility of explaining the abrasion and striation of the rocks of Sweden by glacier action, however much these rocks present surfaces in many respects precisely similar to those produced by glaciers.

The environs of Upsala abound with long, linear, sandy osar, occasionally only containing coarse gravel, and these range from north to south, particularly to the east of the river, whilst to the west of that stream, low long ridges of granitic rock are parallel to them. In other words, the osar appear as undulating deposits of unequal altitude, occasionally rising to 100 or 150 feet above the lower country, and they appear to have here assumed their linear direction in consequence of the rocky elevations on their flanks. In these osar we have the clearest proofs that the large angular erratics are always at the surface†. On the same line of os is the hillock immediately to the S.W. of Gamla Upsala (Old Upsala), to which I have particularly directed attention in my work on Russia, as exhibiting not only many angular blocks both near its summit and on its southern face, but also peculiar small terraces on its northern face and slope, which seemed to me to render it more probable that such great angular superficial blocks had been quietly transported to their present habitats in icebergs or on rafts of ice than any other example hitherto cited. I here reproduce the diagrams (figs. 13, 14). They seem to support the hypothesis I advocate not only by illustrating the comparative absence of blocks on the north side and their increasing abundance from the summit to the south side, but also by accounting for the gravel terraces, since I assume that, after the completion of the osar drift, a large iceberg must have been floated southwards by currents then prevailing, and was arrested on the northern face of the apex of the hill; that at first there was accumulated around its base the larger and lower terrace (*a*), and that with the lapse of successive seasons and the perpetual action of

* The heights of some central grounds in Bleking and Smoland are quite as great as those in the districts further north.

† One of these, called the Stor-Stens-Kulle, to the north of Upsala, is perched on the very summit of a sandy and gravelly os.

the current, this was successively reduced so as to account for the gradually smaller and higher terraces *b*, *c*, *d*. I suppose also, that while melting it parted at intervals with some of the blocks which it carried, until, worn away to the minimum size at which it could hold together, the mass was entirely dissolved and its spoils deposited on the summit and southern slope of the hill to which the waters would naturally bear them.

Fig. 13.

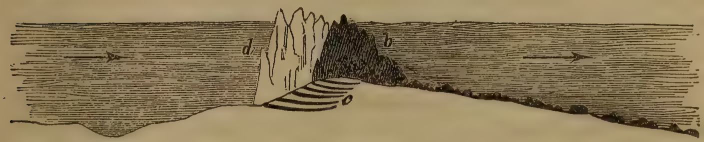
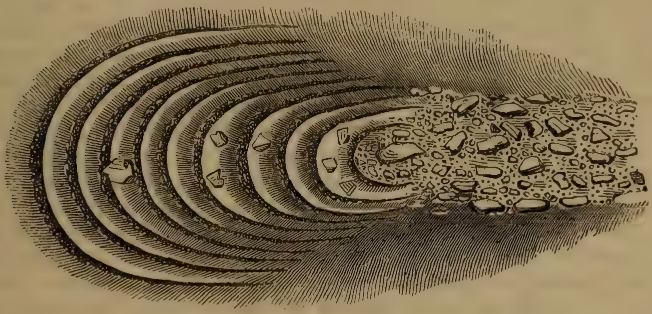


Fig. 14.



The environs of Upsala are also of much interest in establishing, beyond the power of contradiction, that the osar subjacent to the angular blocks were really aqueous and marine drifts; for in the sandy and gravelly beds of the os on which the castle stands, Mr. Marklin found several species of shells, including the *Tellina baltica*. Other argillaceous beds of blue clay which occupy the banks of the river, on either side of which the osar rise up, are also in some spots absolutely loaded with this shell, showing that the whole base of the soft and overlying formations is truly of aqueous origin of no very distant date, the shells being specifically the same as those now living in the adjacent Baltic, and exhibiting their nacre perfectly preserved *.

In proceeding to the north of Upsala, whether to Hedemora and

* Mr. Lyell has already stated this fact respecting the presence of Baltic shells in and below the osar. They occur, in fact, in many parts of Sweden, and thus afford proof, in addition to the fact of the numerous raised sea-beaches of Uddevalla, that the sea covered all the low tracts of Sweden at a comparatively modern period.

Fahlun on the one hand or to Danemora and Gefle on the other (both of which routes were followed by M. de Verneuil and myself), the osar are exhibited at intervals in still greater force, and are often composed of coarse rounded materials, but in other places of hills of almost pure sand. But the feature which most strikes the traveller, particularly on the road to Danemora, is the increased size of the superficial angular blocks as he approaches the source of their origin. Thus at Hysby, one of the first stations, we viewed and measured a block of granitic gneiss having perfectly sharp angles and rent by great fissures whose length was forty feet, width twenty-three, and height twenty-five feet; and at Fellen, to the N.W. of Gefle and Hannebo, we observed another 140 feet in circumference and thirty feet high.

In the tract between Danemora and the little sea-port of Kahkholm, the osar, consisting of true rolled and sandy detritus, are frequently arranged in circular heaps of about 100 paces in diameter, each capped by coarse angular blocks. Now, the water-worn materials are, it will be observed, thus circularly grouped on the lowest elevations in the midst of small plains or flats from one to two and three miles wide, which are devoid of those distinct longitudinal encasing ridges of granitic rocks whereby the osar have usually obtained their prevailing long and ridge-like character. This circular configuration, which very much reminded me of the "escars" in certain basin-shaped valleys in Ireland, seemed perfectly to exclude the possibility of such bodies being *moraines*, the residue of glaciers. None of the loose materials, I would further observe, have scratched surfaces, like those of the loose fragments in a glacial moraine. The boulders are also of all sizes, from the dimensions of the fist to three and four feet diameter; and the rolled materials are here as elsewhere perfectly distinct from the subjacent angular blocks. It is moreover worthy of notice, that in the district in which these circular osar occur, the mounts of granite and granitic gneiss have in several instances been ground down and polished on their southern as well as on their northern faces,—a fact which, whilst it is totally irreconcileable with the action of glaciers, is in perfect accordance with the belief that such results proceeded from aqueous currents, which in these bays or depressions impelled the drifted shingle and sand in whirlpools and eddies, and thus lashed on all sides the protruding hummocks of hard rock. These however are very remarkable exceptions to the prevailing rule.

In travelling northwards towards Sala, it is soon made apparent, that if some of the angular blocks may have been moved short distances, the rocks from which they have been derived are usually to be seen not far off, and to the north. Nay, a phænomenon soon presents itself, which is, as far as I know, without parallel in any other part of the earth, and which must be carefully noted in our endeavours to form any rational theory respecting the causes of a chief feature in the northern phænomena. The woody ridges traversed in the second station between Upsala and Sala, *i.e.* from Kölfva and Brunsätra, constitute the most southern point, at which the traveller (after passing innumerable hillocks of rock whose northern sides are rounded and worn) is suddenly immersed in a chaos of angular blocks, some of them of a gigantic size. Through these the road meanders amid the most profuse vegetation of aspen, birch and fir trees that rise out from the crevices between the fragments. Seeing no proof that these millions of angular blocks were deposited on osar, like those before adverted to, and perceiving that they were nearly all composed of similar granitic gneiss, we began to think, particularly from the distinct linear arrangements they afforded, that they must be simply fragments *in situ*, the subjacent or parent rock being hidden by their great profusion in these low eminences; but we were once more thrown into doubt by perceiving that as soon as we emerged from this forest near Härfsta, true sandy osar, also trending from N.N.W. to S.S.E. and parallel to the angular block ridge, presented themselves, and were capped by angular erratics. We further saw, that as the country opened, the broader depressions and valleys were invariably exempt from the large angular blocks, but that wherever an elevation occurred, sometimes not exceeding fifteen or twenty feet above the lower levels, it was covered with angular blocks of all sizes, accumulated in this instance upon a substratum of clay. On entering Dalecarlia, however, we passed a true granitic plateau, which was covered in parts with angular blocks, the mass of which, exactly like those above alluded to, forcibly reminded us, by its superficial aspect, of the broken volcanic "cherres" of Auvergne; and thus we had no doubt that whilst the osar were capped with such materials which had been transported from other localities, other linear ridges, particularly those on which the whole surface is covered by rock, nearly all of one kind, were indeed fragments *in situ*, the subjacent rock from whence they had been broken off appearing here and there. This view was completely confirmed when we passed over the low hills to the south of Fahlun, where the angular blocks and the underlying parent gneiss are clearly exposed. Without such an explanation, the sea of wild and irregular fragments dotted over the plain immediately south of the copper-mines of Fahlun would indeed seem marvellous, since in that district the trees having been cut off or withered by pestiferous sulphureous fumes, the tract might represent a return of chaos, or a period when life was extinguished upon the surface of the globe.

In Dalecarlia however, as in the central and southern regions, the distinction between the erratic blocks and the water-worn osar are strikingly displayed. This is well-seen in a long line of osar separating the lakes between Jordbro and Brusdeck on the river Dal Elf, near the southern frontier of Dalecarlia, where transverse or east and west sections exhibit in one place finely laminated sands covered with coarse worn boulders and gravel, and these again by angular erratics, each from ten to twelve feet high. In this tract, as represented in the accompanying diagram (fig. 15), the small houses of the Swedish peasants are seen built upon an os between lakes, and the road is as it were half-buried under the great erratic blocks.

The fall of some of these blocks, together with the accompanying mass of gravel and sand, would, in fact, cover up and destroy one or more of these cottages; and if the tract were abandoned for

Fig. 15.

centuries by human beings, future geologists might reasonably be led to contend, if judging from these evidences alone, that from the vestiges of subjacent buildings, the angular blocks and even the rounded gravel had been transported over this continent subsequently to its habitation by man.

In approaching Hedemora, or in ascending to that town, which lies about 150 or 200 feet above the river Dal Elf (a stream which there, as in many parts of its course, resembles a quiet lake), the whole tract is one of undulating hilly sands exactly similar to those south of Christianstad in Scania, and equally resembling the bottoms of a former sea, the summits in both cases being capped with angular blocks of crystalline granitic and gneissose rocks. In approaching Säter, these sands constituting linear osar, which are here and there united by cross bands or bars, are covered by worn boulders and gravel; and further on the osar are entirely composed of waterworn boulders, as coarse as those forming the os of Bronkeberg near Stockholm. Osar like these, which separate the water-courses and lakes, are, as M. Brongniart has before remarked, natural *chaussées* or elevated mounds on which all the roads run. Again, the ravines at Säter, in which the water-course in a deep dell bounds over gneissose rocks, the river banks on either side (as indeed in numberless places along the Dal Elf) consist of mounds of finely laminated sandy loam, the surface of the plateau alone being occupied by large and angular blocks, which are still found in the narrow valleys or ravines, except when their incoherent sides have given way within the modern period. In this case, the superjacent blocks have been precipitated into the chasm below, and have carried with them gravel or clay, according as the nature of the original submarine materials or drift may determine.

It is however essential to remark, that although upon the whole the osar may be viewed as long narrow banks, such in fact as they were described by M. Brongniart, there are very numerous exceptions. The prevalent linear or north and south direction, and the shape of these masses, have necessarily been determined by the chief physical features of Sweden, which consist of frequent alternations of ridges of crystalline rocks and longitudinal depressions, the latter being either filled with water or occupied by the gravelly accumulations in question. In numberless tracts however, where the valleys and lakes are of circular or elliptical shapes and of some breadth, the gravel heaps are (as I have already shown) arranged in isolated hillocks, like the Irish "escars." In other places the linear accumulations are so connected by transverse bands composed of similar materials (and the neighbourhood of Hedemora may be specially cited), that it would be difficult to say that any one direction prevailed more than another. An inspection of the map of Forsell will show, in fact, that the outline of the drifted materials has been determined by the physical outlines of the country and the form of the encasing rocks in each tract.

Some of the wider low expanses of Dalecarlia, subtended by granitic gneiss or low ridges of other crystalline rocks, are singularly exempt from every sort of transported material. Such are the sands and loams, sometimes finely laminated, that are seen in following the Dal Elf through the fertile tracts of Gustafsland, where the overlying erratics are seen only near the higher edges of the arable lands, and between them and the surrounding granitic ridges.

Intending to describe the palæozoic and eruptive rocks of this district on another occasion, I will not now advert to the almost innumerable examples which Dalecarlia affords of promontories of hard rock, rounded off towards the north; of ridges which by some cause have been broken up *in situ* and present the external form of volcanic "cherres" before alluded to; of osar of various composition, everywhere exhibiting in their imbedded materials proofs of powerful aqueous action; and of large surmounting angular blocks, some of which have evidently travelled only very short distances to their present abodes.

To show however how the general direction of the drifted materials, whether consisting of rounded boulders or of angular erratics, has been from the north or N.N.W. throughout this portion of Sweden, I would here observe, that throughout the tract extending from the sea to near Leksand, all the detritus (with the exception of local detritus of red sandstone near Gefle) consists of gneissose and granitiform rocks, which distribution is coincident with the fact, that the tract to the north and N.N.W. is also entirely composed of such rocks. No sooner however do we advance as far west as Leksand at the southern extremity of the great Siljan Lake, than porphyries begin to prevail among the transported materials; and further to the N.W. these broken materials are found to increase rapidly as we approach the great masses of porphyry which occupy the higher hills beyond Mora in the parishes of Elf Dal, &c. These rocks are however mixed with fragments of syenitic granite of more recent date, which has in several portions of that tract upheaved and dislocated those Lower Silurian rocks of which I intend to speak on a future occasion.

The country at the southern end of the great Wenjan Lake is also extremely interesting as showing the north and south direction of the drift, and also the phænomenon of a large area of angular blocks *in situ* of very different composition from any hitherto alluded to. In traversing from the Siljan to the Wenjan Lake and the station of Johannisholm, we passed through a country of low-wooded porphyry peaks, the parent rock of which, as in the case of the granites mentioned above, is almost entirely obscured by vast quantities of local angular blocks, whilst the rounded materials in the lower grounds or valleys are more varied, and occasionally constitute coarse osar. In approaching Johannisholm however, the observer is suddenly struck with the appearance of a quantity of debris of sandstone, and on turning to the north he has only to travel for a few miles along the eastern shore of the Wenjan Lake to perceive that all other detritus disappears, the whole mass consisting of angular blocks, occasionally of enormous size, composed of hard, red, purplish, greenish or whitish sandstone. These constitute, in truth, the mere cover of a vast expanse of horizontal sandstone, which further to the north is detected beneath this chaos, and which I shall give reasons for believing, in a subsequent memoir, to be the equivalent of the old red sandstone of the British Isles, and therefore of the same age as rocks which I have described in Norway. This great sandstone range is, in fact, encased between great bands of porphyry that occupy wooded hills, the eastern limit of which is that traversed in passing from the Siljan to the Wenjan Lake, while the other limit forms the western bank of the latter lake. In this way, by passing from east to west or west to east across the southern ends of such ranges, the observer can correctly define how truly the Swedish detritus has been propelled in *trainées* deviating slightly only to the east and west of their general direction from north to south. But the chief point on which I wish to dwell, is the extraordinary aspect presented by this "felsenmeer" or "cherres" of enormous angular blocks of finely laminated sandstone, which occupy a tract many miles in length, no part of which is more than 100 or 200 feet above the lake*. My companion and myself were absolutely lost in astonishment at the scene which lay before us as we penetrated further and further into the undulating woodlands of this chaos, the confusion of whose piles of angular sandstone over a wide flat district is here and there quite as striking as if the debris were lying on the steep slopes of the Alps, whether at Rosbach in the canton of Schweitz, or in many other known localities, where, from subsidences on the sides of inland or ma-

* The reader will bear in mind, that although the higher parts of Dalecarlia are rather more mountainous than the portion of Sweden to the south of them, there is rarely a porphyry summit which exceeds 1200 or 1500 feet above the sea, whilst the depressions, whether occupied by rivers or inosculating river lakes, are at very small elevations above the sea, and the whole drainage of the region is most tranquil. In short, Dalecarlia (from which the rivers descend to the sea at quite as small inclinations as in the sloping and flat tracts of England and France) is as *anti-glacier* a country as can be well imagined, and is only surpassed in that character by the great mass of the Scandinavian continent to the south of it. At the confines of Norway the elevations begin however to assume an Alpine character, and there (within certain limits) the glacialist might begin to apply his theory. But even there he is met by M. Durocher, who has observed and described large horizontal tracts of sand in which the quartz grains only remain, the mica and felspar of the original matrix having been dissolved and washed away,—a condition of things only to be explained by aqueous causes.

ritime cliffs, such falls of angular masses of rock are not unfrequent. In numerous spots, indeed, the blocks of sandstone, though completely disjointed and widely separated, conform on the whole to a horizontal arrangement, and it was only at very rare intervals that we could detect the subjacent horizontal parent rock from which they had been dislocated*.

Whatever may be the cause assigned for the production of this chaos *in situ*, there can be no sort of doubt that the same agent has operated over several degrees of latitude in Sweden, effecting exactly similar results on innumerable low ridges of hard rock, whether they be composed of granite, of gneiss, of quartz rock, of porphyry, or of finely laminated sandstone. If therefore some authors have been disposed to attribute the abruptly broken fragments of certain granites, as well as their degraded surfaces†, to the mere action of the atmosphere and concentric exfoliation, how can they contend that such an agent can also have produced the same appearances in stratified sandstones? How, in a word, can atmospheric agency, which, if it did anything, would only round off the edges of hard sandstone, have piled up these masses in every grotesque attitude on each other, at all angles of inclination in reference to their original bedding, and even sometimes in vertical positions? The observation of such phænomena in a low and slightly undulating region, remote from high mountains, is important as enabling us to discard any partial views founded on the exfoliation of certain granitic rocks, and compels us to seek for some powerful mechanical agency by which the chaotic arrangement of enormous blocks apparently *in situ* has been produced in such situations. Before we consider this question, which leads to one of the general conclusions with which this memoir will be terminated, I may say, that most of these blocks consist of finely laminated and slightly micaceous hard sandstone, and that many of these split into large flagstones of variegated colours, and with spots and ripple-mark surfaces, while others are more indurated, thick-bedded and quartzose, splitting under the hammer rather with a conchoidal than a laminated fracture. As a whole, however, they so evidently belong to one original mass extending over an area of many square miles, that independently of the existence of horizontal sandstones in places which are quarried in this range a little to the north, it is quite clear, from this uniform structure alone, that the rocks constitute merely one subdivision of the Old red formation of Scandi-

* In the discussion which followed the reading of M. Durocher's memoir before the Geological Society of France in November, and in which I took part, my friend and companion, M. de Verneuil, stated some of the facts relating to this singular tract. But the phænomenon is too important to be parenthetically disposed of, and requires the further explanation which I now offer.

† I fully admit that in Cornwall, and in many other granitic tracts, atmospheric action has so affected the rocks (in the manner ably explained by Dr. M^cCulloch), that the detached blocks have often the appearance of superficial detritus. But the "tors" and granitic blocks *in situ* of those countries are wholly unlike the great angular and abruptly broken blocks of the tracts under consideration.

navia, which stretching over a wide expanse in these parts, has been thus broken up without exhibiting those changes of lithological character which are so conspicuous wherever deep escarpments, like that of the Tyrifiord near Christiania, are exposed, and where conglomerates and hard siliceous beds occupy the summit, thick-bedded and earthy sandstone the centre, and flagstones the base.

Now, notwithstanding the almost perfect angularity of these broken masses (which are just like the fragments that fall from natural joints in a quarry), it is curious to observe that occasionally (though rarely) a small rounded boulder of porphyry may be detected between their interstices, and that here and there a considerable quantity of sandstone and smaller detritus is mixed with loose sand, and is seen lying around the base and lower edges of the blocks. This fact seems to prove, that by whatever cause the blocks were dislocated, water has since passed over and between them, though not with such power in this tract as to abrade them, and merely transporting a very few foreign pebbles, has only had sufficient energy to clear away much of the intermediate loose sand and smaller broken materials, converting them into the fragmentary shingle which we see in the trainées to the south of this sandstone range. From these facts* I would infer, that the currents which proceeded to those countries from Scandinavia acted with much greater intensity on certain lines than on others; in some leaving "cherres" of broken rock almost unaltered, like the one now under consideration, and in others powerfully abrading the surface by hurling over it prodigious masses of detritus.

In quitting the region of Silurian rocks, Old red sandstone and porphyry at Furadal, on the northern frontier of Dalecarlia, and in travelling thence westwards towards Alfta, all trace of porphyritic or sandstone detritus vanishes as soon as we regain, on a more northern parallel than that just described, the region of granitic gneiss, large tracts of which exhibit the usual phænomena of angular gneiss blocks *in situ*, or the same material partially transported to the summits of other rocks, or osar of sand, clay, sand or gravel, as the case might be: all the detritus is granitic or gneissose; and thus the proofs are complete respecting the independence of the trainées of Scandinavian drift, as derived from the normal positions of the rocks *in situ* to the north of them.

In our published work on Russia, my friends and myself have endeavoured to explain at some length our ideas upon the whole subject of the northern detritus, and the evidence obtained during our last tour seems materially to strengthen the probability, that in respect to all the low countries of Scandinavia, the assumption of heavy masses of drift having been swept over the surface by powerful aqueous currents will alone explain the phænomenon of the abrasion and striation of the subjacent rocks, and that the outlines and relations

* This view is indeed also sustained by all the superficial phænomena of Russia, Poland and Northern Germany, to which countries the Scandinavian gravel and worn detritus have been propelled in distinct trainées from north to south, each one separated by tracts in which few or no erratic materials are found.

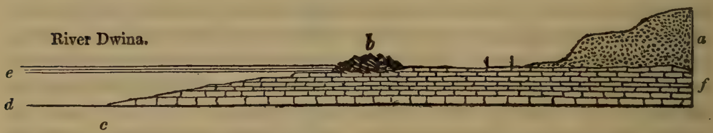
of the region are such, and the details in it are so developed, that by no physical possibility could terrestrial glaciers have traversed these vast low and undulating tracts, still less could such bodies have advanced from the Baltic, up-hill over the Valdai hills and other eminences of Poland and Germany, from whence the rivers descend to the Baltic on the north. We believe that at the period when these currents were set in motion (and this we believe to have been effected by successive and sudden upheavals of the northern chain of Scandinavia, aided perhaps by a corresponding depression to the south, which deepened the sea in that direction, and which also produced great waves of translation), various appearances were produced by friction and by the passage of masses of gravel and sand, which left behind them an impress on the surface of rocks since raised into dry land, very similar to that which has been produced in mountainous or alpine countries by land glaciers. We saw no reason at the time, nor do we see any reason now, to doubt that great and heavy masses of drift, when impelled by powerful, active and rapid marine currents, may have produced effects similar to those now and formerly produced by the slow onward march of a glacier. In addition to our former hypothesis, we now, however, willingly append to it a portion of the theory of M. Durocher, who, not considering the weight of the drift as a necessary postulate, explains the polished and grooved sides and surfaces of narrow canals and longitudinal cavities by the greater velocity and force of the currents wherever they were confined and forced through contracted channels.

But in excluding, together with Sweden, all the lower tracts of northern Europe, and also of the British Isles, from the possible application of the glacier theory, we differ somewhat from M. Durocher, and are disposed to admit its strict and true application to many isolated tracts, whose lofty mountains and divergent valleys afford, as in Norway, the geographical features required and the postulates of the Alpine problem. The surfaces of these, indeed, offer proofs of the movement of glaciers having formerly acted on their surfaces, and we doubt not that the present glaciers of Norway (some of which exhibit proof of having formerly extended to greater distances than at present from their respective common centres) may have been more extensive at a former period, particularly in their range to the N.N.E. We think that parts of them may then have been prolonged into a glacial or icy sea, which when broken up afforded, in the first instance, many of the materials of the drift we have described, and that from their edges may afterwards have been detached numberless icebergs, which floated away many angular blocks to distances of hundreds of miles to the spots where they are now seen piled up, often upon the surface of low eminences.

The feature however of the immense masses and piles of angular blocks in ridges and *in situ*, by which the attention of my fellow-traveller and myself was last year most especially arrested, is one for which it is perhaps more difficult to assign a probable cause.

Any one unacquainted with certain northern operations of frozen water might well view these piles of angular blocks, strewed irregularly over and lying directly upon the parent rock from which they had been torn up, as having resulted from sudden shocks or jars, which, without throwing up the beds into different and distinct ridges, as in many other parts of the world, simply shattered them into numerous fragments by general convulsive earthquakes which affected broad horizontal areas. But whether or not such a cause be admitted as having had any share in originating the cracks and fissures, the tumultuous condition into which the enormous fragments have been thrown may, it seems to me, be best explained by supposing that they were thus piled up in a shallow glacial sea, the ice of which forming in their interstices and around them would, during periodical thaws and debacles, rend the jointed masses asunder, and by its expansion and elevation mingle them in that chaotic fashion which drift ice is so often seen to assume in the polar regions, and which I have myself witnessed on the surface of the great Russian lakes during the spring thaw. In further explanation of this view, I simply refer the Society to an explanation which I formerly presented to it of the manner in which rocks *in situ* on the banks of the Dwina near Archangel are now raised up into ridges of angular materials by the bursting of the river ice, and which, in reference to angular block ridges of former date at different levels along the sides of the lake of Onega, has been illustrated at length in the work upon Russia and the Ural Mountains *.

Fig. 16.



f. A ledge of carboniferous limestone.
c. Slope of ditto ditto.
b. Broken pile of fragments of ditto.
a. High bank of sand.
e. High water of river.
d. Low water of ditto.

The first of these figures (16) represents the bank of the river Dwina, occupied by a ledge of carboniferous limestone (*f*), from the upper portion of the sloping talus of which (*c*) are piles of angular fragments (*b*) which lie between the high water mark (*e*) and the summer level of the stream (*d*); the angular blocks (*b*) having been thrown up by the expansion and bursting of the frozen water formed in the interstices of the parent rock. The loose sands (*a*) have resulted from aqueous action of a former period.

Diagram (17) represents a triple tier of angular blocks (*b*, *b*, *b*) on the western shore of the lake Onega, south of Petrozavodsk, where the action of frozen water (during northern spring debacles) is presumed to have acted at successive periods, before the lake was reduced from its former levels (*c*, *c*, *c*) to its present level (*d*), in the same manner as on the Dwina at the present day. In this example, the rock is a hard sandstone, not very unlike that of the

* *Loc. cit.* vol. i. p. 568.

Wenjan Lake, whilst the local angular blocks *in situ* (*b*, *b*, *b*), identical in structure with the parent rock (*a*), are strikingly contrasted

Fig. 17.

with the far-transported crystalline erratics (*f*) which occupy the higher portion of the hill.

Whether this hypothesis, founded on a cause now in operation, be accepted or not, to account for the Dalecarlian phænomenon, no one can view these great broken and remarkable piles on level surfaces without seeing that they are the original sources from whence many of the angular erratics which cover the tracts to the south of these have been derived, and no one has yet ventured to offer any rational explanation of how such masses should have travelled hundreds of miles and yet have preserved their angularity, except by supposing that they were transported by floating ice. The examination of North Sweden and the ridges in question leads me to believe that icebergs, as derived from terrestrial glaciers, do not in themselves offer a sufficient cause for all the features of the erratic phænomena; but that if large and lofty icebergs were required to float blocks to great distances, we must also imagine that sea-formed sheet-ice, encompassing certain shattered and rocky ridges and islets, may also have urged southwards for certain distances on ice-floes or ice-rafts, a great number of those angular erratics which extend over the northern and central parts of Sweden.

In offering these hypothetical views, I care little for their adoption or rejection. My main object in thus bringing additional facts before geologists is to show, that however inadequate my own theory may be to account for all the northern superficial phænomena in question, strong reasons at all events exist for the restriction of the terrestrial glacier theory to its legitimate domain; and not doubting that many surface appearances (undoubtedly all those in flat regions) have been produced by nothing but aqueous drift, put in motion by vibrations of the crust of the earth, which brought into action the great transporting power of water, whilst other debacles were caused by glaciers, and others again by the breaking up of former glaciers and glacial seas, it is clear that in reference to this subject our future business as geologists is, not to contend for the exclusive operation of any one of these causes, but to endeavour calmly and patiently to work out each case on its own merits, instead of appealing to one universal cause for the production of rounded, polished, abraded, grooved and striated rock-surfaces.

And here I would further observe, that however it may be argued, that in mountainous tracts torrential rivers and their feeders may have descended in past times as they do now, and may thus have produced rounded materials in valleys, the argument is, at all events, perfectly inapplicable to the formation of the Swedish osar. These linear ridges have not only been accumulated in long trainées and lengthened mounds or terraces high above the valleys, and offering appearances entirely unlike those produced by rivers, but it is at the same time evident, from the most casual inspection of the country, that as it now contains no torrents (all its streams being gently-gliding waters which merely connect inosculating and long lakes), so in the period immediately preceding our own, when the relations of outline must have been, *pari passu*, the same which now prevail, no such river torrents can have acted in the level and undulating countries of Sweden. But even this refutation is uncalled for, since large portions of these flat countries offer indisputable proof in their included marine shells of having been beneath the sea during the accumulation of water-worn gravel and sand-banks, which extend over at least ten degrees of latitude.

In studying phænomena more deeply seated than those under consideration, the phænomena on which the very elements of sound geology now rest, a few years only have elapsed since the scientific world was agitated by Wernerian and Huttonian theories, neither of which, when exclusively considered, have proved to be entirely true, but which, when combined, have been found to harmonize with the observed laws and order of Nature; and so, if I mistake not, will it be with the glacial and aqueous transport of materials over the surface of the globe, each of which will be found to have performed its due part in bringing about those superficial appearances; for it seems unphilosophical, if not impossible, to attempt to explain them all upon any one hypothesis. In apportioning, however, to each of these causes its true effects, I doubt not that in regarding the surface of the globe, we must look to the action of water as of infinitely wider operation than that of ice.

In concluding this memoir, I beg to add, that the conclusions at which the distinguished naturalists, Owen and Edward Forbes, have recently arrived, as drawn from their researches into the causes of ancient zoological and botanical distribution from common centres, seem to harmonize strikingly with my own views and those of my colleagues as expounded in the work on Russia or as developed on this occasion. Professor Owen has given reasons, which to my mind prove to demonstration, that the British Isles must have been connected as dry and habitable land with the continent of Europe, when the large mammalia of lost races, as well as many quadrupeds still living among us, were extended into our country. Professor E. Forbes, on the other hand, has shown* that the occurrence of certain isolated groups of Scandinavian plants on the summits of some of our mountains can be best accounted for by the floating of icebergs, which transported plants and seeds as well as northern

* Memoirs of the Geological Survey of Great Britain, vol. i. p. 336. Professor

blocks from the Scandinavian chain during the post-pliocene or glacial period, when the highest points only of the British Isles are supposed to have been above the waters.

Coupling these inductions of eminent naturalists with the geological phænomena exhibited around the British coasts, and even at great distances in the interior of our islands, where shells of the post-pliocene or glacial period are found at considerable heights, we must admit, that here, as in Scandinavia, some of the greatest modifications of the physical outlines of all these countries, and the most powerful changes in the relations of land to water which the chronicles of the earth can furnish, have taken place in those last great geological operations which apparently link on our own period to a former condition of things. What grander movements of elevation and depression can, for instance, be appealed to, than those by which European Russia and Northern Germany (which were unquestionably submarine when the erratics were distributed) were raised up into massive continents to be tenanted by quadrupeds, most of which have now passed away? or when Scania was raised into land and peopled by great mammalia common to it and to the adjacent continent, whilst vast tracts to the north of it were still beneath the sea, or uninhabitable from other causes? Yet, since the period when such animals roamed from Germany into Scania, the deep fissures of the Sound and the adjacent Baltic have been scooped out; whilst, according to Danish legends, supported indeed (according to Professor Forchhammer) by much geological evidence, vast tracts of land were simultaneously submerged along the western coasts of Denmark. Coming then to our own homes, we there find, from a combination of zoological and botanical with geological evidence, that although, in the most recent of former epochs, the British Islands were beneath the sea, they must, in common with the great masses of the continent above alluded to, have been subsequently raised into dry land, and must have continued united during a period of sufficient length to allow numerous genera and species of plants and animals to extend themselves from their original centres of creation to our "Ultima Thulé"; and finally, that after this comparatively recent continental diffusion, the lands have been severed and isolated by the formation of those channels which now constitute the German Ocean, the Straits of Dover, and the Irish Sea.

Truly, therefore, may geologists be allowed to draw largely upon time in calculating their periods from the present day to the dawn of the protozoic age, when they see that the last great superficial changes—changes as it were of yesterday, when viewed as a part of the whole terrestrial cycle—have occurred since the creation of many species of beings whose descendants are among our associates.

E. Forbes's paper is entitled, "On the Connexion between the Distribution of the existing Fauna and Flora of the British Islands, and the Geological Changes which have affected their area especially during the epoch of the Northern Drift;" and the subject was first presented to notice at the Meeting of the British Association held in Cambridge in 1845.

APRIL 22, 1846.

Captain Otter, R.N., and J. H. Perry, Esq., were elected Fellows of the Society.

The following communications were read:—

1. *On the Subdivision of the genus* TEREBRATULA. By JOHN MORRIS, Esq., F.G.S.

THE genus Terebratula is one of the most interesting of the family BRACHIOPODA, inasmuch as it ranges under every variety of form throughout the whole series of deposits from the palæozoic to the tertiary formations, and is found widely distributed, although not numerous in species, at the existing epoch.

The name *Terebratula*, first used by Llwyd, although not adopted by Linnæus, was appreciated by Bruguière, and finally established by Lamarck in the 'Système des Animaux sans Vertèbres,' where he classified and described a large number of species, which appear, with additions, in the same work as re-edited by M. Deshayes.

The great number of species which have been added of late years to this genus has long made it desirable to subdivide it, and various attempts have been made by different authors to establish subordinate groups; of these it is necessary to give some account before proceeding to that which it is now proposed to substitute for them, as being founded on the discovery of a different mode of classification.

Lamarck (1819) simply divided the Terebratulæ into two groups, namely 1. smooth, without longitudinal grooves, and 2. longitudinally striated. Defrance (1827), in the 'Dictionnaire des Sciences Naturelles,' followed this order in his notice of the fossil species, and De Blainville did so also for the recent ones described in the same work; the latter author however suggested another arrangement founded on the greater or less development and form of the apophysary system.

Of the many special treatises on this genus, that by Baron Leopold von Buch is the most important and perfect, as it attempts to classify the various species upon sound principles and by a careful examination of all the characters; and this classification indeed forms to a certain extent the basis of the arrangement on which, with some modifications hereafter proposed, the Terebratulæ may be based. In this memoir* it will be perceived that Von Buch classed the Terebratulæ under three sections: 1st, "*Umfassend*," the deltidial area completely embracing or surrounding the foramen; 2nd, "*Sectirend*," the deltidial area enclosing only a small portion of the foramen; and 3rd, "*Discret*," the deltidial area not

* Abhand. der Akad. der Wiss. zu Berlin, 1833, p. 36; Mém. de la Soc. Géol. de France, tom. iii. p. 118.

being continuous throughout, but separated into two distinct parts; and although all the species so arranged by Von Buch do not exactly accord with the sections we now propose, it is interesting to observe that nearly all of those belonging to the first section are also species of our second group *Hypothyridæ*, and are not punctate, while the second and third sections contain, with very few exceptions, all the species included under our *Epithyridæ*, or punctated group. In speaking merely of the Terebratulæ, it is not necessary to refer to the other subdivisions of the Brachiopoda proposed by Sowerby, Dalman, Von Buch, or Professor Phillips; the latter adopts the variation of the foramen as the principle of his classification, and subdivides the genus Terebratula (*Cyclothyridæ*) into *Epithyris* and *Hypothyris*, as indicating the position of the foramen, these two groups nearly according with the view adopted in the present memoir.

In my early investigations of the Terebratulæ, I ascertained that among the recent species, one only, *T. psittacea*, was not punctated*, and this species also has an acute beak, below which there is a deltidial opening, the deltidium being scarcely developed on each side, and a slight apophysary system. Of this type there is now another recent species known, whilst all the other recent species with which we are acquainted have a minutely punctated structure, the beak of the dorsal valve being more or less truncate, and the internal apophysary system more developed.

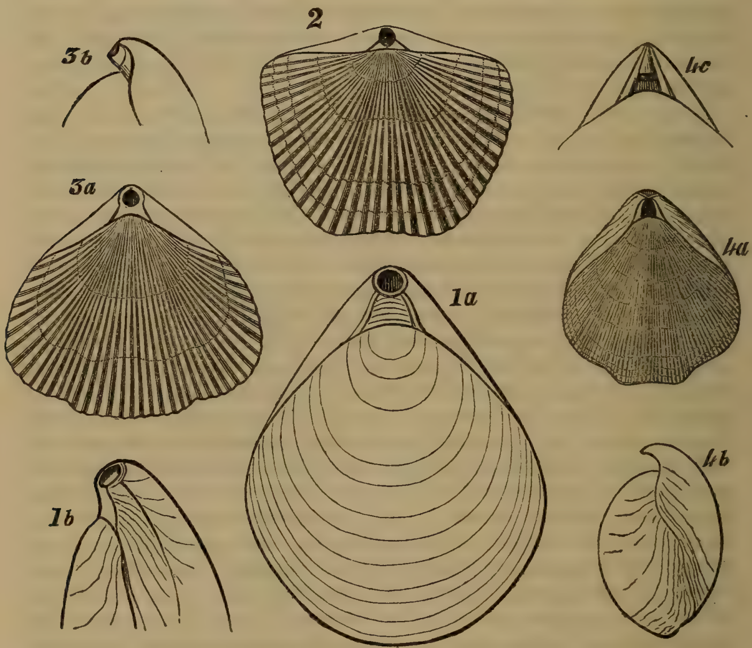
Dr. Carpenter has also added considerably to our knowledge of the structure of Terebratula, in his Report to the British Association 'On the Microscopic Structure of Shells,' and after examining about fifty species, he arrives at the conclusion, "that with scarcely an exception, the perforated (punctated) species are smooth, or but slightly plicated, whilst the non-perforated (non-punctated) species are deeply plicated" (Report, 1844, p. 18†). In this memoir Dr. Carpenter simply divides the species into perforated and non-perforated, without pointing out any other modification connected therewith; but as certain and constant characters, more especially about the foramen and cardinal area, co-exist with the absence or presence of these punctations, I think there can be no doubt, as stated in that paper, "that the punctation must have some intimate relation with the structure and habits of the animal, and that it must consequently be a character of zoological importance."

On separating the two general forms which exist among the Terebratulæ, those of plicated and smooth species, it will be found that the majority of smooth species have a *truncated* beak and a *punctated* shell; on the other hand, a very large number of the

* This fact was mentioned to Mr. J. Sowerby in 1841, and alluded to in his observations on the genus *Atrypa*, published in No. 108 of the 'Mineral Conchology.'

† In this paper Dr. Carpenter cites *T. coarctata* and *T. subrotunda* as non-punctated species, and *T. acuta* as punctated, whereas the two former are punctated and the latter non-punctated, and therefore agree with the other characters belonging to the foramen, &c.

plicated species have an acute beak and a non-punctated structure. Following out this simple observation, in connection with the other characters before mentioned, we arrive at constant and definite characters for two subdivisions of this genus, entirely dependent on the following general proposition: viz. that *certain positions of the foramen with regard to the beak, its form, character and relation to the deltidial area, always accompany the presence or absence of a punctated structure.* To the two divisions thus established, we have applied the terms *Epithyridæ* and *Hypothyridæ*, as suggested by Professor Phillips.



Typical forms of Terebratulæ.

Fig. 1. *T. ovalis*, Lam., showing the truncated form of beak and large deltidial area (EPITHYRIDÆ): 1 *a*. front view; 1 *b*. side view.
2. *T. Menardi*, Lam., the deltidial area not surrounding the foramen (EPITHYRIDÆ).
3. *T. plicatilis*, Sow. (HYPOTHYRIDÆ). In consequence of the thickening of the margin of the foramen, the figure does not well illustrate this group, but the base of the foramen is within the deltidial area: 3 *a*. front view; 3 *b*. side view.
4. *T. psittacea* (HYPOTHYRIDÆ); the plates of the deltidium are not joined in this species: 4 *a*. front view; 4 *b*. side view; 4 *c*. view showing the beak more distinctly.

In the first group, Epithyridæ, the beak is always more or less obliquely truncate, the foramen being almost entirely surrounded by the substance of the dorsal valve and lying above the deltidial area*,

* I have used the term *deltidial area* to express the small triangular space which

which only bounds the lower or anterior part of it or leaves it open below, this area varying very much in extent, form and direction, sometimes the area forming but a very limited portion of the enclosure of the foramen, at others enclosing one-third or one-half of it, but never entirely surrounding it (see fig. 1 and 2). Within this area the deltidium is more or less developed, and when the foramen is entire the deltidium generally fills up the whole space of the area between the anterior part of the foramen and the umbo of the ventral valve (*T. australis*, &c.). In some cases the deltidium extends nearly across the area, leaving a small fissure in the centre, so that the foramen is open below (*T. dorsata*); in others it occupies but a small portion on each side of the base of the area, and in this case the opening is large, being formed by the foramen and the unclosed portion of the deltidial area together, and only bounded by the ventral valve (*T. rubra*, *T. truncata*, *T. detruncata*)*. All the species having these characters, whether plicated, costated or smooth, have a punctated structure, and are generally longer than wide. The species constituting this section, and which may be considered as true Terebratulæ, are very various in external form and character, and may be subdivided into four or five minor groups; they are readily distinguished from those of the next section by the absence of the acute beak, and by the fact that the deltidial area never surrounds the foramen. All the recent species at present known (with two exceptions) belong to this division, but of the fossil forms belonging to it there are very few simple plicated species (*Plicosæ*, Von Buch), while of the *Dichotomæ*, species with bifurcating costæ or striæ, there are four divisions differing in the greater or less development of the deltidium. In the first of these, *Costatæ* (*T. cardium*, Lam.), the beak is slightly produced and the foramen is entire. In the second, *Rostratæ* (*T. lyra*, Sow.), the dorsal beak is much produced, the foramen terminal, and the deltidium extending from below it to the ventral valve. In the third, *Striatæ* (*T. striatula*, Mant., *T. caput-serpentis*), the deltidium is only partially developed towards the base, and the foramen is consequently not perfectly enclosed. In the fourth, *Expansæ* (*T. truncata*, Lam. &c.), the deltidium is also only partially formed, and the opening is generally large, combined with a straight cardinal area. In the *Loricatæ* (*T. Menardi*, Lam.) (see fig. 2) the shell is wider than long, and the deltidium separated or rarely continuous, so as to produce an entire foramen; the cardinal area is large and straight. In the *Cinctæ* (*T. quadrifida*, Lam.) the beak is slightly curved, the foramen is small and entire, as is also the deltidium, which apparently surrounds about one-half of the opening. In the small size of the foramen the Cinctæ are well-contrasted with some of the other smooth species belonging to the *Jugatæ* and *Carinatæ*. In the *Ju-*

is placed below the beak in all the species of Terebratula, and which is more or less filled up by the two pieces of shell called the *deltidium* by Von Buch, and which separates the foramen from the hinge line of the ventral valve.

* *Vide* 'Thesaurus Conchyliorum,' part 7, by G. B. Sowerby, for figures of these recent species.

gatæ there are two distinct forms; one (*T. carnea*, Sow.) in which the foramen is small and the deltidium scarcely visible, while in the other (*T. ovalis*, Lam., *T. longirostris*, Nilss.) the foramen is large and the deltidium well-developed. The *Carinatæ* may be also divided into (1) *Sinuatæ* (*T. perovalis*, Sow.), having a large foramen almost entirely formed by the dorsal valve, the deltidium bounding but slightly the anterior portion, and (2) the *Acutæ* (*T. resupinata*, Sow.), with an incurved beak, a small entire foramen, and the deltidium expanded at the base.

In the second group, *Hypothyridæ*, the beak is always acute and never truncate; the foramen is entirely below the beak and placed completely within the deltidial area; the deltidium either nearly surrounds the foramen, as in *T. vespertilio*, &c. and those species in which the foramen is entire (see fig. 3), or it partly lines the sides of the deltidial area in *T. psittacea* and those species where the foramen is not entire, but open anteriorly and bounded only by the umbo of the ventral valve (fig. 4); the margin of the foramen, when entire, is either simple, or thickened and produced by the expansion outwards of the deltidium itself (see fig. 3 *b*). In this section all the species have a *non-punctated structure*, are mostly deeply plicated or costated, generally wider than long, and they have usually an elevated central portion representing the mesial ridge among the Spiriferæ.

This group, which is peculiarly marked by the absence of the truncated beak and by the foramen or opening being always within the deltidial area, includes only two recent species, and nearly all the fossil ones arranged by Von Buch under the *Pugnaceæ* and *Concinnæ*, two minor divisions well-distinguished from each other; the *Pugnaceæ* (*T. acuminata*, Sow.) having the margin of the ventral valve more elevated than the middle, the beak incurved or somewhat adpressed against the ventral valve, and the foramen small and entire, although the deltidium is not much developed; the *Concinnæ* (*T. concinna*, Sow. &c.) having the middle of the ventral valve more elevated than the margin, the beak acute and produced, the deltidium surrounding the foramen, and the margin in some species (*T. vespertilio*, *T. depressa*, &c.) thickened and produced outwards. In other species of this group however (*T. psittacea*) the foramen is not entire, the deltidium being only slightly developed at the sides of the area.

Founded on the above characters, and using the previous classification of Von Buch and Professor Phillips for secondary divisions, the genus Terebratula may be either divided into two sections of Epithyridæ and Hypothyridæ, as stated above, or the second group may become a subgenus, for which either the term *Hypothyris*, Phillips, or *Cyclothyris*, as proposed by M'Coy, may be used. The description of the genus therefore stands thus:—

TEREBRATULA, Llwyd.

Shell inequivalved, dorsal valve perforated posteriorly; beak acute or truncate, produced or recurved; perforation either above or within the deltidial area, and more or less separated from the hinge-line by the deltidium or open below. Shell punctated or non-punctated.

The genus is divided into two sections, *Epithyridæ* and *Hypothyridæ*.

Epithyridæ.

Beak truncate, a circular or oval perforation above the deltidial area, either entire and surrounded principally by the dorsal valve, or a round opening in the dorsal valve more or less bounded at the sides by the deltidium. Shell punctated.

Group 1. PLICATÆ.

1. DICHOTOMÆ.

a. Costatæ.
T. orbicularis, *Sow.*
(T. cardium, *Lam.*)
T. oblonga, *Sow.*
T. Adrieni, *De Vern.*

β. Striatæ.
T. substriata.
T. striatula.
T. Defrancii.
T. chrysalis.
T. Toreno, *De Vern.*

γ. Rostratæ.
T. lyra, *Sow.*
T. pectita, *Sow.*
T. rostrata, *Defr.*

δ. Expansæ.
T. truncata.
T. detruncata.

Group 2. NON-PLICATÆ.

2. COSTATÆ.

Loricatæ.
T. coarctata.
T. loricata.
T. ferita.
T. Menardi.
T. Sayi.

Cinctæ.
T. trigonella.
T. quadrifida.
T. numismalis.
T. digona.
T. lagenalis.
T. cornuta.
T. diphya.
T. hastata.

3. LÆVES.

Jugatæ.
a. Repandæ.
T. carnea.
T. semiglobosa.
T. longirostris.
T. elongata.
T. ornithocephala.
T. vulgaris.
β. Excavatæ.
T. sufflata.

Carinatæ.
a. Sinuatæ.
T. biplicata.
T. perovalis.
T. ampulla.
T. Harlani.
T. globata.
β. Acutæ.
T. impressa.
T. resupinata.
T. carinata, *Lam.*

Hypothyridæ.

Beak acute, perforation below the beak and within the deltidial area; entire, and nearly surrounded by the deltidium, or not entire anteriorly, but bounded on each side by the deltidial plates. Shell non-punctate.

Group 1. Plicatæ.

1. Plicosæ.

α. Pugnaceæ.
T. acuminata, *Sow.*
T. pugnus, *Sow.*
T. ringens.
T. varians, *Schloth.*
T. tetrahedra, *Sow.*
T. triplicata, *Phil.*
T. acuta.
T. bidens, *Phil.*

β. Concinnæ.
T. concinna, *Sow.*
T. obsoleta, *Sow.*
T. decorata.

2. Dichotomæ.
T. subsimilis.
T. spinosa.
T. senticosa.

3. Striatæ.
T. reticularis.
(T. affinis, *Sow.*)
T. aspera.

The above two lists contain the names of the species only that have been examined, and they include most of the typical forms of Terebratula.

In adopting the subordinate divisions of Von Buch, it is necessary to state, that in his memoir no allusion is made to the important relation exhibited between the structure of the shell and certain characters afforded by the position of the foramen with regard to the deltidial area, and it is probably from these relations having been overlooked that the genus *Atrypa* has become the receptacle of many species which are well-marked and belong to one or the other of the above-proposed groups, as for example *T. hastata*, *T. sacculus*, &c., which are all punctated species, associated with others, *T. pugnus*, *T. pleurodon* and allied forms, all of which are non-punctated.

The characters of the groups above-described, especially the Hypothyridæ, are more easily recognised in the species belonging to the oolitic than to the palæozoic series, in consequence of the beak of the dorsal valve being more produced in those of the former than in those of the latter system; still, a careful examination of the palæozoic species can generally detect the embracing deltidial area.

With regard to the geological distribution of the two different sections, it will be found that the species belonging to the Hypothyridæ predominated considerably during the palæozoic æra, a few species only of this period belonging to the other section. In the jurassic and cretaceous epochs the Epithyridæ increased, and even outnumbered those of the other section; and the same group appears at the existing period to include (with two exceptions, and those northern forms) all the hitherto-described species of Terebratula.

In conclusion, it must be admitted, that however easily the above characters may be recognised, as forming a primary basis for the arrangement of the numerous species of Terebratula, it will yet require a minute investigation into the form and position of the internal apophysary system, which doubtless is as various in the fossil as in the recent species, before we can finally decide on the subordinate divisions of each of the sections above-proposed; thus we find among the Hypothyridæ the *T. affinis* and *T. aspera*, which with an embracing area have a spiral apophysary system vertically placed, whereas in the Pugnaceæ and Concinnæ this system becomes variously modified, and more or less strongly developed. In the Epithyridæ the *T. ferita* has also a spiral apophysary system, but laterally placed as in the Spiriferæ; in the *T. digona* (Cinctæ) the two internal pieces simply diverge towards the margin, and are again reflected and joined posteriorly; in the Jugatæ (*T. carnea*) this system is more modified, and resembles somewhat that of *T. vitrea* of the existing period; and many other diversities of form of this part may be well studied in the different recent species belonging to this section.

It will be observed in the above notice, that a small group of shells generally arranged among the Terebratulæ, the *T. concentricæ*, have been omitted; these species possess only a small deltidial area without any foramen*, are wider than long, with no cardinal area, are concentrically striated or laminated, non-punctated, and furnished with a spiral apophysary system laterally developed, as in Spirifer. Mr. J. Sowerby, in adopting the genus Atrypa, has divided it into three sections, under one of which he has included the small group of shells above-mentioned; and however different in character from the species previously classed by Dalman under the same name, there can scarcely be any doubt that they differ considerably from the true Terebratulæ, and form a passage into the group of the smooth Spirifers, the "*Spiriferæ glabratæ*" of Professor Phillips. Mr. M'Coy has constituted the generic term *Athyris* for their reception, and placed them with the Spirifers under the Delthyridæ.

In the other Terebratuliform genera, *Pentamerus*, *Strigocephalus* and *Magas*, the opening for the passage of the muscle of attachment is always within the deltidial area; in Pentamerus it is however partly concealed by the curvature of the dorsal valve; in Strigocephalus the deltidium is more fully developed, and in one species, *S. dorsatus*, entirely surrounds the circular or oval foramen; the structure of the shell is fibrous, and the inner layer is somewhat punctated, whereas in Pentamerus it is more laminated: in both these genera the apophysary system is singular and distinct. Magas apparently presents an anomaly in its general characters; for with a deltidial opening beneath an acute beak, it possesses a punctato-tuberculated structure (the opposite characters in the two groups of Terebratulæ being here combined), and a rather complex apophysary system. This genus is probably more nearly allied to some species of Orthidæ, as *O. elegantula*, which has also a similar punctated structure, with a deltidial opening, but a simpler apophysary arrangement.

* Many of the published figures of these species represent them as having a circular foramen, but I feel convinced that this appearance is deceptive, and that the beak is entire and not perforated.

2. *Description of the* DUKINFIELD SIGILLARIA. By E. W. BINNEY, Esq.

THE fossil described in this communication was discovered in the colliery of Messrs. Swire, Lees and Co., at Dukinfield, about seven miles east of Manchester. It was found in the Victoria pit at a depth of 1100 feet from the surface, and in the floor of the Cannel or Two-feet mine*. The following is a section of the beds in the vicinity of the tree:—

	ft.	in.
Black mine (COAL)	4	6
Grey metals, layers of rock and black shale	135	0
Ironstone mine (COAL)	1	5
Shale, with bands of ironstone	9	0
Stone mine (COAL)............................	2	6
Black shale, &c.	12	0
Cannel or Two-feet mine (COAL)	2	6
Tender metals (containing the tree).........	66	0
Peacock mine (COAL).........................	2	4

The dip of the strata is nearly due west, at an angle of 29°.

The Cannel or Two-feet mine consists of sixteen inches of good cannel and ten inches of ordinary coal. The floor is a dark-coloured fire-clay, called by the miners "tender metal," containing numerous nodules of ironstone. Its depth I traced to between three and four feet, and it may extend much deeper. The geological position of the Cannel-coal is in the lower part of the middle division of the Lancashire coal-field, about 120 yards above the last thick seam in the series, a position nearly the same as that of the deposits in which the St. Helens' trees were discovered†, but the distance between the two localities in a direct line is about twenty-eight miles.

The fossil in question was first examined and noticed by Mr. M. Dunn, and the tree had been removed and brought to Manchester before I went down into the mine to view the place where it was found.

I examined the bed of fire-clay and the spot where the fossil had lain, and found traces of the east root (that which appeared on the rise of the strata), in the shape of four Stigmariæ. From the nature of the excavation, the stem and roots of the tree could not have penetrated the floor to a greater depth than about three feet. The latter at their commencement ran nearly level, but after a distance of four feet, when they began to exhibit all the usual characters of Stigmaria, they appeared to have gone in a slightly upward direction. None of the roots were traced to their termination.

The floor, as before stated, is a dark fire-clay. Owing to its colour, scarcely any traces of plants can be distinctly seen in it; but on a careful examination I found it to be entirely traversed by the long stringy fibrils so characteristic of Stigmaria, and which have,

* The fossil has since been presented to the Manchester Geological Society.

† Phil. Mag., March 1844 and October 1845.

in all probability, discoloured the deposit with the carbon liberated by their decomposition.

The fossil, as it now lies in the museum of the Manchester Geological Society, consists of a detached stem and three main roots. The stem is unquestionably that of a Sigillaria, exhibiting all the ribs, furrows and scars of that genus. It is about fifteen inches high, four feet ten inches in circumference at its base, and four feet one inch at the top. The diameter at the top measures one foot five inches by one foot three inches. Down the side is a longitudinal depression, like those so generally found on the stems of Sigillaria. The inside presents no trace of structure, being filled with dark fire-clay. On the outside is a coating of bright coal one-third of an inch in thickness, very much resembling that found on the *S. pachyderma*. Prominent ribs project, and rather irregular furrows of about an inch in breadth intervene. On removing the coal, the decorticated part of the stem presents the usual fine longitudinal striæ, together with ribs of about an inch in breadth, parted by furrows. On the surface of the inner ribs are markings, some of which resembled the double impressions characteristic of *Sigillaria reniformis**, and others a single impression resembling that of *S. organum*. Some of the upper portions of the stem, which exhibited these characters in a more marked degree than appear in the drawing, were destroyed in removing the specimen. Owing to the circumstance of the fire-clay filling up and adhering to the furrows upon the outside of the fossil, it is difficult to detach the former and examine the external markings without removing the whole of the coaly envelope. In every respect this stem resembles the two St. Helens' trees before alluded to, and also bears great resemblance to the Dixon Fold trees† described by the late Mr. Bowman‡.

Although the stem is now separated from the roots, there is no question but that it was connected with them. Independently of the evidence of Mr. Dunn and the men who removed the fossil, it bears sufficient proofs of its having been attached.

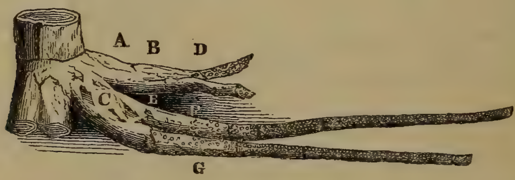
In the present paper it is only intended to describe one main root, namely that marked A in the drawing. At its commencement it is covered with a smoothish coating of thin coal, which on being removed shows a wrinkled surface (covered with iron pyrites), like that seen upon the roots of recent aged trees. The breadth across this main root, as it now lies on the floor, is three feet one inch. After running nearly level for sixteen inches, it divides into two secondary

* A specimen of Sigillaria in the Manchester Museum exhibits all the different characters of *S. catenulata*, *S. reniformis*, *S. organum* and *S. alternans*, on one stem. Many of the present specific characters are probably to be attributed to the various stages of the growth of the plant and the circumstances under which it has been preserved.

† The author of this paper accompanied Mr. Bowman, and showed that gentleman the Dixon Fold trees. As only parts of the main roots of these fossils were exposed, there was no chance of seeing whether or not they possessed Stigmaria roots.

‡ *Vide* Transactions of the Manchester Geological Society, vol. i. p. 112.

roots, B and C, having similar external characters to the main ones. Each of the latter measures fifteen inches across. Each of these again, after running sixteen inches, dichotomizes into four roots, D, E, and FG, which respectively measure ten and a half inches across



at their commencement. The outsides of these latter roots present a rougher appearance than the secondary ones for about two feet, after which they gradually assume all the true characters of Stigmaria, with depressed areolæ, &c., never again exhibiting traces of dichotomization. The roots marked D and E run upwards more than those marked F and G, the latter extending more in a horizontal direction. Some of the Stigmaria roots are slightly compressed, while others are nearly cylindrical in different parts; but for fifteen feet, the distance they have been traced, they average about five inches across, without any signs of terminating. Their outsides are composed of ironstone, but internally they consist of a very fine-grained silty sandstone, and show distinct evidence of an internal pith or cylinder. The latter however does not show structure. It is a singular fact that the stem of the plant should be filled with dark-coloured fire-clay and the roots (especially the Stigmaria portion of them) with a different material *.

The St. Helens' trees appeared to me to exhibit *in situ* all the facts necessary to prove Stigmaria to be the root of Sigillaria, and thus firmly fix the origin of all seams of coal having such roots in their floors without having to resort to the drift hypothesis. It is satisfactory to have my views confirmed by a specimen which everybody who will go into the museum where the fossil is deposited can see and judge for himself. The extraordinary regularity which prevails in the roots of Sigillaria was noticed in the paper published by myself and my friend Mr. Harkness in the 'Philosophical Magazine' of October last. The Dukinfield tree confirms our opinions on this point.

At St. Helens the trees had eight feet of silty clay to run into, and the roots there struck down at angles varying from 50° to 60° before they took a horizontal direction, and exhibited all the characters of Stigmaria. In the present instance, the roots having to

* The late Mr. Bowman, in his description of the fossil trees at Dixon Fold (Trans. of the Manchester Soc., vol. i. p. 129), attempts to explain the removal of the inner portion of the tree by decomposition after entombment, and its subsequent filling with sand and clay from above. So the dark-coloured fire-clay may possibly have come from the floor of the Stone mine after the roots had been previously filled with silty sand from some prior deposit.

run in a stiff clay, went in a horizontal direction without striking so deeply into the mud*.

As before stated, no distinct fibrils can be traced for any distance in the matrix of fire-clay at Dukinfield owing to the dark colour of the deposit, but at St. Helens the whole of the strata teemed with them, and they could be traced five or six feet from the roots, radiating in all directions; some were found within fifteen inches of the commencement of the stem and before the depressed areolæ could be distinguished, but at four feet distance the roots became true Stigmaria and then no further dichotomization took place.

It seems evident that Sigillaria was a plant of an aquatic nature from the position of the St. Helens' trees, which were found on the identical spots where they grew, imbedded in a fine silty clay sixteen yards above and sixteen yards below, or midway between two seams of coal; but more observations on the internal structure of its wood are required before we can pronounce with certainty as to the true nature of this extraordinary fossil plant.

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3. *On a Group of Erect* Fossil Trees *in the* Sydney *Coal-Field of* Cape Breton. By Richard Brown, Esq.

In a hasty sketch of the geological structure of the island of Cape Breton, which appeared in the second number of the 'Quarterly Journal of the Geological Society†,' I stated that excellent sections of the Sydney coal-measures were exhibited in the sea-cliffs extending from Miray Bay to Cape Dauphin. I have recently examined one of the most interesting sections within those limits, viz. that afforded by the cliffs on the N.W. shore of Sydney Harbour, which runs directly at right angles to the strike of the strata, exposing almost every individual bed from the old red sandstone, through the overlying carboniferous limestone, millstone grit and coal-measures.

The total thickness of the coal-measures, calculated from the highest bed of the millstone grit to their abrupt termination on the sea-coast, is 1843 feet, their dip being N.E. at an angle of 8°.

In this section erect fossil trees are found at various levels, but they are more particularly abundant in a stratum of arenaceous shale lying almost immediately under the main coal, where within a space of eighty feet, measured along the base of the cliff, eight erect trunks are seen with roots and rootlets attached to them.

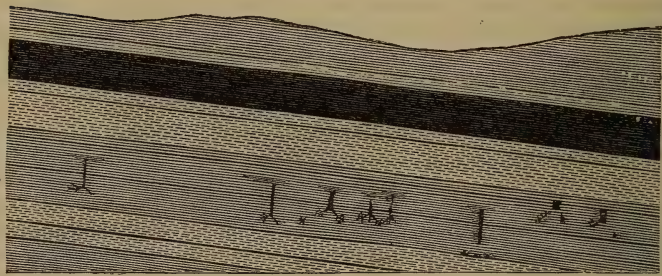
Fig. 1 is a section of the strata under the main coal, showing the

* The roots D and E must indeed have gone upwards at such an angle as to have been soon lost in the bed of coal.

† *Vide* vol. i. p. 207.

relative positions of the trees at right angles to the planes of stratification, as they appear in the face of the cliff, the upper part of

Fig. 1.



which overhangs and prevents us from observing how far the stems continue upwards. In the descending order we have the following series of beds:—

	ft.	in.
o. Strong white sandstone	4	0
n. Slaty blue shale	2	0
m. The main coal-seam	6	0
l. Soft fire-clay.......................................	2	0
k. Indurated clay	6	0
i. Slaty shale	1	3
h. Slaty gritty shale	5	0
g. Soft blue clay	0	0½
f. Dark slaty gritty shale............................	4	0
e. Soft clay and coal mixed	0	3
d. Fire-clay	3	2
c. Carbonaceous matter	0	0½
b. Indurated clay	2	4
a. Strong sandstone	8	0
Total height of the cliff	44	1

The sandstone, *a*, is quite destitute of fossils, but the overlying beds of clay, *b* and *d*, abound in Stigmariæ, with their rootlets radiating and crossing each other in every direction; they also contain some small scattered nodules of clay ironstone. Each of these beds has apparently been the surface-soil upon which forests of trees flourished, whose only remains are the numerous roots of Stigmariæ and the thin layers of coal, *c* and *e*, derived probably from the stems and branches.

The superincumbent beds, *f* and *h* (separated by the thin layer of blue clay, *g*), in addition to the upright stems with their roots and rootlets attached, growing at different levels, contain also vast quantities of flattened stems of Sigillariæ, Calamites and Lepidodendra, lying both in oblique and horizontal positions, and a great variety of Ferns, &c. Immediately under the roots of one of the trees, I found *Neuropteris cordata* with basal leaflets, two species of *Sphenophyllum*, two of *Pecopteris*, *Sphenopteris crenata*, *Asterophyllites*, and *Pinnularia capillacea.*

All the upright stems apparently belong to the same species, and are evidently young individuals, ranging from two to sixteen inches in diameter only. In some other parts of the coal-field, fossil stems three to four feet in diameter are not uncommon.

It must be observed, that with the exception of the thin layer of clay, *g*, there are no appearances of distinct surface-lines in the beds *f* and *h*, although the eight trees have clearly grown upon at least five different levels; from which it may be inferred that the strata were gradually subsiding during the period of their growth, the amount of which subsidence, as well as its comparative rate, may be estimated by the difference of level between the base of each stem, and the diameter it attained, before the surface on which it grew became submerged.

The bed *i* is a soft slaty shale overlaid by the underclay *k* and *l* of the main coal-seam; Stigmariæ are numerous in this bed, but they are by no means so plentiful as in the lower beds *b* and *d*. The bed of shale *n*, which forms the roof of the main coal, varies in thickness, and is sometimes altogether wanting; it abounds in coal-plants of almost every description.

Fig. 2.

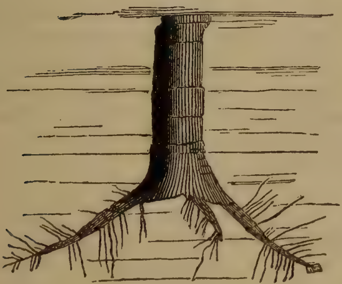


Fig. 3.

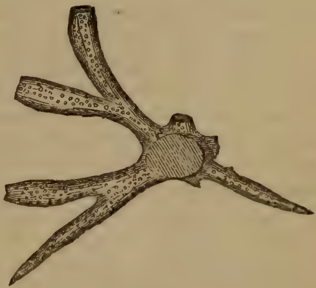


Fig. 2 is a sketch of one of the trees as it appeared when first discovered in the face of the cliff, with roots of Stigmariæ united to it.

Fig. 3 is a horizontal section, showing the direction of the roots, with their ramifications, so far as they could be conveniently followed. This section was obtained by cutting into the cliff until the rock became so hard that no further progress could be made without great labour.

The stem, although standing exactly at right angles to the dip, is slightly flattened, the diameter in one direction being eight and in the other only six inches, as shown in fig. 3. The bark, converted into bright coal, is very thin ; it is marked with longitudinal furrows and ridges ; the latter are about half an inch in width : the furrows are deep, but not always parallel and continuous, frequently waving and running into each other; they are also occasionally wrinkled, the effect probably of the squeezing which flattened the stem. As the furrows approach the base of the tree they become less distinct, but nevertheless do not wholly disappear; they may even be traced some six or eight inches down the upper surface of the roots. I could not observe any appearance of leaf-scars.

The stem and roots are filled with a fine-grained greyish white sandstone. In the latter I observed some slight remains of a central pith, but there are no traces whatever of organic structure in the sandstone of the stem.

The roots, which are true Stigmariæ, with rootlets or (as they generally have been called) leaves spreading out in every direction, are about three inches in diameter at their junction with the stem; at their extremities, or as far as they could be traced, they are flattened to a depth of about one inch: two of the roots, it will be observed by fig. 3, have been followed to their terminations, where they gradually thinned out to a mere line in one direction, being about three-fourths of an inch in width. They are thickly studded with tubercles, presenting an imperfect spiral arrangement, and covered with a thin bark or coating of carbonaceous matter.

The rootlets, varying in length from three to twelve inches, as shown in fig. 2, are compressed or flattened, being much broader near their junction with the roots than at any other point: they must have been composed of some soft substance, as they are in all cases flattened, whether lying in horizontal or vertical positions.

All the other stems represented in the section resemble so nearly the one I have attempted to describe, that it is not necessary to refer to them further, enough having been said, I hope, to prove that Stigmariæ and their leaves are in reality the roots and rootlets of a class of trees allied probably to Sigillariæ. If this be admitted, we must conclude that all beds in the coal-measures containing Stigmariæ, with their delicate rootlets united to them, have at successive periods been surface-soils, supporting forests of trees; that in the section before us, which represents only a perpendicular thickness of forty-four feet, there have been at least seven such surfaces, corresponding with an equal number of subsidences; and that the intervals of rest between each successive subsidence were comparatively small, until the bed became the surface-soil, which continued in a state of repose of sufficient duration to produce the immense mass of vegetable matter required for the formation of the main coal.

May 6, 1846.

Dr. Joseph Hooker, Sir Thomas Phillips, Arthur Grote, Esq., James Foster, Esq., Francis Forster, Esq., and the Rev. T. W. Jenkyn, D.D., were elected Fellows of this Society.

The following communications were read :—

1. *On the* Wealden Strata *exposed by the* Tunbridge Wells Railway. By J. Prestwich, Jun., Esq., F.G.S., and J. Morris, Esq., F.G.S.

In Dr. Fitton's valuable memoir "On the Strata below the Chalk," it is incidentally observed, that "the relations of the strata at Tunbridge Wells, and in the tract on the north of it towards the valley of the Weald, are well-deserving of attentive examination." (Geol. Trans., 2nd Ser., vol. iv. p. 171, note.) At that period no extensive sections were visible by which the superposition of the beds in this district could be accurately traced; but the deep cuttings for the Tunbridge Wells branch railway, traversing some of the longitudinal ridges of the Wealden sandstones, have fortunately afforded some information on the subject, a brief account of which is now laid before the Society, as exhibiting some interesting sections of the Upper Wealden series, as well as a remarkable flexure and fault by which these beds have been affected. Our object in the present communication is simply to record the details of structure and superposition of the strata cut through; and if their correct superposition with reference to any given line can be established, they may then be connected with other deposits whose position with regard to the same base may have been already determined.

The Dover railway traverses the Upper Wealden district from a short distance beyond the Redhill station nearly to Ashford, the branch line proceeding southward to Tunbridge Wells, deviating from it nearly at a right angle about a quarter of a mile beyond the Tunbridge station.

It is well-known that the strata of the Wealden consist in their lower part of thick-bedded light-coloured sandstones with subordinate beds of shales and clays, whilst in the upper part dark-coloured shales and clays predominate, the peculiar freshwater remains of this series occurring principally in the argillaceous beds.

The accompanying diagrams and sections give a partial detail of the superposition of the upper part of the lower series, and of the lower part of the upper series, but they do not show the complete sequence to the base of the lower greensand; and indeed a good and detailed section of the thick beds of clay presumed to form the uppermost stratum in this district is yet wanting.

These uppermost beds occupy the valley between the greensand escarpment five miles north of Tunbridge and the base of the hill immediately south of this town, at which point our section commences. We here find the beds rising with the hill, and consisting, 1st, of thirty feet of brownish laminated clays (A) underlaid by twenty feet of dark-coloured laminated clays and shales (B). The cutting is continued in these beds to the entrance of the tunnel on the north, and through the tunnel for about 300 yards; on the south side of the tunnel we see the lower portion of the same clays occupying the upper part of the cutting and gradually cropping out, giving way to the important sandstone beds which rise from below them. The dip of these argillaceous beds being about 2° or 3° north, their probable thickness is about 170 feet.

The mass of the clay is of a dark bluish grey colour, occasionally greenish, finely laminated and shaly, and it contains several very thin bands of dark impure argillaceous limestone, some tabular and others ferruginous and concretionary, and we also find in them thin tablets of clayey sandstone. The organic remains of these beds are exceedingly abundant; the thin limestones are full of *Cyrena media*, *Paludina elongata* and *Cypris Valdensis*. The same species are also common in the clays, but the abundance of the Cypris in them is a remarkable feature, generally producing a lamination of extreme thinness entirely covering every freshly separated surface. The shelly coverings of the Testacea and Cyprides are better preserved in the clays than in the limestones, but they are frequently crushed and always very friable. Singular vermiform impressions are also found on some of the more indurated clays, and may be especially observed covering the surfaces of the impure sandstone tablets.

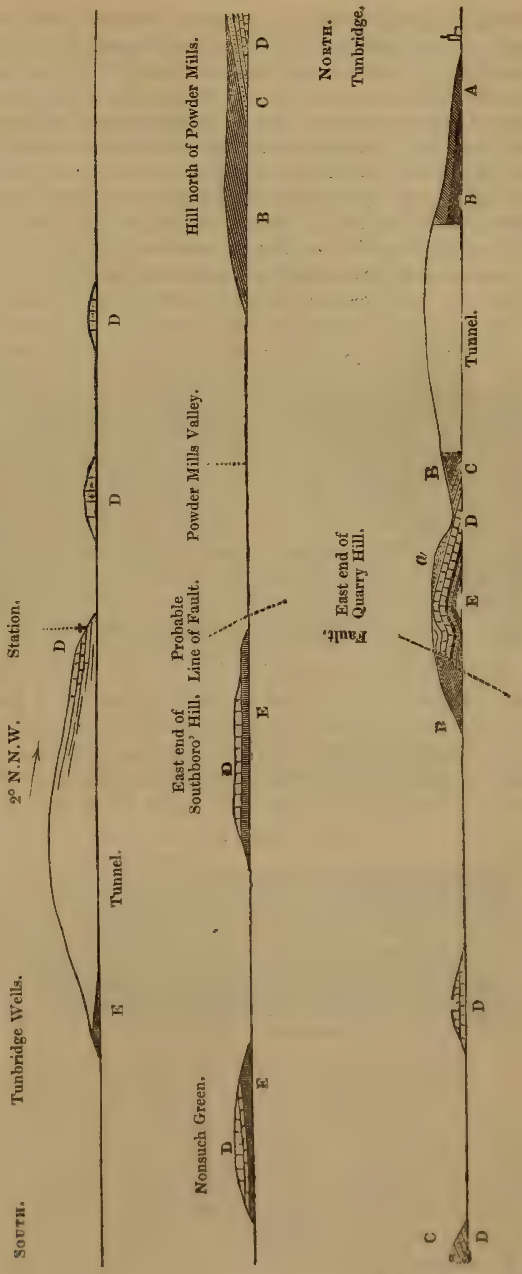
Underlying these clays are three beds of light-coloured sandstone (C) separated by dark brown clays, forming a thickness of twenty feet, and containing the *Unio Gaulteri* and *Cyrena subquadrata* and imperfect impressions of plants.

The next division (D), although conformable in general stratification, presents a slightly uneven and water-worn line of separation with stratum C (see general section, fig. 1, at point *a*), a fact corroborative of some change of condition, as further evinced by the almost entirely arenaceous structure of this lower division in contrast with the generally argillaceous characters of the upper ones (C and B). This structure is rendered very visible by the dark brown colour of the lower part of the upper division, and the nearly pure white of the clayey sand forming the upper bed of the lower division. This sand is underlaid by two feet of black lignite clay; below this clay is a series of sixty to seventy feet of thick-bedded light-coloured sandstones (D), sometimes massive, at other times fissile, and occasionally exhibiting false stratification. Many of the upper beds of this division, although apparently firm and compact when first exposed, decompose readily by exposure to the atmosphere in consequence of the base of the sand-rock consisting of fine white clay. About fifty feet from the top of this division is a strongly-marked band of lignite clay from eight to twelve inches thick, which rises from the base of the cutting ten or twelve yards on the north side of the forty-second mile-post; the beds of sand-rock about ten feet above and below this lignite band are slightly

Fig. 1. Section on the Tunbridge Wells branch of the South-Eastern Railway,

Showing the probable relations of this portion of the Wealden strata.

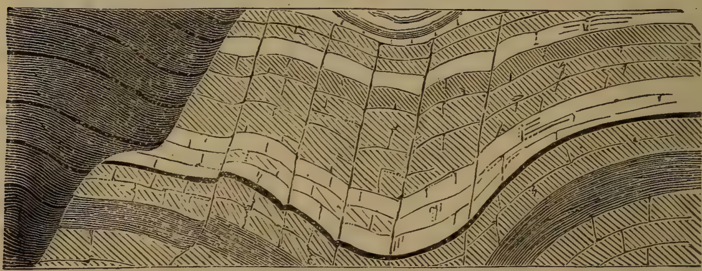
Horizontal scale, 4 inches = 1 mile.



ferruginous, siliceous and compact; below these compact beds are eight feet of dark soft shaly sandstones overlying twelve feet of sand-rock (E), this bed being the lowest visible in the section, and forming the base of the curve, which with the adjoining flexure and connected fault produces the remarkable and picturesque feature of this portion of the section. (See general section.)

The fossils of this division are exceedingly few, and confined chiefly to the upper beds, the remains of plants being more abundant than those of Testacea: of the former few can be recognised, with the exception of the *Equisetum Lyellii*, which is irregularly dispersed, and fragments and lumps of coaly lignite; associated with these are some casts apparently belonging to one or two species of *Unio*.

Fig. 2. Enlarged view of the FAULT at E, QUARRY HILL SECTION (fig. 1).



The fault* just alluded to (fig. 2) exhibits the dislocated edges of these light-coloured sand-rocks in contact with a dark clay, which may be identified by its organic remains and lithological structure with that of the upper division (B) above the sand-rocks. The same clays continue to the end of the cutting. (See general section.)

Crossing the valley we arrive, at a distance of about a quarter of

Fig. 3. SECTION North of the POWDER MILLS.

6. Dark grey clays full of *Cyrena media*, passing downwards into a lightish green clay, and then into greenish grey shaly clays full of the *Cypris Valdensis*, and with numerous bands of concretionary and nodular calcareo-argillaceous ironstones full of the *Unio Gaulteri*, *Cyrena media*, *Paludina elongata*, and *Cypris*; also thin slabs of sandstone covered with vermiform impressions.
5. Whitish soft massive sandstone; at the top of it, Cyrena and vegetable impressions are common.
4. Soft white decomposing argillaceous sandstone.
3. Whitish massive sandstone, with probable traces of Unio.
2. Traces of grit.
1. Dirty white fissile sandstone; lower part more massive: stratification very irregular and slightly unconformable to the overlying bed.

* The difference of level produced by this fault may probably be about 200 feet.

a mile, at a short section of twenty feet deep, consisting of soft friable sandstone imperfectly exhibited, and at a similar distance beyond it commences another good and long section through the hill north of the Powder Mills valley (fig. 3).

At the north end of this section the dip is reversed in the opposite direction from that which prevails at the Quarry Hill section, being about two degrees to the south. The lowest beds here observable (D) present some peculiar features; they form about fifteen feet of soft argillaceous sandstones, of a dirty white colour*, whose stratification is rather irregular and confused, and the beds appear not to be perfectly conformable to those of the overlying stratum C (fig. 3).

This latter consists of twelve feet of massive sandstone, with subordinate soft white argillaceous bands, and with a very slight underlie of pebbly grit, possibly representing C at the Quarry Hill section, since the same fossils, although rare and consisting only of a few impressions of *Cyrena* and *Unio*, are occasionally repeated in each †. Superimposed upon these are thirty feet of dark shales and clays, which we could not distinguish either by organic remains or lithological character from the Cypriferous shales (B) of the first section. They are laminated and shaly, of a dark bluish grey colour, with occasional green tints. They contain in abundance the *Cypris Valdensis*, and present several bands of impure concretionary limestones full of casts of *Cyrena media*, *Paludina elongata*, &c.

Proceeding across the valley for about half a mile, the railway section cuts through the east end of Southboro' Hill, and exposes about twenty feet of soft, marly, red and ferruginous sandstone, with subordinate beds of whitish sand and red clay overlying fifteen feet of green and dark grey shales (E), the position being nearly horizontal. For reasons hereafter given, we consider it doubtful whether these beds are a continuation of the shales described in the last section. The following is the sequence at this spot, given in descending order:—

3. Yellow clay and imperfect sandstone.
   Whitish sand and clay.
2. Soft yellow and ferruginous sandstones only occasionally massive, with black partings, mixed and imbedded in reddish clay, with small concretionary fragments of ironstone. The lower part of this stratum at the south end of the cutting passes into red clay and small ironstones only, with an underlie of grey clay full of irregular matter.
1. Shales and clays. South end—upper part green, then whitish, passing down into dark grey. As this bed trends northward, all the upper part becomes of a dark grey, passing down into a light greenish grey. Contains thin sandstone slabs covered with vermiform impressions, but no organic remains.

Between this point and the Tunbridge Wells section are three small cuttings, the first of which is similar in structure but not so

* From their general lithological character and position, this stratum (D) may correspond with the top of stratum D at the Quarry Hill section. Organic remains are extremely scarce at both localities, and afford no evidence.

† There are a few vegetable remains which also appear to be similar, but are equally indistinct.

well-developed as that at the last cutting; the other two imperfectly exhibit a few beds of sandstone, whose position appears to be nearly horizontal.

The railway reaches Tunbridge Wells by a tunnel under the hill upon which a part of the new town is built; the works are at present (February 1846) incomplete, but the following section is tolerably well-exposed in the cutting at the entrance to the tunnel.

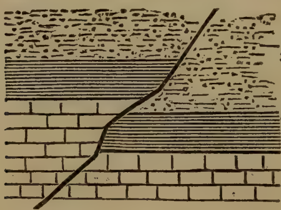
Tunbridge Wells Section.

	Thickness in feet.
10. Thin-bedded yellow clayey sandstone with no organic remains, passing upwards apparently into the thick-bedded soft sandstones forming the summit of the hill	10
9. Brown clay with numerous imperfect vegetable impressions...	1 to 3
8. Soft whitish sandstone. This and the overlying clay thicken considerably as they trend southward	3 to 6
7. Bluish grey or greenish clay: no organic remains	1 to 2
6. White argillaceous sandstones, thin-bedded and soft	3
5. Compact sandstone	2
4. Light grey soft fissile sandstone	2
3. Very fine white soft sandstone with irregular patches and traces of vegetable impressions and fragments of lignite. Upper layers are thick-bedded and disintegrate into a fine white sand; in descending it becomes thinner-bedded and greyer	15
2. Dark grey clay and shale with numerous impressions of plants	1
1. Whitish sandstone	5

Organic remains are extremely scarce in all the beds of this section: we met with no remains of Testacea and but few indeterminable impressions of plants in some of the layers. The bed of sandstone (3) presents a ferruginous pisolitic appearance. The dip of these beds is about two degrees N.N.W. They are undisturbed, with the exception of a slip trifling in amount but peculiar in character, as seen in the annexed section.

Fig. 4. Reversed Fault, Tunbridge Wells Cutting.

(Difference of level = 1 foot.)



The tunnel passes through beds of sandstone, being a continuance of those described in the section No. 4, but at the southern entrance are some greenish-coloured shales, apparently lower in the series, resembling in lithological character and in the absence of organic remains those at the section at the east end of Southboro' Hill.

As the railway traverses these Wealden strata for a distance of four miles at right angles to their strike, and as the dip of the beds both at Tunbridge and Tunbridge Wells is a few degrees northward, it might lead to an inference of a considerable vertical development between these two points; but this however does not appear to be the case.

The first portion of our section at Tunbridge shows probably the lower part of the Wealden clay with the upper beds of the Hastings sands rising from below them, the line of separation, if such it may be termed, being well-defined both by change of condition and slight irregularity of connecting surfaces. (See point *a* in the Quarry Hill section, fig. 1.) The clays and shales which again appear at the end of this cutting beyond the fault, we consider to be a repetition of the strata B. From the dip of these clays there can be little doubt that the sand-rock at the forty-two-and-a-half mile-post underlies them; and it is probably a continuation of this bed which reappears in the next section (D), having however a reversed dip to the south.

The position of the dark clays in the Southboro' Hill section is apparently obscure; at first sight, from their dip and position, they appear to be a prolongation of the cypriferous shales at the hill north of the Powder Mills*; but as they differ from them in their non-fossiliferous character, and as they evidently underlie the whole mass of the sandstone forming the high ridge from Southboro' Hill to Tunbridge Wells, where we see them again cropping out from below the sandstone at the south end of the tunnel (see section, Tunbridge Wells), we are rather inclined to consider them as lower in the series, their present continuous level with the clays (B) of the preceding section (north of Powder Mills) being due to the disturbances hereafter alluded to; for if they represented a prolongation of those clays, the sandstones of Southboro' Hill and Tunbridge Wells would (the strata at Quarry Hill and at the hill north of the Powder Mills being equivalents) be more recent than those of the Quarry Hill section, which have been shown to underlie the cypriferous clays, and consequently would have to be regarded as subordinate members of the mass of the Weald clay between Tunbridge and the greensand escarpment,—a district, the physical features of which seem to preclude the possibility of the recurrence of any such important sandstone strata.

As therefore the shales (E) are not higher in the series than those (B) at Quarry Hill, and further, as they do not appear to be synchronous with them, we must assign to them a lower position, in which case the sandstones at the section east end of Southboro' Hill and at the north entrance of the Tunbridge Wells tunnel might be the lower part of those (D) at the Quarry Hill section, and con-

* There is however no reason why the shales at the first-named cutting might not be an upper and non-fossiliferous layer of the shales at the last cutting, but in this case we ought to find the cypriferous strata cropping out to the south of Tunbridge Wells. To this we cannot speak from personal observation, and we are not aware that such a fact has been noticed.

sequently the sandstones at Tunbridge Wells would be the equivalents in greater development of those at Quarry Hill. The organic remains, although not numerous, tend to confirm this view, as the *Unio Gaulteri* and *Unio antiquus* are the characteristic fossils in the upper beds at both localities.

The sections described above traverse one of the principal longitudinal lines of disturbance of the Weald, the effects of which have been clearly pointed out by Mr. Hopkins in his interesting paper* "On the Structure of the Wealden District." He describes it as extending through Bidborough and Brenchley Hills, showing at both these places distinct evidence of an anticlinal ridge varying in importance.

At the point where the railway intersects the plane of disturbance, the anticlinal ridge has been removed by denudation, causing the remaining strata to present phænomena of rather complex character. The dotted line in the section shows the probable position of the anticlinal line, one of the lateral effects of which is exhibited in the fault at the Quarry Hill section. On the south side of the ridge there is also evidence of a probable lateral fracture in the vicinity of the Powder Mills valley, as evinced by the change of level of the lower clays (E) to which we have before referred, and by other facts observable in some of the adjacent quarries on the slope of the hill on the north side of the Powder Mill valley, in one of which is a succession of numerous small faults rising southward. This in general is an indication of the proximity of some larger fault or faults in the same direction. In the same plane as these changes, and with the same parallelism to the Bidborough anticlinal, are the disturbances described by Mr. Hopkins at Nashes, a point a few miles westward of the above locality.

We have therefore the effects of a movement of relative elevation venting itself in an anticlinal ridge flanked by parallel fractures of depression, thus:

Fig. 5.

a system of structure not perfectly satisfactory to our minds; but after a careful study and examination of the question, we are induced to offer it as a possible solution to the stratigraphical difficulties of the problem, and as being, as well as we could ascertain, in accordance with the observed phænomena.

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* Geol. Trans. vol. vii. p. 12.

Note appended by the Authors subsequently to the reading of the paper.

We feel the difficulty there is in supposing the groups of strata marked B, C and D in the section of the Powder Mills Hill to be the same as the strata so marked in the Quarry Hill section. It involves several apparent anomalies. Mr. Hopkins suggests that if this is the correct structure, there must exist two transverse faults, parallel to and flanking the railway section, the one between the section and Bidborough Hill, and the other between the section and Brenchley Hill, and that the district between these two faults presents a local structure deviating from the normal structure which is exhibited in the anticlinal ridge of Bidborough and Brenchley Hills. He thus accounts for the origin of this transverse valley, and adduces it as another fact in explanation of the singular transverse drainage of the Wealden.

Should it prove that the shales (E) at the section at the east end of Southboro' Hill correspond with the upper part of the shales (B) in the Powder Mills section, then these latter would form, with the sandstones C and D, the lowest series in the district, underlying all the strata at Quarry Hill. Still however our main argument, that the sandstones at Tunbridge Wells were the representatives of those at Quarry Hill, thus placing them at the top of the Hastings sands division of the Wealden, would hold good, and the hypothetical structure would be the same, but simplified; for the sandstones would range without break in a slightly undulating and nearly horizontal position from the Wells along Southboro' Hill to Bidborough Hill, to the north of which they would meet with the Quarry Hill fault, and dipping rapidly towards it would disappear below the shales (B), both these strata appearing again at a higher level on the north side of the fault. (See general section, Quarry Hill.)

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2. *On the Newer Deposits of the* Southern States *of* North America. By Charles Lyell, Esq., F.G.S.

In a communication formerly made, I gave a short notice on the Alabama coal-fields; I now propose to say something, but very briefly, of the newer deposits of the South, the post-pliocene and tertiary, so far as I have examined them in my present tour.

First, in regard to the post-pliocene occupying the coast and the lowest lands for some leagues inland in Georgia, the marine shells contained in deposits of clay and sand differ in no way from those of the adjoining sea. They are found arranged in groups, littoral and pelagic, as now on or near the shore. Such is observed to be the case in the island of Skiddaway, which is part of the delta of the Savannah river, and in the country between the mouth of the Alatamaha and the Turtle river in Glynn county, Georgia. These marine sandy deposits resemble exactly those which must be now forming off the neighbouring coast, and are covered in some spots by dark-coloured clay containing the remains of quadrupeds of extinct species, the *Megatherium*, *Mylodon*, *Mastodon giganteus*, *Elephas primigenius*, the Horse and others, with a large Chelonian*. I visited numerous localities on the Brunswick canal, near Darien, in company with Mr. Hamilton Couper, to whom we owe the discovery and careful exhumation of these remains, nearly all of which he has munificently presented to several public museums in the United States, especially those of Washington and Philadelphia. Everywhere I observed that there is no intermixture of the deposit containing the land animals with the subjacent bed containing the marine shells, and the mammalian remains appear to me to have been deposited in one of the arms of the ancient delta of the Alatamaha, when the relative level of land and sea was not the same, and yet differed but slightly from the present.

Mr. Couper's collection of the fossil shells underlying the bones comprises a large proportion of all the species which have been found on the coast of South Carolina, Georgia and Alabama. I have myself seen most of these fossils *in situ*, near Savannah or in the excavations made for the Brunswick canal, and they establish the fact that the ocean was inhabited before the time of the extinct mammalia by precisely the same conchological fauna as now: nor ought this conclusion to surprise us, as it is quite in harmony with that which I formerly deduced from the association in all parts of North America, from Canada to South Carolina, of the bones of the Mastodon and other lost quadrupeds with freshwater and land shells, not differing specifically from those of the adjoining rivers, lakes and forests. Such facts seem distinctly to imply that the temperature both of the atmosphere and the ocean has not materially changed since the time of the lost quadrupeds.

Secondly, on the coast of Georgia I examined, with Mr. H. Couper, the position of those submerged trunks or stools of the cypress (*Cupressus disticha*) which Bartram formerly alluded to in his 'Travels,' as showing that the level of the land on this coast had changed relatively to the sea in modern times. These trees can only grow in freshwater swamps, and there they are not permanently submerged at their base even in fresh water. At the mouth of the Alatamaha they are now found below the level of high tide in the salt marshes, with a deposit of mud over them. They also occur all with their upper surfaces cut off at the same level, and covered with several feet of alluvial matter in swamps higher up than the line of

* The *Hippopotamus* and *Sus* were formerly enumerated by Mr. Cooper and Dr. Harlan in their list of the fossil genera met with in digging the Brunswick canal. But Prof. Owen, in a communication recently sent to the Academy of Sciences at Philadelphia, has shown that the tusk referred to the Hippopotamus belongs to the Mastodon, so that there is now no evidence of a fossil Hippopotamus in America. The jaw to which the name of *Sus americana* had been applied exhibits a new type of organization, making some approach both to Lophiodon and Toxodon, but differing from either. For this fossil Mr. Owen has proposed the name of *Harlanus americanus*.

brackish water. They are so placed as to show a vertical depression of the land to the amount of at least four feet. But a full explanation of the curious appearances presented by them would require diagrams and a more detailed description than I have now time to send.

Thirdly, on the shores of the Bay of Mobile which opens into the Gulf of Mexico, I first met with inland deposits of that bivalve shell called *Gnathodon cuneatus*, an inhabitant of brackish water, but now met with in banks of sand extending several miles above the influence of the salt water, and rising three or four feet above the height of the present tides. Mr. Conrad first directed my attention to this remarkable formation, and I was taken to see it at several places by the Rev. Mr. Hamilton at the mouth of the Alabama river and in the suburbs of the city of Mobile. In neither of these localities, where large and small individuals of the Gnathodon form dense, shelly masses, could I detect any intermixture of other shells; yet on examining the mud of the adjoining sea-shore at low water, about a mile west of the embouchure of the Alabama, I met not only with the Gnathodon abounding in a living state in the mud, but also with a Nerita, and occasionally shells of *Cyrena carolinensis*. I tasted the water here and found it perfectly fresh, but was assured that this was owing to the wind blowing off the shore, and that the same testacea cannot live in water permanently fresh. The Gnathodon is not known to exist at present at the mouth of any American river farther north than the Alabama. The accumulation of fossils is far too considerable and extensive to be referred to the Indians, who are supposed by some observers to have used them for food, and to have left the shells scattered over the ground. On the other hand, the facts above stated may perhaps be explained without assuming that there has been an upheaval of the coast since the brackish waters of the Gulf of Mexico were inhabited by the Gnathodon. It is possible that the action of the waves on the shore may have thrown up these shells in the form of sea-beaches.

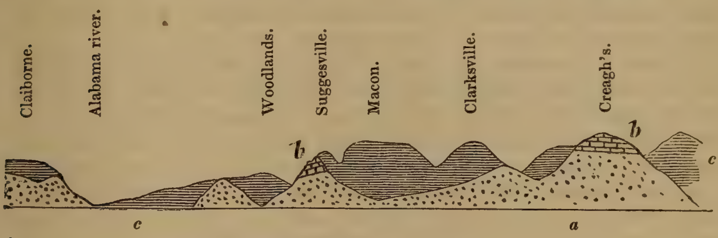
Fourthly, I have not fallen in with any deposits of miocene shells in the course of my present tour in Georgia and Alabama. The most southern point where I know them to occur is South Carolina. Dr. Gibbes of Charleston showed me a large number of miocene fossils obtained by him and Mr. Tuomey on the banks of Goose Creek, near the mouth of the Cooper river, at a place not visited by me in 1842.

Fifthly, the eocene formations are of great thickness, and occupy an extensive area in Georgia and Alabama. I formerly described in the Society's 'Proceedings' and 'Journal' the two formations of this age which I saw in 1841–42 in South Carolina and Georgia, the one chiefly calcareous, consisting of white limestone and marl, the other the burr-stone formation, composed principally of clay and sand; and I showed in a diagram representing a natural section at Jacksonboro', Georgia (Journal of the Geol. Society, vol. i. p. 438), the manner in which these different members of the eocene series, both horizontally stratified, rest one upon the other. My examination of the cuttings recently made for a railway about 200 miles in length between Savannah and Macon in Georgia, in a line parallel to the section which I formerly observed in the bluffs of the Savannah river, has confirmed the opinions before expressed by me, namely, 1st, that the clays and sands containing the burr-stone are eocene, as shown by casts of testacea and corals; 2ndly, that they overlie the calcareous eocene limestone and white marl. In like manner I have found throughout Alabama that the lower tertiary deposits in which the calcareous strata predominate are horizontal, with a very undulating or uneven surface, and have been covered by newer beds, also horizontal, of blood-red clay, silt, quartz gravel, white porcelain earth, yellow ochreous clay, and white, pink and yellow siliceous sands and ferruginous sandstone. Chert occurs in some places in this upper deposit, which is so barren of organic remains in Alabama, that I could only infer its eocene date from the analogy of Georgia. The older eocene limestone and marl must have had a very uneven surface, shaped into hills and valleys, often bounded by steep precipices, before the incumbent clay and sand, which is occasionally from 300 to 400 feet thick, was thrown down. When the original inequalities had been for the most part removed by the deposition of the argillaceous and sandy beds, the existing ravines and valleys were excavated at the expense of both formations, and hence it occasionally happens that two closely adjoining sections, each on the same level and of the same height, exhibit a distinct series of horizontal beds. This diversity is exemplified in different parts of the bluff at Claiborne on the Alabama river, which has become celebrated for the great number of perfect fossil shells obtained from it by Messrs. Conrad and Lea. At the new landing, the perpendicular precipice exhibits more than 150 feet of the calcareous formation, chiefly composed of white limestone and marl, while the red clay and sand appear only at the top of the cliff about twenty feet thick. But this upper formation, about a mile lower down in the same bluff at Claiborne, is more than 100 feet thick, composed of sand and clay without fossils, a small portion only of the calcareous beds cropping out from beneath.

Sixthly, owing to the extent and thickness of the overlying clay and sand, it is often impossible to obtain a clear section of the various subdivisions of the eocene white limestone of Alabama. To this cause I attribute the obscurity in which the true age of the nummulite limestone of Alabama has hitherto been involved. It has been considered sometimes as an upper cretaceous group, sometimes as intermediate in age between the tertiary and secondary series. After visiting Claiborne and the country on the other side of the Alabama river in the fork of that river and the Tombecbee, passing by Suggsville, Macon, Clarksville and Creagh's, all in Clarke county, I am persuaded that the nummulite limestone is an eocene rock, newer than all the beds of the well-known Claiborne bluff. It is in fact more modern than the sandy deposit from which the eocene shells described in the publications of Messrs. Conrad and

Lea were derived. The annexed section will explain my view of the structure of this country better than a detailed description.

SECTION showing the position of the NUMMULITIC LIMESTONE near CLAIBORNE.



a. White eocene limestone, marl, &c.
b. Nummulitic limestone (eocene).
c. Blood-red clay, yellow sand, &c. (eocene ?)

I am informed by Captain Bingham the engineer, that some of the hills between Clarksville and Creagh's, on the tops of which I observed the nummulite limestone, are about 400 feet higher than the top of the bluff at Claiborne.

Seventhly, the conclusion last-stated will make it necessary in future to omit from all lists of American cretaceous fossils such species of shells as have been considered secondary, simply on the ground of their occurrence in the nummulite limestone of Alabama. The fossils which I have met with most abundantly in the latter are the *Nummulites Mantelli* and *Pecten Poulsoni*. I have however many others, especially casts of shells and corals, which I shall hereafter describe. The nummulitic formation is from 50 to 100 feet in thickness, consisting for the most part of a soft cream-coloured stone, hardening on exposure, while in other beds it is highly indurated. In its lower portion, where it joins the ordinary white limestone, I found *Pecten perplanus*, *Ostrea panda* and *Plagiostoma dumosum*. Lunulites and other corals also occur in this rock. The recognition of the true place of this limestone in the series will remove almost every fossil from the list of those species which were still supposed to be common to the cretaceous and tertiary groups of the United States.

Eighthly, I have visited several of the principal localities where the bones of that gigantic cetacean, called Basilosaurus by Dr. Harlan and Zeuglodon by Mr. Owen, have been discovered in Clarke county before-mentioned. These bones are everywhere in the same geological position, namely in the eocene white 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.

Ninthly, on Creagh's plantation and about four miles and a half S.W. from Clarksville, I visited the spot where Mr. Koch procured in 1845 the head and part of the vertebral column, about thirty feet in length, of the Zeuglodon, called by him Hydrarchos. I was accompanied by Mr. William Pickett, a gentleman who also assisted

Mr. Koch in the exhumation of those bones. From him and other persons I learn that the main body of the vertebræ which entered into the skeleton exhibited in the United States by Mr. Koch in 1845 under the name of Hydrarchos were procured in Washington county, Alabama, at a place fifteen miles distant in a direct line from the locality where the head was dug up.

I have information of about forty other places where separate bones of this huge animal have been met with in Clarke and Washington counties alone. From several of these I have seen the bones, and they are in so perfect a condition and so bulky, so distant the one from the other, and must have been so difficult to transport, that I can hardly doubt their having belonged to forty distinct individuals.

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3. *On some Footmarks and other Impressions observed in the* New Red Sandstone *Quarries of* Storton, *near* Liverpool. By John Cunningham, Esq., F.G.S.

The author, in a communication dated January 5, 1846, and addressed to Dr. Buckland, observes, "the small slab which I herewith send * contains an impression *in intaglio* of what I conceive to be the footprints of small birds. They are the only impressions having a resemblance to those of birds that I have hitherto been able to detect among the numerous indications of reptiles associated with them in one of the beds of the Storton quarries, and if they should prove to be Ornithichnites, I do not despair of finding the larger impressions in some of the strata of Storton Hill; but the other quarries around Liverpool are quite barren of all impressions."

In a further communication made on the 30th of March, Mr. Cunningham states, "I am glad to inform you, that on Saturday last, being at Storton, I discovered on the face of a slab three most distinct indurated impressions of a bird's feet of pretty large size, measuring two inches and a half in length. The feet had three toes; the intermediate space between two impressions is ten inches, and so far as they go, the impressions are right and left. There can, I think, be no doubt of the animal that produced them having been a bird, and probably one of the *Grallæ*. There was no appearance of a web between the toes.

"This discovery I consider important, as proving beyond a doubt the existence of warm-blooded animals in this country during the period of the deposit of the New red sandstone. I have long looked for something of the kind, and am now hoping to discover some of the large Ornithichnites."

* This slab was presented by Mr. Cunningham to the Geologic Society.

May 20, 1846.

The Rev. J. G. Cumming, M.A., Vice-Principal of King William's College, Isle of Man, and C. H. L. Woodd, Esq., were elected Fellows of the Society.

The following communications were read:—

1. *Description of a New Species of* Plesiosaurus, *in the Museum of the Bristol Institution.* By Samuel Stutchbury, Esq., F.G.S. &c.

Plate XVIII.

The animal about to be described in the following pages was discovered in the grey lias, which is largely quarried throughout Somersetshire for building-stone and other economic purposes.

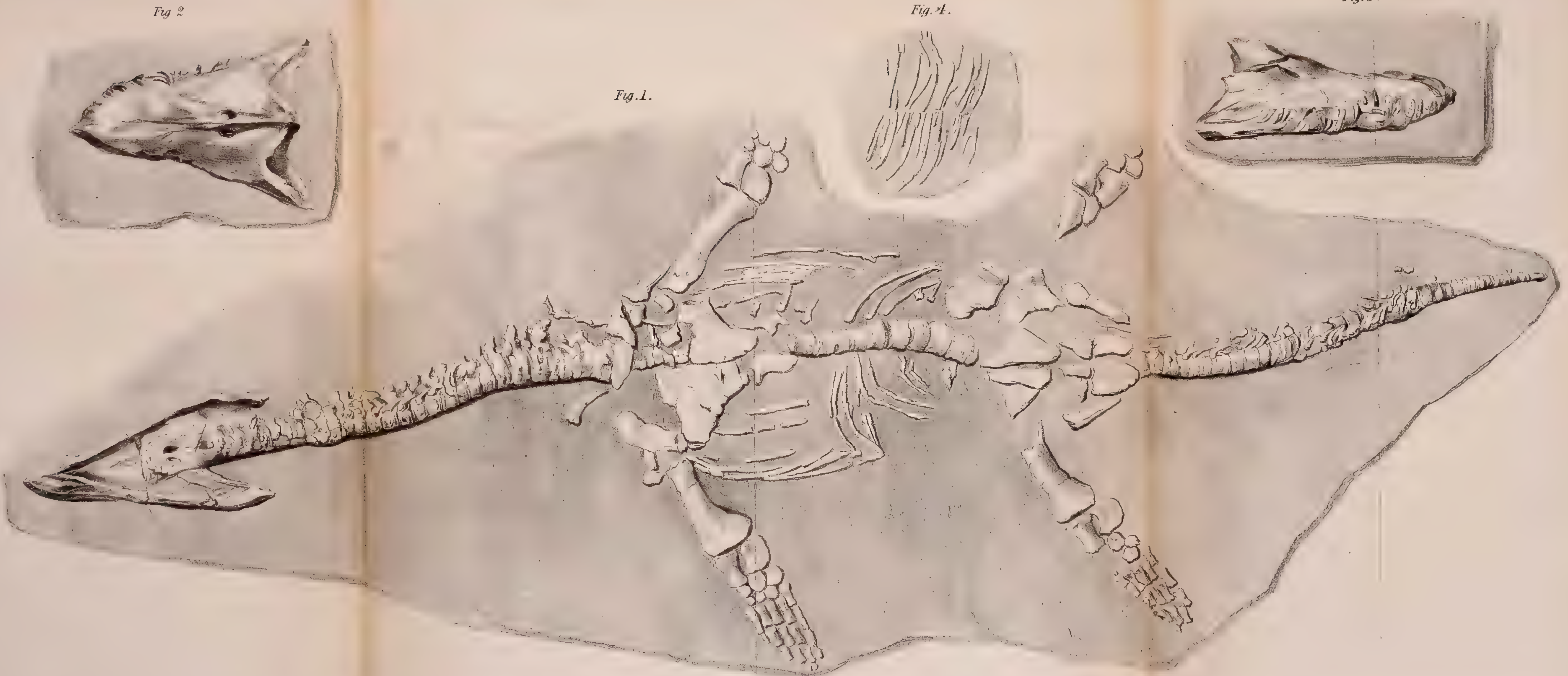
The remains of Enaliosaurians are distributed through the whole Liassic period, and it has been observed in the majority of cases as relates to the two genera Plesiosaurus and Ichthyosaurus, that specimens of the first-named genus are mostly found lying upon their backs, while the Ichthyosauri are generally lying upon their sides; but in a few instances the parts of the skeletons of both have become dislocated and detached from one another, not even retaining in any manner their relative position.

In the first of these cases I imagine, that after the death of the animal, gases, evolved principally among the abdominal viscera, have been retained by means of the tough dermal covering, aided by the support of the sterno-costal arcs, and the body becoming gradually water-logged, was quietly deposited on the muddy bottom and afterwards silted up*.

The fact of the Ichthyosauri possessing a more fish-like form, the depth in their supero-inferior diameter being greater than their lateral width, accounts for their being so constantly found lying upon their sides; and the occasional dislocated condition to which I have alluded results from their tough integuments having held together until the interior of the body was so much macerated as to disunite the whole skeleton, which would then be similar to a number of loose bones held in a bag or sack.

But as these animals generally appear to have been quietly deposited, it would seem that they must have been protected in some manner from the attacks of their own predaceous race, as well as from those of the fishes, of which numerous remains attest the existence during that period; and these saurian remains appear also to have belonged to individuals of all ages. Hence the opinion has arisen, as noticed by Dr. Buckland, that these creatures experienced a violent death.

* Since this paper was read, the author's attention has been directed to a notice in the Geol. Trans., 2nd series, vol. v. p. 513, by Professor Owen, and he finds that he has used arguments very similar, respecting consequences after death, to those used by that author.



From a Drawing on Zinc by J. Erxleben.

Day & Haghe lith^rs to the Queen

Plesiosaurus megacephalus. Stutchbury.

If we suppose some sudden diffusion of mephitic gas through the waters, produced by submarine volcanic action, this would be a cause sufficient for the immediate destruction of all animals within its influence, and during its continuance would also prevent other animals entering within its poisonous precincts, thus allowing time for the dead bodies to be quietly deposited in the manner before suggested.

To these or some such causes and effects we are indebted for the means of examining the remains of the Enaliosaurians in the very perfect condition in which they are generally found.

In the descriptive detail which the admirable state of preservation of the specimen before us enables me to give, I shall adopt the nomenclature of Professor Owen *, as being most applicable to this particular order.

Plesiosaurus megacephalus.

Animal with spinal column consisting of ninety-four vertebræ in the following divisions:—cervical twenty-nine, dorsal and lumbar? thirty-four, sacral and caudal thirty-one. Total ninety-four.

Head large, in length equal to two-thirds that of the neck, and one-sixth of the whole length of the body.

The whole length of the animal from the anterior portion of the muzzle to the posterior extremity of the tail, measured along its curvatures, is sixteen feet three inches.

The superior portion of the head, posterior to the orbits, is so much crushed as to prevent any examination.

The teeth, of which more than sixty can be counted in the two jaws anterior to the line of the orbits, are finely striated towards their apex in the young state, but perfectly smooth in the matured teeth.

The sixth tooth from the front in the lower jaw outside the socket is in length 1 inch $\frac{8}{10}$ths, and the diameter at the base $\frac{6}{10}$ths inch.

In this specimen there is an inner row of small mucronate teeth situated parallel to the principal or external teeth †.

The *columellar bone* is in this specimen clearly displayed, and is separated at its superior extremity, and slightly shifted at its inferior, now lying on the same plane as the whole inferior surface.

* *Vide* Report on the 'British Fossil Reptiles,' laid before the British Association in 1839.

† Professor Owen regards these as the young teeth in progress of growth, and describes them as follows:—"The germs of the successional teeth are developed at the inner side of the bases of the old teeth, but do not penetrate these teeth; the apices of the new teeth make their appearance through foramina situated at the inner side, and generally at the interspace of the sockets of the old teeth. Here, therefore, the growing teeth may be included in closed recesses of the osseous substance of the jaw, and emerge through tracts distinct from the sockets of their predecessors."—*Odontography*, p. 285.

And again,—"The dentition of the Plesiosaurus differs from that of the Crocodile, inasmuch as the new tooth, instead of emerging from the pulp-cavity of the old tooth, or even from the same socket, protrudes its apex through a distinct foramen at the inner side of the alveolus of its predecessor."—*Ibid.* p. 282.

The *Pterygoid*, as seen from the inferior surface, remains nearly in place, its posterior extremity being in contact with the articular bone of the lower jaw.

	ft.	in.	10ths.
Length of the lower jaw from the anterior part of the muzzle to the end of the articular bones	2	8	0
Inferior surface of the head from the muzzle to the basi-occipital	2	0	5
Ditto ditto to the anterior wall of the nasal openings	1	6	0
Length of the symphysis of the lower jaw		5	6
Breadth of the widest part of the muzzle		5	2
Widest part across the occipital region	1	3	5
Superior surface of the head; from the muzzle to anterior part of the nasal openings		9	6
Antero-posterior length of the nasal opening		1	1
Width of the nasal openings			5
Distance between the nasal openings		1	1
From the anterior part of the muzzle to the anterior wall of the orbit		11	5
Columellar bone, length		5	7
Ditto, diameter			6

Cervical vertebræ.—Twenty-nine in number.

Nos. 1 and 2 appear to be anchylosed.		
No. 3, antero-posterior diameter	1	2
Distance between the inferior point of the neurapophysis to the superior margin of the articular facet for the reception of the cervical rib		5
Vertical diameter of the articulating facet		7
Nos. 4, 5, 6. Antero-posterior diameter	1	2
Height or length of neurapophysis	2	2
Nos. 7, 8. Antero-posterior diameter	1	2
Nos. 9 to 13. Ditto ditto	1	4
Nos. 14, 15. Ditto ditto	1	5
No. 16. Ditto ditto	1	7
Distance between the inferior point of the neurapophysis to the superior margin of the articular facet for the reception of the cervical rib		6
Nos. 17, 18. Antero-posterior diameter	1	7
Height or length of neurapophysis	2	6
Height or length of spinous process above the neurapophysis	1	8
No. 19. Antero-posterior diameter	1	9
Distance between the orifices of the vascular canals		8
Nos. 20 to 26. Antero-posterior diameter	1	9
Articulating facet distinctly separate into two, superior and inferior.		
Nos. 27 to 29. Antero-posterior diameter	2	0
Vertical diameter of the centrum of the vertebra	3	2

The inferior surface of the neurapophysis of the twenty-ninth vertebra is extended outwards, forming a transverse process, carrying part of the articulating facet.

The inferior surface of the centrum of the cervical vertebræ is subcarinated along the median line.

The cervical rib or hatchet-shaped bone is most strongly characterized at about the twentieth vertebra.

The articulating facet for the attachment of the cervical rib is nearly circular, very rough, with a deep and broad groove about one-third above its inferior margin.

	in.	10ths.
Diameter of articulating surface	1	2
Length of pedicle		9
Length of whole rib	1	7
Lateral expansions	2	1

Of the lateral expansions one-third part is anterior and two-thirds posterior.

Dorsal and Lumbar? vertebræ.—Thirty-four in number; the majority of them are now concealed by the sternal bones, which, together with the sterno-costal arcs, were removed for the purpose of examining the number of vertebræ, &c.: the sterno-costal arcs are not restored to their natural position, but kept separate.

The dorsal vertebræ are not carinated upon the inferior plane of the centrum, as are the cervical and caudal. The surface is smooth; they are deeply concave on their inferior line; thus in the thirteenth vertebra, the antero-posterior diameter being $2\frac{5}{10}$ inches, the concavity is half an inch.

Sacral and Caudal vertebræ.—Thirty-one in number.

It has been stated that the cervical vertebræ are carinated on their inferior plane and that the ridge or carina does not exist on the dorsal vertebræ. In the caudal vertebræ there are two strongly-marked angulations or ridges, giving these vertebræ a remarkably distinct character from those of the anterior portion of the spinal column.

The hæmapophyses partake of the general robust character of the whole skeleton.

The true ribs are large, several of them two feet in length, with a diameter of $1\frac{4}{10}$ inch; their exact measurements cannot be obtained in consequence of the overlying of the shoulder and sternal bones.

Entosternum.—This bone is large, but much mutilated; its lateral length in a line with its anterior concavity *was* 16 inches; its antero-posterior length, taken at the widest part across its lateral expansion, is $7\frac{2}{10}$ inches; its anterior concavity $2\frac{2}{10}$ inches in depth.

Sterno-costal arcs.—These have been removed *en masse* for the purpose of exposing the dorsal vertebræ and ribs; they are now placed separately in the same case (Plate XVIII. fig. 4).

	in.	10ths.
Length of the median piece	13	0
Diameter in centre	1	0

Coracoids.

Antero-posterior dimensions	17	0
Breadth from median line to the glenoid cavity	8	8

Scapula and Clavicle.—These bones being anchylosed, form one large triradiate bone.

Its anterior expansion	7	0
Its lateral expansion	6	0

Humerus.

	in.	10ths.
Length from the extreme convexities of the proximal and distal extremities	13	7
Diameter across the head	3	3
Ditto ditto great tuberosity	3	7
Ditto at half its length	3	3
Ditto at its distal extremity	7	0
Anterior edge nearly straight, posterior edge deeply concave; depth of the concavity	1	8

Radius.

Length from proximal to distal terminations	4	6
Breadth across proximal extremity	3	5
Diameter at half its length	2	0
Diameter at distal extremity	2	7

Ulna.

Greatest length of its posterior or convex edge	4	3
Length of its anterior or concave edge	3	3
Breadth at half its length, being from the deepest part of the anterior concavity to the posterior convexity	3	3
Depth of anterior concavity or versed sine		5

Carpal bones.—Six in number.

Diameter of the largest	2	3
Ditto smallest	1	0

The *Metacarpal* and *Digital Phalanges* are expanded at their extremities, the diameter of their centres being as two to three to that of the extremities.

The paddles not being quite complete, the number of the digital phalanges cannot be stated.

Pelvis.

Antero-posterior dimensions of the *Pubic* bones along the median line or symphysis	8	6
Diameter of the *Ischium* taken in the same direction	11	0
Length of the *Ilium* (both of which are remarkably well preserved)	8	5
Diameter across the extremity which forms part of the acetabulum	3	4
Diameter across the sacral extremity	2	1
Ditto at half its length	1	4

Femur.—The head of each femur is broken off, but judging from appearances, I take it to have been about the same length as the humerus.

Length from the trochanter to its distal extremity	9	0
Diameter at half its length?	3	2
Ditto across distal end	6	4

The anterior edge is slightly concave, as also the posterior edge, but not so concave as the posterior edge of the humerus.

Tibia.

Length	4	5
Diameter at femoral extremity	3	9
Ditto at tarsal	3	10
Ditto at half its length	2	7

Fibula.

	in.	10ths.
Greatest length of its posterior or convex edge	4	5
Length of the anterior or concave edge	2	7
Diameter at half its length, from the depth of its anterior concavity to the posterior convex edge	3	7

Tarsal bones.—Four in number; the three posterior bones being large.

Diameter of the largest of the three	2	3
Ditto of the smallest	2	1
The anterior tarsal bone is small, its diameter		6

The metatarsal and digital phalanges consist of five ranges, larger and broader than in the anterior paddles, but not being complete, the number of digital phalanges cannot be enumerated.

Proportions.—The whole length of the animal, as before stated, is 16 feet 3 inches; for the sake of comparison I shall call it 1000. We shall then have:—

Length of lower jaw	160
Length of neck	245
Width across lower jaw	78
Length of humerus	67
Width of distal extremity of humerus	35
Antero-posterior length of coracoid	98
Width of coracoid	47

The length of the head is two-thirds the length of the neck; it bears the same proportion with regard to the thirty-four vertebræ comprising the tail.

P. megacephalus differs from the undernamed species in the following particulars:—

P. Hawkinsii, Ow.	*P. megacephalus.*
The neck is three times the length of the head.	The neck is only one-third longer than the head.
The tail is two and a half lengths of the head.	The tail is but one-third longer than the head.
The cervical vertebræ are thirty-one in number.	The cervical vertebræ are twenty-nine in number.
The cervical vertebræ are smooth on their external surface.	The cervical vertebræ are slightly rugose.
The length of the largest of four or five adult specimens does not exceed seven feet six inches.	The whole length is sixteen feet three inches.
P. dolichodeirus, Con.	
The neck is as four to one of the head.	The neck is as three to two of the head.
The head is as one to thirteen of the whole length of the animal.	The head is as one to six of the whole length of the animal.

P. macrocephalus, Ow.	*P. megacephalus.*
The neck is as four to two of the head.	The neck is as three to two of the head.
P. brachycephalus, Ow.*	
The head is equal in length to fourteen of its anterior cervical vertebræ.	The head is equal in length to twenty of its anterior cervical vertebræ.
P. macrourus, Ow.	
The anterior paddles are the largest, as in Ichthyosaurus.	The anterior paddles are smallest, as in most of the Plesiosauri.
P. arcuatus, Ow.	
The vertical height of the cervical vertebra is seven inches.	The vertical height of the cervical vertebra is seven inches eight tenths.
The length of the humerus is fourteen inches.	The length of the humerus is thirteen inches seven tenths.
Diameter of the expanded symphysis of the lower jaw is four inches.	Diameter of the expanded symphysis of the lower jaw is five inches two tenths.

Upon comparison with descriptions of the remaining species, there are essential and especial differences which at once distinguish from all those the known species hitherto discovered.

DESCRIPTION OF PLATE XVIII.

Fig. 1. *Plesiosaurus megacephalus.* Scale one inch = 1 foot.
2. Ditto. View of the upper part of the anterior portion of the head.
3. Ditto. Side view of the anterior portion of the head. Scale 2 inches = 1 foot.
4. Ditto sterno-costal arcs removed to show the dorsal vertebræ.

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2. *On* Foot-marks *discovered in the* Coal-measures *of* Pennsylvania. By Charles Lyell, Esq., F.G.S.

I intended to draw up a paper on what I have learned and observed respecting the proofs alleged to have been found of the existence of mammalia, birds and reptiles in the Pennsylvania coal-field; but I cannot do this until I receive my specimens, and have had more time to make sections and maps, in order to do the subject justice. I must therefore content myself with this brief notice. The discoveries of the impressions to which I shall refer were made by Dr. King, a physician of this place, whom I have seen, and who has been most anxious to facilitate my investigations, and to give me every help in arriving at the truth, which was his only thought,

* The skull is mutilated in the specimen on which this species was founded.

whether I confirmed or invalidated his conclusions. I shall first speak of the reptilian foot-marks.

The quarry where they were found is about five miles S.E. of Greensburg, in the county of Westmoreland, Pennsylvania. The stone quarried is a sandstone which rises up from beneath the main or Pittsburg seam of coal, which has been worked at its outcrop in the immediate neighbourhood*. There are several other seams of coal, which lie at lower levels, and impressions of Lepidodendron, Sigillaria, Stigmaria, Calamites, Ferns, and other plants have been found in the beds which lie above and below the sandstone containing the foot-marks. The slabs of sandstone, which are extracted in the quarry for paving, are separated by parting layers of a fine unctuous clay, such as would be admirably fitted to receive the most delicate and faithful impressions of the feet of animals treading upon it.

One of these Cheirotherian impressions was observed by Dr. King imprinted on the upper surface of one of the layers of clay or shale before-mentioned, but the specimen was unfortunately left exposed, and was destroyed by the weather. Twenty-two other footsteps were discovered on the under sides of the slabs of sandstone, standing out in relief from a surface which also exhibits those large and small mud-veins, which are the casts of cracks produced by the drying and shrinking of the mud on which the animal walked. The shrinkage took place after the foot-marks were made, so that these prints were traversed and slightly distorted by the cracks. The casts of these shrinkage cracks were mistaken for Fucoids.

The Cheirotherian tracks occur in pairs, each pair consisting of a hind- and fore-foot. There are two rows of these, which are parallel, or have been formed, the one by the right fore- and hind-feet, the other by the left; the toes turning one set to the right and the others to the left, and the distances between the successive footsteps being about the same throughout.

I shall now advert to the supposed foot-prints of birds, and of quadrupeds resembling dogs, cloven-footed and other animals.

The principal place where these imprints were observed, and which I visited, is about a mile distant from the town of Derry in Westmoreland county, Pennsylvania. They were not found beneath the soil, nor on the under surface of solid strata, like the Chirotherian marks at Greensburg, but consisted of impressions or incisions on the upper surface of a denuded ledge of white coal-grit or sandstone, which has been exposed for ages, and so acted upon by water, that channels and cavities have been shaped out, and numerous deep pot-holes, some of them more than a foot in diameter and eighteen inches deep, excavated in it. To suppose a series of deep and sharp foot-prints of birds to have been retained unblunted by weathering, or by the currents of water which denuded the sandstone, would be sufficiently difficult; but still more to account for the fact, that the last of the imprints is on the steep end of the ledge, inclined at an

* "The Pittsburg seam is 10 feet thick, and has been ascertained to occupy an area of about 14,000 square miles."—*Lyell's Travels in America*, vol. ii. p. 27.

angle of 22°, so that the bird, after walking on the planes of stratification, which are nearly horizontal, must have gone over the edges also. Loose sand, capable of receiving an impression, could never have acquired the present outline in a ledge of rock; and, on the other hand, sand consolidated into stone, as this evidently was when denuded, could never have been marked subsequently by any known agency but the hand of man, in imitation of the feet of birds and quadrupeds.

In order to explain the great number of the foot-prints appearing on so uneven a surface, and where several different stratified layers of sandstone have been cut into, we should have to imagine that there were originally a multitude of impressions on each superimposed layer, all nearly in one direction; that wherever the denuding action of water had happened to cut into any inferior layer, it always laid open to view new tracks. But this hypothesis is so far from being borne out by the facts, that after cutting into the stone in more than twenty places, and removing small slabs with imprints on them, Dr. King has never been able to detect a single indication of a foot-mark in the rock below.

One of the dog-like foot-prints on this Derry stone agrees with one of those which are found in another locality, in Fayette county, near Connelsville, nineteen miles from Greensburg, and about thirty from Derry. Dr. King and the Rev. Mr. Hackey, who have visited that place, inform me that unquestioned Indian hieroglyphics, and the representation of a serpent and two human heads, are there to be seen with bird tracks and those of hoofed quadrupeds. I have seen good imitations of the foot-prints of birds brought to Indiana by Dr. David Dale Owen from St. Louis, Missouri, on slabs of limestone sculptured by Indians; nor can anything be more probable, than that the aboriginal inhabitants of North America, who are so accustomed to trace and follow the trail of every kind of game, should occasionally employ as symbols of birds and quadrupeds, an imitation of the foot-prints which they leave on soft mud and sand. As Dr. King agrees with me in abandoning as spurious all the imprints except those of the large reptile, I will not dwell longer on the refutation of the evidence; but I may mention that there are numerous graves of Indians near the sculptured sandstone of Derry, and it is known to have lain in the line of one of their principal paths leading from the Alleghany mountains to the west.

The rectification of a few mistakes, with which some of the first observations in this new field have been connected, is a matter of small interest and moment compared to the important truth which has been brought to light through Dr. King's exertions;—that the land on which forests of Sigillaria and Lepidodendron grew, gave support also to large air-breathing quadrupeds. Few geologists will now be prepared to believe that this single species or genus of reptiles, or that one class only of vertebrated animals, had possession of the islands and continents on which so widely-extended and magnificent a vegetation flourished.

It may be as well for me to add, that the rejection of the supposed Ornithichnites of Derry as spurious has by no means led me to doubt the genuineness of those that I formerly examined in the red sandstone of the Connecticut valley, and which have been so fully described by Professor Hitchcock. On the contrary, those fossil foot-prints were found under circumstances in all respects analogous to those which lead me to believe in the reality of the Cheirotherium which has been discovered in the coal strata near Greensburg. These reptilian tracks occur in one locality only; no others have yet been found in the same place, nor under similar circumstances elsewhere.

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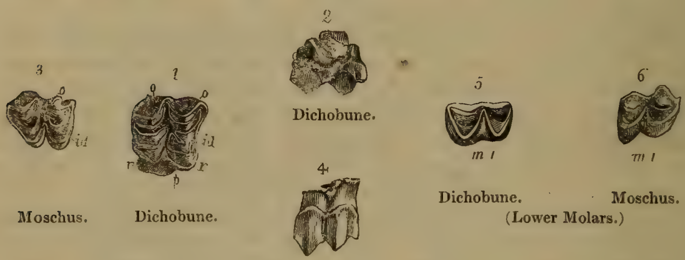
3. *Description of an Upper Molar Tooth of* Dichobune cervinum *from the Eocene Marl at* Binstead, Isle of Wight. By Prof. Owen, F.R.S., F.G.S. &c.



Moschus. Dichobune. Dichobune. Moschus. Dichobune. Moschus. (Lower Molars.)

The species of Anoplotherian quadruped described in the 'Geological Transactions,' second series, vol. vi. p. 41, and in my 'British Fossil Mammalia,' p. 440, under the name of *Dichobune cervinum*, has hitherto been known only by the fragment of lower jaw with three molars, first described and figured by S. P. Pratt, Esq., F.R.S., in the third volume of the same series of 'Geol. Trans.,' p. 451. As the lower molar teeth are less characteristic of the aberrant Anoplotheriidæ and less distinct from those of the Ruminantia than the upper ones, the opportunity of examining an upper molar tooth of a *Dichobune* was much to be desired, more especially since Cuvier had not been able to obtain more than one small fragment of the upper jaw, with two premolars, of this subgenus, from the Eocene formations in France*.

I am indebted to Hugh Strickland, Esq., F.G.S., for the desired opportunity of examining the upper true molar, either first or second of the left side, here figured (figs. 1, 2). It was obtained at Binstead, in the Isle of Wight, from the same quarry as the lower jaw of the *Dichobune cervinum* above referred to, and it presents

* See 'Ossemens Fossiles,' 4to, 1825, vol. iii. pl. lvi. fig. 7.

exactly the proportions which might be expected in the upper molars of that species; having the same superior transverse diameter, as compared with the antero-posterior diameter, which the upper molars of all herbivorous and most other mammals present, compared with the lower ones. (Compare figs. 1 and 3 with 5 and 6.)

The Anoplotherian character of the tooth is shown by the large size of the lobe *p*, fig. 1, and the subgeneric peculiarity by the continuation of its dentinal base with that of the inner and anterior lobe *id*, at the early stage of attrition presented by the crown of the tooth in question. In the large and typical Anoplotheria the lobe preserves its insular form and uninterrupted contour of enamel until the crown is more worn down. In this respect, as in the modifications of the lower molar teeth, the genus *Dichobune* shows its closer affinity to the true Ruminants; but the little fold of enamel dividing the lobe *id* from *p* distinguishes the upper molar tooth in question from that of any Ruminant. From the genus *Moschus* (fig. 3) it further and more particularly differs in the equal concavity of the outer surface of the outer lobes *o, o,* the anterior of which in *Moschus* is traversed by a strong vertical ridge (fig. 3, *o*). The basal ridge (*r*) along the inner side of the crown of the upper molar of Dichobune distinguishes it from those of *Moschus* and of any known Ruminant of corresponding size. For the better elucidation of these distinctive characters, figures of the homologous teeth of *Moschus moschiferus* (figs. 3, 4 & 6) are subjoined.

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4. *On the Wealden Beds of Brora, Sutherlandshire, with Remarks on the Relations of the Wealden Strata and Stonesfield Slate to the rest of the Jurassic System, and on the marine contemporary of the Wealden Series above the Portland Stone.* By Alexander Robertson, Esq., F.G.S.

[The publication of this paper is postponed for the present.]

PROCEEDINGS,

ETC.

POSTPONED PAPERS.

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1. *On the Packing of the Ice in the River St. Lawrence; the occurrence of Landslips in the Modern Deposits of its Valley; and the existence of Marine Shells in them and on the Mountain of Montreal.* By W. E. Logan, Esq., F.G.S.

[Read June 15, 1842.]

The island of Montreal stands at the confluence of the rivers Ottawa and St. Lawrence, and is the largest of several islands splitting up these mighty streams, which cannot be said to be thoroughly mingled until they have descended some miles below the whole cluster. The rivers first come in contact in a considerable sheet of water called Lake St. Louis, which separates the upper part of the island of Montreal from the southern main. But though the streams here touch, they do not mingle. The waters of the St. Lawrence, which are beautifully clear and transparent, keep along the southern shore, while those of the Ottawa, of a darker aspect, though by no means turbid, wash the banks of the island; and the contrast of colour they present strongly marks their line of contact for many miles.

Lake St. Louis is at the widest part about six miles broad, with a length of twelve miles. It gradually narrows towards the lower end, and the river as it issues from it becoming compressed into the space of half a mile, rushes with great violence down the Rapids of Lachine, and, although the stream is known to be upwards of eight feet deep, it is thrown into huge surges of nearly as many feet high as it passes over its rocky bottom, which at this spot is composed of layers of trap extending into floors that lie in successive steps.

At the termination of this cascade the river expands to a breadth of four miles, and flows gently on, until it again becomes cramped up by islands and shallows opposite the city of Montreal. From Windmill Point and Point St. Charles above the town, several ledges of rock, composed of trap lying in floors, which in seasons of low water are not much below the surface, shoot out into the stream about 1000 yards; and similar layers pointing to these come out from Longeuil on the opposite shore. In the narrow channel between them, the water, rushing with much force, produces the *Sault Normand,* and cooped up a little lower down by the island of St. Helen and several projecting patches of trap, it forms St. Mary's Current.

The interval between St. Helen and the south shore is greater than that between it and Montreal; but the former is so floored and crossed by hard trap rocks that the St. Lawrence has as yet produced but little effect in wearing them down, while in the latter it has cut out a channel between thirty and forty feet deep, through which the chief part of its waters rush with a velocity equal to six miles per hour. It is computed that by this channel alone upwards of a million of tons flow past the town every minute.

Between this point and Lake St. Peter, about fifty miles down, the river has an average breadth of two miles, and proceeding in its course with a moderate current, accelerated or retarded a little according to the presence or absence of shoals, it enters the lake by a multitude of channels cut through its delta, and forming a group of low flat alluvial islands.

The frosts commence about the end of November, and a margin of ice of some strength soon forms along the shores of the river and around every island and projecting rock in it; and wherever there is still water it is immediately cased over. The wind, acting on this glacial fringe, breaks off portions in various parts, and these proceeding down the stream constitute a moving border on the outside of the stationary one, which, as the intensity of the cold increases, is continually augmented by the adherence of the ice-sheets which have been coasting along it; and as the stationary border thus robs the moving one, this still further outflanks the other, until in some part the margins from the opposite shores nearly meeting, the floating ice becomes jammed up between them, and a night of severe frost forms a bridge across the river. The first ice-bridge below Montreal is usually formed at the entrance of the river into Lake St. Peter, where the many channels into which the stream is split up greatly assist the process.

As soon as this winter barrier is thrown across (generally towards Christmas) it of course rapidly increases by stopping the progress of the downward-floating ice, which has by this time assumed a character of considerable grandeur, nearly the whole surface of the stream being covered with it; and the quantity is so great, that to account for the supply, many, unsatisfied with the supposition of a marginal origin, have recourse to the hypothesis that a very large portion is formed on and derived from the bottom of the river, where rapid currents exist. But whatever its origin, it now moves in solid and extensive fields, and wherever it meets with an obstacle in its course, the momentum of the mass breaks up the striking part into huge fragments that pile over one another; or if the obstacle be stationary ice, the fragments are driven under it and there closely packed. Beneath the constantly widening ice-barrier mentioned, an enormous quantity is thus driven, particularly when the barrier gains any position where the current is stronger than usual. The augmented force with which the masses there move, pushes and packs so much below, that the space left for the river to flow in is greatly diminished, and the consequence is a perceptible rise of the waters above, which indeed from the very first taking of the bridge gradually and slowly increase for a considerable way up.

There is no place on the St. Lawrence where all the phænomena of the taking, packing and shoving of the ice are so grandly displayed as in the neighbourhood of Montreal. The violence of the currents is here so great, and the river in some places expands to such a width, that whether we consider the prodigious extent of the masses moved, or the force with which they are propelled, nothing can afford a more majestic spectacle, or impress the mind more thoroughly with a sense of irresistible power. Standing for hours together upon the bank overlooking St. Mary's Current, I have seen league after league of ice crushed and broken against the barrier lower down, and there submerged and crammed beneath; and when we reflect that an operation similar to this occurs in several parts from Lake St. Peter upwards, it will not surprise us that the river should gradually swell. By the time the ice has become stationary at the foot of St. Mary's Current, the waters of the St. Lawrence have usually risen several feet in the harbour of Montreal, and as the space through which this current flows affords a deep and narrow passage for nearly the whole body of the river, it may well be imagined that when the packing here begins the inundation rapidly increases. The confined nature of this part of the channel affords a more ready resistance to the progress of the ice, while the violence of the current brings such an abundant supply, and packs it with so much force, that the river, dammed up by the barrier, which in many places reaches to the bottom, attains in the harbour a height usually twenty, and sometimes twenty-six feet above its summer level; and it is not uncommon between this point and the foot of the current within the distance of a mile, to see a difference in elevation of several feet, which undergoes many rapid changes, the waters ebbing or flowing according to the amount of impediment they meet with in their progress from submerged ice.

It is at this period that the grandest movements of the ice occur. From the effect of packing and piling and the accumulation of the snows of the season, the saturation of these with water, and the freezing of the whole into a solid body, it attains the thickness of ten to twenty feet, and even more; and after it has become fixed as far as the eye can reach, a sudden rise in the water, occasioned no doubt in the manner mentioned, lifting up a wide expanse of the whole covering of the river so high as to free and start it from the many points of rest and resistance offered by the bottom, where it had been packed deep enough to touch it, the vast mass is set in motion by the whole hydraulic power of this gigantic stream. Proceeding onward with a truly terrific majesty, it piles up over every obstacle it encounters; and when forced into a narrow part of the channel, the lateral pressure it there exerts drives the bordage up the banks, where it sometimes accumulates to the height of forty or fifty feet. In front of the town of Montreal there has lately been built a magnificent revêtement wall of cut limestone to the height of twenty-three feet above the summer level of the river. This wall is now a great protection against the effects of the ice. Broken by it, the ice piles on the street or terrace surmounting it, and there stops; but before the wall was built, the sloping bank guided the moving mass up to those of gardens and houses in a very dangerous manner, and many accidents used to occur. It has been known to pile up against the side of a house more than 200 feet from the margin of the river, and there break in at the windows of the second floor. I have seen it mount a terrace garden twenty feet above the bank, and crossing the garden enter one of the principal streets of the town. A few years before the erection of the revêtement wall, a friend of mine, tempted by the commercial advantages of the position, ventured to build a large cut-stone warehouse 180 feet long and four or five stories high, closer than usual upon the margin of the harbour. The ground-floor was not more than eight feet above the summer level of the river. At the taking of the ice, the usual rise of the water of course inundated the lower story, and the whole building becoming surrounded by a frozen sheet, a general expectation was entertained that it would be prostrated by the first movement. But the proprietor had taken a very simple and effectual precaution to prevent this. Just before the rise of the waters he securely laid against three sides of the building, at an angle of less than 45°, a number of stout oak logs a few feet asunder. When the movement came the sheet of ice was broken and pushed up the wooden inclined plane thus formed, at the top of which meeting the wall of the building, it was reflected into a vertical position, and falling back, in this manner such an enormous rampart of ice was in a few minutes placed in front of the warehouse as completely shielded it from all possible danger. In some years the ice has piled up nearly as high as the roof of this building. Another gentleman, encouraged by the security which this warehouse apparently enjoyed, erected one of great strength and equal magnitude on the next water lot, but he omitted to protect it in the same way. The result might have been anticipated. A movement of the ice occurring, the great sheet struck the walls at right angles, and pushed over the building as if it had been a house of cards. Both positions are now secured by the revêtement wall.

Several movements of the grand order just mentioned occur before the final setting of the ice, and each is immediately preceded by a sudden rise of the river. Sometimes several days and occasionally but a few hours will intervene between them; and it is fortunate that there is a criterion by which the inhabitants are made aware when the ice may be considered at rest for the season, and when it has therefore become safe for them to cut their winter roads across its rough and pinnacled surface. This is never the case until a longitudinal opening of considerable extent appears in some part of St. Mary's Current. It has embarrassed many to give a satisfactory reason why this rule, derived from the experience of the peasantry, should be depended on. But the explanation is extremely simple. The opening is merely an indication that a free subglacial passage has been made for itself by the water, through the combined influence of erosion and temperature, the effect of which, where the current is strongest, has been sufficient to wear through to the surface. The formation of this passage shows the cessation of a supply of submerged ice, and a consequent security against any further rise of the river to loosen its covering for any further movement. The opening is thus a true mark of safety. It lasts the whole winter, never freezing over even when the temperature of the air reaches 30° below zero of Fahrenheit; and from its first appearance the waters of the inundation gradually subside, escaping through the channel of which it is the index. The waters seldom or never however fall so low as to attain their summer level; but the subsidence is sufficiently great to demonstrate clearly the prodigious extent to which the ice has been packed, and to show that over great occasional areas it has reached to the very bottom of the river. For it will immediately occur to every one, that when the mass rests on the bottom its height will not be diminished by the subsidence of the water, and that as this proceeds, the ice, according to the thickness which it has in various parts attained, will present various elevations after it has found a resting-place beneath, until just so much is left supported by the stream as is sufficient to permit its free escape. When the subsidence has attained its maximum, the trough of the St. Lawrence therefore exhibits a glacial landscape, undulating into hills and valleys that run in various directions, and while some of the principal mounds stand upon a base of 500 yards in length, by a hundred or two in breadth, they present a height of ten to fifteen feet above the level of those parts still supported on the water.

On the banks of the St. Lawrence, in the neighbourhood of Montreal, there is an immense collection of boulders, chiefly from rocks of igneous origin, and among them syenite greatly abounds. They are of all sizes, but many are very large, and multitudes must be tons in weight. From their appearance above the surface in shallow parts of the river it is very probable the bed of it teems with them also; and it is remarked by the inhabitants that the positions of these boulders, both in the river and on the banks, frequently appear changed after the removal of the ice in the spring. I spent several days in the autumn of last year examining the boulders along shore, all the way from Montreal to Lachine, a distance of nine miles; and on again looking at them in the spring I missed some which had particularly attracted my attention, but as I had not mapped their positions I may inadvertently have passed them over. But when we consider the manner in which the ice packs and subsequently moves, it cannot fail to appear a very probable agent in transporting these blocks. Closely jammed together down to the very bottom of the river over such extensive areas as have been mentioned, and there solidified by severe frosts around the projecting materials that present themselves to its grasp, the ice must seize a multitude of the loose boulders below; and not only will these be carried away, occasionally to very considerable distances, when it breaks up in the spring, but firmly set in their glacial matrix, they will, when in the course of the movements that occur, such masses as hold them are forced over shallow places, act as gravers to register in parallel grooves on the face of such rocks as they encounter, a memento of their progress as they pass along.

The boulders in the middle of the river may at once be occasionally carried to considerable distances; but it can scarcely be so with such as are stationed at or near the borders. For though these may become packed and imbedded in marginal ice, and by the force of a general movement or *shove*, as it is termed by the inhabitants, be driven obliquely up the bank, as soon as this ceases they will there be left; and as these general movements occur only three or four times during a season, and are never of long continuance, and even where the marginal ice is driven up the bank the friction it suffers soon causes succeeding portions to pile over one another, it is evident the boulders would not be carried by it to any very great distance. When a break-up occurs in the spring, it is the great body of ice in the middle of the river that is carried away, which, separating from the grounded portion on the margin, leaves this to be melted down by the increasing temperature of the season. The movements of succeeding winters may push marginal boulders farther and farther on, but they must at the same time have a tendency to carry all within a certain range gradually nearer to the bank, and at last place them in a position at the very limit of their influence. And it is certainly the case, that in the neighbourhood of Montreal there are in many places along the borders of the river collections of boulders sufficiently great to induce the supposition that their presence may be accounted for in this manner.

It is not however only on the immediate banks of the St. Lawrence that boulders abound. They are more or less spread over the whole island of Montreal, and over the plains on the opposite side of the river. I do not pretend to have ascertained their distribution with the precision necessary to permit the expression of an opinion as to the causes which placed them, but I may state that they appeared to me more abundant in the upper part of the island than in the lower, and that proceeding down the valley of the St. Lawrence they ceased altogether not many miles below the island in question: and it may be further remarked, that they did not seem of less weight at the limit of their range than elsewhere.

The country to a considerable distance on both banks of the St. Lawrence, from Montreal to Lake St. Peter and even to Quebec, is very level, and it is in general covered with a deep and highly levigated deposit of argillaceous, arenaceous and calcareous matter, the constituents of which vary in their proportions in different localities. This deposit rests upon a shallow trough of black shale and black and grey limestone, the fossils of which are palæozoic, and resemble those figured as belonging to the Lower Silurian rocks of Britain.

This trough is bounded on the N.W. side by a range of moderately elevated granitic and syenitic hills, which rise up without tilting or much disturbing the limestone, and follow the river all the way to Quebec; and from below the limestone on the S.E. there crops a hard quartzose conglomerate, succeeded by a formation of pyritiferous clay-slate, with a cleavage cutting the layers of deposit in a N.E. and S.W. direction, which is that of their general strike. The bounding rocks on both sides of the trough present a surface undulating into hill and dale, and those on the S.E. give rise to a picturesque country, very much resembling some of the slate counties of Wales. The plains between them covering the trough constitute the valley of the St. Lawrence, and may occupy a breadth of forty miles, and the nature of the material of which they are composed renders it impossible to conceive a region more fitted for the purposes of agriculture.

Between Montreal and Lake St. Peter, the plains on the south side of the river do not appear to attain the elevation they exhibit on the N.W. Occasionally so low, close by the margin of the stream on both sides, as to allow the formation of marshes, the banks in general present a height of twenty to thirty feet above the level of the water; but on the N.W. side, and ranging with the river, at a distance varying from one to six miles from the water's edge, there occurs a sudden upward step in the land of about 100 feet, forming an elevated terrace between this point and the granitic country already mentioned, which rises up in another step, and though undulating in the interior, has a general additional elevation of 200 to 300 feet.

The terrace at the foot of the granitic step has a very even surface over a great area, slightly modified in a few places by the protrusion of the underlying limestone through the soft deposit of which it is composed. It is chiefly, however, in the beds of the rivers which cross the plain in their course to the St. Lawrence that the limestone strata are visible; and some of these tributaries, dashing down the side of the granitic step, cut at once into the terrace below, very nearly to the level of the main stream, and winding through the deposit in question, show it to possess considerable depth. When any tributary has excavated so deep a passage, the banks are occasionally subject to landslips, sometimes of a very serious character, and having visited the scene of one on the banks of the Maskinongé, it appears to me worthy of particular notice.

The waters of the Maskinongé take their rise in a chain of mountains to the N.W., and passing through a series of small lakes, fall into one about nine miles in circumference bearing the same name. Issuing thence they flow through about twelve miles of country before they are precipitated in a beautiful cascade down the side of the granitic step on to the plain at its foot. Making a deep section into this, they wash bare the outcrop of some limestone strata, which exhibit a gentle dip of 3° to 4° southward; and from this point to the mouth of the tributary at the head of Lake St. Peter, there is very little fall, with the exception of a spot six miles below the cascade, where there is an accumulation of large boulders, evidently derived from the granite further up. At this spot a mill-dam across the stream occasions a fall of about fifteen feet, which with a very small addition will represent the whole amount of descent in the river from the granite hills to the lake receiving it, a distance of twelve miles.

The general course of the river is from N.W. to S.E., with, however, a few meanderings. Where the landslip occurred, about nine miles below the cascade, the stream is from ten to twenty yards wide. Flowing nearly south, it suddenly turns to the west, and running in that direction for about 700 yards, it again turns direct south. The valley in which it winds its way is of uniform breadth, the summit of the banks being about 200 yards apart. The banks, as may be inferred from what has been said, are about 120 feet high, and the landslip in question took place on the right bank, in the middle of the western turn mentioned.

On the 4th of April 1840, while the snows of winter were yet upon the ground, about eight o'clock in the morning, the inmates of the farm-houses on the spot were alarmed by the agitation of their wooden dwellings, and looking from the windows, became aware, from changes in the relative positions of the trees in the neighbourhood, that the ground on which they stood was in motion. They of course quitted their houses with precipitation and fled in great terror to rouse the country around, and the confusion and dread which the event occasioned while in progress disabled the population from making very accurate observations of the phænomena with which it was accompanied; but from an examination and survey of the spot after it had happened, and such accounts as I could collect, it would seem that a mass of the soft deposit, covering the solid rocks, about 200 yards wide and 700 yards long, but how deep is uncertain, slipped out of the bank endways towards the river. This was followed in quick succession, at intervals of a few minutes, by four others, occupying with the first an area of about eighty-four acres, of an irregular form, somewhat resembling the section of a long-necked flask, the whole length of which was 1300 yards, and the widest part, removed a considerable way back from the river, was 600. The contents of this huge trough, consisting of a marly clay, slipped out at the long narrow spout where the movement began, crossed the river, struck the opposite bank, and splitting into two parts, one-half proceeded up the stream about three quarters of a mile, the other an equal distance down, and thus completely blocked up the valley for half a league. The whole operation was completed in about three hours, and for a considerable time after it began the surface of great patches of the moving mass continued unbroken. More than half the amount was covered with fine sugar-maple trees, and these for the most part travelled in an erect position on the surface of the earthy deluge as it poured both ways through the valley; but occasionally a tree or two in different places would be prostrated, and a few, caught below, were crushed and engulfed. Two farmsteads were carried away, and though the people escaped, horses, cows and sheep were not so fortunate. Those remaining shut up in the stables perished with them, as the houses one after another were crushed and sunk in various places. But of the poultry, two hens, and also a cock that was heard to crow most lustily as the mansion in which he was cooped up sailed along, were found alive after the event.

The masses that blocked up the valley travelled with a height of about sixty feet, and while their surface was slightly culminated, the front of each terminated in a blunt point projecting in the middle and lower part. As these great double-acting ploughshares were propelled along, they turned up the soft mud from the bed of the river, casting it on the bank on each side; and the stench which arose during the operation, caused probably by the disengagement of sulphuretted hydrogen from the decaying vegetables displaced, was so utterly intolerable, that no one could approach the river to within 100 yards. Where the first mass struck the opposite bank the height it attained was seventy-five feet, and from this the culminating ridges gradually recurved until they gained a position in the middle of the valley, gradually lowering also until they reached the height of sixty feet, as above mentioned.

No sooner was the valley thus blocked up than the waters above the impediment began to rise. Houses, logs and planks, and indeed everything composed of wood, were set afloat for nine miles up, being as far as the granite hills. But it was two days before the lake thus formed attained a sufficient height to overtop the obstacle. The water first found an escape by the gully between the original bank on the left and the slope on the east side of the culminated impeding mass, making a slight detour where favoured by a depression through a wood round the point where the launch first struck the bank in question; and its erosive action thus put into operation was sufficient in the course of six months to carry away nearly the whole of the clay lodged in the valley. The quantity must have been several millions of tons; and in the month of October so much had been swept into Lake St. Peter, that the Maskinongé above the slip was then not more than ten feet beyond its ordinary depth.

Though the surface of the great area disturbed remained for some time unbroken after the general movement began, it gradually sunk as this continued, and at the period I saw the place, in the subsequent autumn, the bottom of the chasm was thirty feet below the level of the surrounding country, while about 400 yards from the river there was a sudden descent of fifteen feet more, from which the ground sloped gently to the water's edge. There was then very little of the original surface to be seen. Here and there was visible a small grass-covered patch, and occasionally there might be seen, still entire, twenty or thirty yards of the wooden fence used in the country for the divisions of property. But nearly the whole area exhibited the greatest confusion, being thrown up into a multitude of parallel clay hillocks, from three to four feet high. No doubt these mounds were occasioned by the pressure of mass against mass in the direction of motion, at right angles to which would be their greatest diameter. From the shape of the mounds, it appeared that the motion of the landslip must have been down the middle of the chasm towards the river, and from the sides to the centre.

A circumstance connected with the form of the area affected by the slip appears singular. The ground moved constituted part of the general plain of the neighbouring country; but on all sides of it, with the exception of the northern extremity, there was a depression in the surface, between which and the chasm produced, there remained after the slip a narrow ridge at the original height, forming a bounding rim to the cup which the chasm presented. The depression on the east side was formed by the slope of the right bank of the river and an offset or bay of lower land than the general plain of the country, and on the west by a dingle furnished with a brook. The rim was not many feet wide on the top, but its parallelism to the depression was remarkable, and it was only broken through in one place where a tributary dingle had joined the one on the west.

It would not be very difficult to prove that there is scarcely any other mode of satisfactorily accounting for the movement of this mass of land than its pressure on an inclined surface, assisted by the action of water on some bed below. The layers of the deposit itself appeared all perfectly horizontal: the slip therefore could not have been on one of them. But the dip of the underlying limestone, wherever I could detect its appearance for miles around, was precisely in the direction of the slip, with an inclination of about 4°; and although none of it was visible near the spot, I am persuaded it could not be very deep below the bottom of the river. It is highly probable that the surface of one of its beds presented the plain which gave occasion to the launch. Supposing any boulders to exist at the bottom of a deposit moved in the manner described, it is easy to see that parallel grooves and a polish on surfaces of rock may not in all cases be attributable to the agency of ice.

The age of the deposit constituting the extensive plains on the banks of the St. Lawrence is a question of great interest. Its marine origin is demonstrated by sixteen species of fossil shells collected by Captain Bayfield in the neighbourhood of Quebec, and described by Mr. Lyell (Geol. Trans. vol. vi. series 2), who appears inclined to consider them of the newer pliocene period, though he does not think the evidence sufficient to remove all doubt of a more modern date. Unable to add anything to the evidence in respect to age, the discovery in the neighbourhood of Montreal of four of the species mentioned by Mr. Lyell, at a higher elevation than that of the Quebec fossils, puts it in my power to extend the probable range of the deposit through Canada, and widen the boundaries of the ancient sea of which it was the bottom. The greatest height given for any of the Quebec fossils is 300 feet above the Gulf of St. Lawrence. But those of Montreal occur on the neighbouring mountain at an elevation of 430 feet by barometrical measurement above the river in the city harbour. This, as near as I have been able to ascertain, is about 460 feet above the Atlantic; and as the locality bears very much the character of a raised beach, it may possibly mark the ancient oceanic shore, and indicate the limit of elevation the land has experienced since the plains of Canada were raised from beneath the waters. This elevation is 240 feet above the level of Lake Ontario and seventy-five feet above the Falls of Niagara; but it falls short of Lake Erie by about 105 feet.

It is remarked by Mr. Lyell that the Quebec shells resemble those of Uddevalla in Sweden. Every one of the species found near Montreal has, I understand, a representative among those observed by Mr. Murchison and his companions in their late Russian investigations at Ust Vaga, at the mouth of the Vaga on the Dwina, about 250 miles from the White Sea and 130 feet above its level.

List of Fossil Shells from Montreal.

1. *Saxicava rugosa.* This is very abundant on the mountain near the town, to the north of the road to the Côte de Neiges. The locality is 430 feet above the St. Lawrence, and the fossils lie in a bed of coarse sand, which inclines conformably with the side of the hill, and has above it a layer of pebbles and small boulders. The shell occurs also, but not in abundance, above the village of St. Henry, on the road to Lachine. Here the fossils are at the top of the deposit which forms an elevated terrace along the bank of the St. Lawrence, about 120 feet above the river. Another locality is on Logan's farm on the same terrace.

2. *Tellina Groenlandica.* This shell is in great abundance at the St. Henry locality. It occurs in smaller quantity on Logan's farm and on the mountain.

3. *Tellina calcaria.* Only one valve of this was picked up in the mountain locality.

4. *Mya truncata.* Several hinges of this were found at the St. Henry locality.

5. *Mytilus* —— ? Only a broken piece of a valve was found on the mountain.

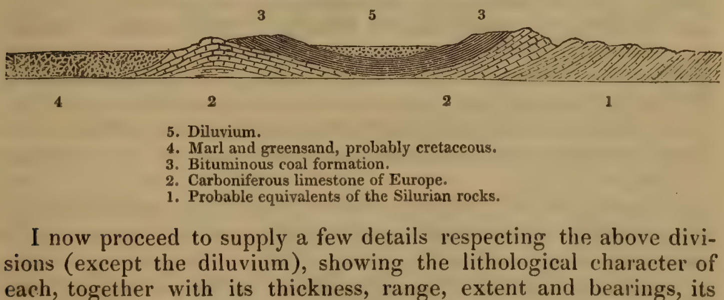
2. *On the Geology of the* Western States *of* North America. By David Dale Owen, M.D., of Indiana, U.S.*

[Communicated by Mr. Lyell.—Read November 2, 1842.]

Plate XIX.

The remarks here submitted will be confined chiefly to that part of the Western States of North America watered by the rivers Ohio, Wabash, Illinois, Rock, Wisconsin, Cumberland and Tennessee, lying between the 35th and 43rd degree of N. latitude and the 81st and 91st of W. longitude. The district includes the states of Illinois, Indiana, Ohio, Kentucky, Tennessee, and the Du Buque and Mineral Point districts of Iowa and Wisconsin. This territory occupies an area of about half a million of square miles, but its geological features are remarkably uniform, belonging, with a few partial exceptions, to the periods of the bituminous coal and carboniferous limestone as found in Europe, and the Silurian rocks as described by Sir R. Murchison; the exceptions are the superficial deposits which occasionally cover up these from view over considerable tracts, and these must either be referred to the age of gigantic mammalia and formations of a much newer date, or belong to a marl and greensand found in the western district of Tennessee, probably a portion of the greensand and other members of the cretaceous group. A general idea of the geological formations of the whole tract may be obtained from the annexed diagram.

General Section across the Western States.



5. Diluvium.
4. Marl and greensand, probably cretaceous.
3. Bituminous coal formation.
2. Carboniferous limestone of Europe.
1. Probable equivalents of the Silurian rocks.

I now proceed to supply a few details respecting the above divisions (except the diluvium), showing the lithological character of each, together with its thickness, range, extent and bearings, its organic remains, geological equivalents and mineral contents.

The formations west of the Tennessee river occupy but a small corner of the tract under consideration, and may be dismissed with a few brief remarks, and the more so since I have had but limited opportunities of examining them in person.

* An abstract of this paper was given in the Proceedings of the Geological Society, vol. iv. p. 1. The greater part of the memoir is now printed from the author's MS. and accompanied by his Map (Plate XIX.), in order satisfactorily to establish the claim of Dr. Owen to be considered the original discoverer of many important points in the geology of the North-Western States of North America.

The upper members of this group consist of an argillaceous marl of a light grey colour, and the lower of a greenish sandy marl, very dark-coloured when wet, but of a light green-tinted grey when dry. Its thickness has not yet been ascertained, but Dr. Troost, in his Third Report to the Tennessee Legislature, states that it has been excavated in search of water to a depth of eighty feet without penetrating through it. In no instance, I believe, has either the greensand or marl been discovered east of the Tennessee river, but it exists, according to Troost, under the superficial soil, in most of the counties west of that river, extending probably west and south into the states of Mississippi and Alabama. On the west side of the Mississippi river this formation sweeps off in a west course across the northern tributaries of the Arkansas river*.

Both the marl and greensand are rich in fossils. The most characteristic and most common shells of the marl are species of *Exogyra*. One of these is a large species, *E. costata* of Say, and there is another from near Washington in Arkansas, a different species, but doubtless from the same formation. Other fossils giving character to this formation are, *Ostrea vesicularis*, Brongt., *Ostrea sandalina*, Goldf., *Ostrea* resembling *O. falcata* of Morton, *Gryphæa convexa*, Say. *Exogyra costata*, *Ostrea sandalina* and *Gryphæa convexa* are common to the marl and greensand. Besides these, there occur in the latter stratum, *Ostrea acutirostris*, Nils., *Ostrea flabellula*, Lam., *Ostrea lateralis*, Nils., *Ostrea larva*, Lam.; a *Crassatella*; a *Natica*, species undetermined; *Delphinula*?; a *Rostellaria* with long spinous processes, found by myself in McNairy county, West Tennessee, and described by Troost under the name of *R. macrodactyla*; two species of *Dentalium*; a *Hamite* found by myself in the greensand in McNairy county and described by Troost as *H. Verneuili*; *Hamites Leai*, Troost; *Baculites*, species undetermined. No minerals have, I believe, been observed in the beds of marl and greensand; but on the west bank of the Tennessee river I examined an arenaceous deposit, which Troost considered as immediately overlying these strata; and it contained, besides exogenous trees converted into flint, lignite, pyrites and retinasphalt.

Two distinct and very extensive coal-formations are included in the territory I am describing, as may be seen by reference to the map†.

That on the west is the Great Illinois Coal-field, laid down and defined in my Report on Iowa, Wisconsin and Northern Illinois. It equals in area the entire island of Great Britain, extending from S.E. to N.W., from the waters of Oil Creek and Rome on the Ohio river to the mouth of Rock river on the Mississippi, a distance of 300 miles; from south to north, from the waters of Green River and Tradewater in Kentucky to the waters of Little Vermilion in

* See Map, Pl. XIX., where the marl is inserted on Dr. Troost's authority.

† These coal-fields have since been described at length, and with reference to the other American deposits of the same kind, by Mr. Lyell, in his recent work on America.

La Salle county, Illinois, a distance of 325 miles; and from S.W. to N.E., from St. Louis and the waters of the west branch of Saline river in Gallatin county, Illinois, to the forks of Fox river and Kankakee river, a distance of 250 miles. This gigantic coal-field occupies the greater part of Illinois, about one-third of Indiana, a north-western strip of Kentucky, and extends a short distance into Iowa. Its boundaries have been satisfactorily ascertained, except a small segment in the Burlington district of Iowa, which I have not yet personally explored. That portion of the outline of this and other formations which I do not consider fully determined is dotted on the map. The coal-field is covered in many places in the north by extensive diluvial deposits, sometimes to the depth of more than 100 feet.

The other coal-field of which I have spoken forms a part of at least six states, viz. Ohio, Kentucky, Tennessee, Pennsylvania, Maryland and Alabama; but that portion of it embraced in the three former is alone represented on the map, stretching along its eastern portion. The geologist of Ohio, on whose authority its boundaries in Ohio and Kentucky are there given, estimates its area at 50,000 square miles. The eastern confines of this coal-field in Tennessee are defined on the map, but it is to be remarked, that further north it extends to the eastward beyond the limits of the map, and also for a very short distance south of Tennessee into Alabama. Dr. Troost, according to whom its boundaries in Tennessee are given, remarks, in his Third Annual Report, that the localities in which we may expect to find coal in that state, belong exclusively to the Cumberland range of mountains. These coal-formations consist, as in Europe, of sandstones, shales, slaty clays, seams of coal, and occasionally beds of limestone, the latter usually dark-coloured and bituminous.

At the base of the Ohio formation is a conglomerate from 200 to 300 feet in thickness, which has been referred to the millstone grit of England. A similar conglomerate shows itself in one or two localities at the base of the Illinois coal-field, but in general it is not present as a conglomerate.

The thickness of these coal-fields is estimated at from 1200 to 2000 feet. The Ohio geologists report at least seven workable seams of coal, besides ten or twelve minor beds; and the Illinois field is supposed to include also seven workable seams. All the coal is of a bituminous character; some of the caking variety, some splint coal, some cannel. The upper seams appear to be thinner than the lower, and inferior to them in quality. In some of the upper seams in Indiana I have observed the woody structure displayed so very distinctly, that I succeeded in separating its fibres, as one might in charcoal.

Neither of these coal-fields has suffered much from dislocation. No dikes of trap, whinstone, basalt or greenstone have met my observation in the Illinois coal-basin; nor do the Ohio geologists make mention of any such in their state. On the eastern flank, however, of the Cumberland mountains, the coal is occasionally much disturbed, and is even thrown up nearly vertically, but the strata generally dip at gentle angles towards the centre of the respective basins. The dip, by observation, at Zanesville, Ohio, is E.S.E., at the rate of thirty-five to forty feet per mile.

With the exception of slight shades of specific difference, there is a striking analogy between the fossil flora of our western coal-fields and that of the equivalent strata in Europe. The organic remains are chiefly of vegetable origin; and in the sandstones, shales and slaty clays, almost exclusively so. They consist of *Calamites*, very abundant; numerous species of *Sphenopteris*, *Pecopteris*, *Neuropteris* and *Sigillaria*. Specimens of *Lepidodendron* and *Stigmaria* are abundant, and beautifully preserved. Some species of *Bothrodendron* also occur. *Palms* are not uncommon, and some remains of *Coniferæ* (?) have been found. I have also obtained remarkable specimens of the stumps of fossil trees (probably palms), found standing erect with the roots attached, imbedded in slaty clay about twelve miles east of New Harmony; and slender leaves have been found in great abundance in the near vicinity of the stumps imbedded in the clay. On the whole, it appears that the resemblance, both in lithological character and organic remains, between our western coal-fields and those of Europe, is close and striking. If not precisely contemporaneous, they may still be considered equivalent.

Important beds of argillaceous iron ore have been discovered both in the Ohio and Illinois coal-fields, but few furnaces are yet in operation. The ore of these coal-fields must however ultimately prove an important source of income to our States. 300 feet above the conglomerate a valuable bed of burr-stone exists, from two to six feet thick. It is reported as being equal, at some of the quarries where it is wrought, to the French burr-stone.

The most productive brines discovered in the Western States have been procured by boring through the lower members of our coal-measures. This is the position of the salt-wells on the Muskingum in Ohio, on the Kenawha and Guyandot in Virginia, on Sandy river and the headwaters of the Licking and Kentucky rivers in Kentucky, on the waters of the Patoka and Coal Creek in Indiana, and on Saline and Vermilion rivers in Illinois.

Immediately beneath the coal-formations of Indiana, Illinois, Kentucky and Tennessee, are limestones, mostly of a light grey colour and of a compact texture, including occasionally layers and nodules of chert. Some of these limestones assume the appearance of lithographic limestones. The upper beds very frequently have a beautiful oolitic structure*. The thickness of this calcareous group varies at different localities, being thickest towards the south and thinning out towards the north. On the northern margin of the Illinois coal-field it is so thin and so hidden from view by superficial deposits that it is difficult to detect it; but on the southern, south-

* Dr. Troost noticed on the Maramec river in Missouri, the oolitic particles of equivalent beds entirely changed into silex, forming a siliceous oolite.

western and south-eastern terminations of this basin it is well-developed, being from 200 to 300 feet in thickness. On the western slope of the Cumberland mountains in Tennessee, Dr. Troost found it generally about 200 feet thick.

In Ohio these limestones do not appear to exist, at least they have not yet been detected, and the conglomerate before-mentioned occupies their place. The most extensive caves and subterraneous passages in this country are in these limestones: the 'Mammoth Cave' in Kentucky, which has been penetrated to the distance of six miles, is situated in the upper beds of this limestone. Lost River in Orange county, Indiana, disappears from the surface for many miles, and flows through subterraneous passages in the same rocks, and so also do several streams in Kentucky in the vicinity of the Mammoth Cave.

The upper beds of the rocks under consideration are characterized by two very remarkable fossils, the *Pentremite* and the *Archimedes*. Four species, at least, of *Pentremites* have been observed in the oolitic beds: *P. pyriformis*?*, Say; *P. globosa*, Say; *P. florialis*, Say; and *P. ovalis*, Goldf. From the abundance of these fossils, I have been accustomed to designate this group of rocks by the name of Pentremital limestones. The *Archimedes*†, Lesueur, occurs in a bed of limestone of a reddish-yellow cast, the uppermost bed of the series, and the one on which the lowest members of the coal-measures rest. The same stratum often contains Pentremites. The oolitic stratum lies immediately beneath. No workable seam of coal has hitherto been found beneath the beds containing these fossils: they become therefore a trustworthy guide in determining the limits of our coal-formations.

Stylina Peroni, Lesueur, and another species of *Stylina* are also characteristic of these rocks. *Syringopora* (*ramulosa*?), Goldf., is not uncommon in Tennessee and Missouri. I have also obtained a fossil from Terry county, Indiana, having the general aspect of a Trilobite, yet not divided into three lobes. *Bellerophon hiulcus* is considered by Dr. Troost as a characteristic fossil, and near Eddyville in Kentucky he found specimens between five and six inches in length. There is also a coralline different from any I have seen described in Goldfuss or elsewhere, having large and distinct cells of a truncated cup-shape, and disposed in alternating lines. I have named it *Cyathopora Iowensis*: it was obtained in a rock in Iowa, probably a member of this group.

It has been asserted that no Trilobites occur in these limestones;

* This Pentremite differs a little from the drawing of *P. pyriformis* which I have seen; it is more angular or pointed where the interscapula joins the ambulacrum, and the striæ of the ambulacrum run slanting from above downwards, from the central furrow towards the interscapulæ, instead of from below upwards.

† I am not sure that Lesueur ever published his description of this fossil, but I know that while he resided here (at New Harmony) he engraved a plate containing several views of it with that intention. He considers it, I believe, a new genus, but it may be only a new species of *Retepora*; if so, it would be most aptly entitled *Retepora Archimedes*.

but I have found (besides the one above alluded to) several individuals of a small species of *Calymene*. *Productæ* and *Terebratulæ* are abundant in these rocks. It appears therefore from this comparison of the fossils, that these limestones are the equivalent of the carboniferous limestone of Europe.

At the junction of the coal-measures and these limestones occur valuable deposits of iron ore. In many localities in Indiana I have discovered extensive deposits of hydrated brown oxide of iron in this geological position; and Dr. Hildreth describes, in the American Journal of Science for October 1835, a "Great Ferruginous Deposit" bordering south-westerly and northerly on the main coal-measures of Ohio.

Some of the best building-stones in Indiana are from quarries in these limestones. Most of the beds afford lime almost as white as magnesia, forming a striking contrast to that made from limestones of the coal-measures, which is usually of a dark brown colour.

In the southern part of Illinois, thirty or forty miles west of Shawneetown, these limestones are traversed by small veins of galena, associated with fluate of lime and sulphate of barytes. This lead ore has been explored to some extent, but the quantity hitherto obtained has not proved sufficient to render mining in this vicinity profitable. Many have been induced to work this lead ore, on the supposition that it contains a large per-centage of silver, but the specimens that I have been able to obtain and analyse have not yielded more than one per cent. of that metal. By far the finest specimens of fluor spar in these Western States have also been obtained in this locality; some of it crystallized in cubes, the prevailing form, and some of it compact. On a branch of Grand Pierre Creek I noticed a vein of compact fluor spar eighteen inches thick, running across the bed of that stream in a north-easterly course.

On the west slope of the Cumberland mountains the geologist of Tennessee discovered in the bed of a small stream (Calf-killer Creek) a specimen of sulphuret of silver penetrated by crystallized fluate of lime; and another person obtained, near the same spot, a small fragment of sulphuret of silver in combination with sulphuret of lead.

Dr. Troost does not decide where these ores have originated, not having noticed metallic veins in rocks of this vicinity. But as the above stream flows over limestones belonging to the group under consideration, and since these are traversed in Illinois, as we have seen, by veins of galena and fluor spar, I conclude that these minerals may have originated in this limestone formation. I believe no rocks of a similar nature and age have been observed in the Atlantic States.

The rocks which succeed to the Pentremital limestones are those coloured yellow on the map. Their lithological character is usually that of grey or yellow and brown sandstone; soft, fine-grained and siliceous; sometimes argillaceous and free from mica. These sandstones pass, on the one hand, into chert and hornstone, and on the other, into a rock possessing the appearance of tripoli. Interstratified with these argillo-siliceous deposits are beds of limestone, seldom however extending uninterruptedly over any considerable area. Some of these are occasionally oolitic, and the lower part of the series is more argillaceous than the upper, passing in some places into a slaty clay. The range, extent and bearings of the rocks in question may be seen by reference to the map, and their position beneath the Pentremital limestones is shown on the section. To the N.W. this rock runs out, at least I was not able to detect it in Iowa and Wisconsin. To the east and south it is chiefly developed, being 150 to 300 and even 400 feet thick.

As a whole, this group is not rich in organic remains. Crinoidea, Corals and Productæ are the most common. One species of *Producta* occurs in the upper beds, and others some 50 or 100 feet lower in the series. The *Gorgonia* is a fossil very characteristic of the middle beds, and a large *Delthyris* belongs to them. Remains of Dicotyledonous plants have also been found in them.

In Tennessee Dr. Troost has found in this group of rocks *Gorgonia antiqua*, Goldf., a *Pinna* (species undetermined), a *Terebratula* (species undetermined), and hexagonal plates of Echini. A *Leptæna* occurs about 100 feet above the base of this group.

The interstratified limestones in Tennessee are often rich in Crinoidea, and in comminuted remains of *Gorgonia*, *Retepora*, *Ceriopora* and *Eschara*. So few and ill-defined are the fossils of this group, where I have had an opportunity of studying them with attention and making collections, that it becomes difficult for me to pronounce with confidence on its European equivalents. From the occurrence of several species of *Producta* in the upper 100 feet, and their absence in the lower beds, it is not improbable that they ought to be designated as two distinct groups. Mr. J. Hall of New York has referred the upper 100 feet to the Old Red or Devonian system, but no satisfactory evidence has been brought in proof of this reference. No vestiges of *Holoptychius* or *Cephalaspis*, or other fossil fish, have, to my knowledge, been found in it.

In the absence of such palæontological evidence, and on account of its resemblance in lithological character to the underlying strata, and the almost imperceptible blending of the adjacent strata, I have not for the present thought it advisable to separate them. The middle and lower beds of this group are probably the equivalents of the Upper Ludlow rocks of Murchison's 'Silurian System.'

The Portage, Chemung and Ithica sandstones of the state of New York have been referred to this group, and the colossal deposits of hydrated brown oxide of iron, so extensively wrought in Tennessee, are associated with the same rocks. In Tennessee this series usually rests on Encrinital limestone (the uppermost bed of the succeeding group). It is above this limestone, and amongst the overlying siliceous deposits, which usually then assume the nature of chert, that the above-mentioned iron ore has been discovered imbedded in a tenacious clay. The same order of things exists in Jefferson county, Kentucky, and in the base of the Knobs of Floyd county, Indiana, where beds of conglomerate iron ore occur in slaty clay. Small quantities of gypsum have been found in nests, in fine greenish-grey sandstones, about 150 or 200 feet from the base of this formation.

Borings have been made in these rocks, both in Indiana and Ohio, in search of salt water, and brines have been procured, but they are weak, and have not been able to compete with those situated in the coal-measures.

Proceeding in the descending order, we now arrive at the bituminous, aluminous shale and associated limestones. This group consists chiefly of a dark-coloured, schistose, argillaceous deposit, closely resembling the shale of the coal-measures, though somewhat more compact. Beneath it in Indiana and Kentucky are subordinate beds of limestone a few feet in thickness. The lowest of these, as it appears in the bed of the Louisville canal, is argillaceous, and affords a valuable water-cement. Above it, in Floyd county, Indiana, are about two feet of a green ferruginous limestone, of high specific gravity. In the same position, in many places in Tennessee, we find a limestone, which, from its being often remarkably rich in Crinoidea, has been described by Troost under the name of Encrinital limestone. The range and extent of this group are shown on the map, and its geological position is indicated in the diagram. It crops out at the base of the conical-shaped range of hills known in Indiana and Kentucky as the "Knobs." In the base of the hills of the iron region of Middle Tennessee, it is seen both on the northern and on the southern declivity.

To the east, in Ohio, the thickness of the bituminous shale is greatest, and amounts to from 250 to 300 feet*. In Indiana it is upwards of 100 feet. To the south the bed becomes thinner, in Tennessee seldom exceeding twenty or thirty feet, and in some localities is not more than eight or nine feet†. Occasionally in Tennessee this shale is replaced by indurated slaty clay. To the west it runs out, and in Iowa no vestige of it could be discovered.

At no locality, either in Indiana, Illinois, Kentucky or Tennessee, have I ever been able to discover any organic remains in the shale, except some slight impressions apparently of seeds or seed-vessels. Neither have the geologists of Ohio there discovered in this deposit any well-defined fossils. Where the shale is replaced by indurated clay in Tennessee, Dr. Troost says he has found Encrinites and Corals, and also *Orbulites lenticulata*, Lam., and *Favosites spongites*‡. The Encrinital limestone over the shale in Tennessee is rich in fossils, often a mass of agglutinated Crinoidea. Troost enumerates fifteen distinct species. Associated with these are *Spirifer cuspidatus* (?), *S. attenuatus*, and several species of *Gorgonia*, *Flustra* and *Turbinolia*.

The most characteristic fossils of the water-limestone are *Atrypa prisca*, *Orthis lunata* vel *orbicularis*, *Leptæna lata* (?), *Terebra sinuosa*, *Tentaculites* (new species?), *Avicula reticulata* (?), *Calymene bufo*, *Asaphus micrurus*, and several other species undetermined;

* See Report of Ohio Geologists for 1838, p. 105.
† See Troost's Fifth Annual Report, pp. 16 and 17.
‡ *Ibid.* p. 17.

Eschara, species undetermined; *Goniatites*, and one or two other species; also some undetermined species of *Delthyris*.

In the eight feet of limestone situated between the water-limestone and shale, Dr. Clapp informs me he has found *Atrypa prisca*, several Crinoidea, *Favosites Gothlandica* (?), and a small peculiar variety of *Favosites polymorpha*. Dr. Clapp, residing at the Falls of the Ohio, and having had an excellent opportunity of studying these and the adjacent rocks in detail, considers the water-limestone as the equivalent of the Lower Ludlow rocks of Murchison, and also of the Helderberg group (not the Onondaga salt group) of the New York geologists.

The shale must probably be referred also to the Lower Ludlow, and the New York equivalent is the Marcellus shale. The Encrinital limestones of Tennessee and the green ferruginous rock of Indiana may correspond with the Aymestry limestone, but of this I am not certain.

The shale sometimes contains small veins of solid bitumen and imperfect seams of coal, but no coal of any value has ever been discovered associated with it. Pyrites is a very common mineral in these strata. Calcareous nodules also abound in the shale in many localities, often assuming the form of Septaria, which have been mistaken for fossil turtles.

Next in order we reach a highly interesting group of rocks. It consists almost wholly of compact limestones, lying in thick beds without any interstratified marls or shale, and, for this reason, frequently forming cliffs and falls. This bed passes on the Tennessee river, and at some localities in Ohio, into marly or easily disintegrating argillaceous limestones. Where it assumes this character in Tennessee, it forms a series of low and sterile hills, known by the name of "glades." These glades or bald knobs, rising from the midst of the dense forest, have a remarkable appearance.

Siliceous layers and nodules of chert and hornstone are common in this formation, and are often disposed in beds alternating with the limestone, much in the same manner as flints in chalk. The upper beds occasionally become, over a limited area, entirely siliceous. Where the surface has suffered from denudation, such spots, more durable than the surrounding material, rise in the form of irregular and truncated cones above the general face of the country, and obtain, as being the most conspicuous objects in the north-western landscape, the name of "Mounds." The area of this formation is very extensive, as may be seen by reference to the map. It should be remarked, however, that near Lake Erie and Lake Michigan it is covered for a considerable tract with extensive diluvial deposits, so that it seldom emerges to the surface.

This rock is best developed towards the N.W. In the Du Buque and Mineral Point districts of Iowa and Wisconsin it is the prevailing formation, and becomes a true magnesian limestone upwards of 500 feet in thickness. An extract from my Report made in 1840 to the General Government will show how closely this magnesian limestone, as it appears in that region, resembles, both in lithological character, mineral contents, and even proximity to the coal-measures, the "Scar limestone" of England; and how readily, were it not for the guide furnished by organic remains, it might be mistaken for its equivalent.

The thickness of these limestone beds is various: in the southern part of Ohio it is seldom more than 80 or 100 feet; in the southern part of Indiana it is from 150 to 200 feet; while in Iowa and Wisconsin, as we have seen, it is upwards of 500 feet. It attenuates towards the south; so thin, indeed, and altered in its appearance is this rock in Middle Tennessee, that were it not for the test furnished by organic remains, it would be difficult to recognise it at all. Dr. Troost has included this and the succeeding group in one; but the difference in lithological character and mineral contents, where they are well-developed, fully warrants a separation.

Though not uniformly rich in organic remains, many of the beds of the group in question are highly fossiliferous. The *Catenipora escharoides* is very abundant in its upper beds in Iowa, and so are *Pentamerus huspodus* and *P. oblongus* (?)*.

Next in importance and character are *Aulopora tubæformis* (?)†, Goldf., *Sarcinula organum*, Lam., *Favosites Gothlandica* (?), Goldf., *F. basaltica*, Goldf., *F. spongites*, Goldf., *F. fibrosa*, Goldf., *F. polymorpha,* Goldf., besides some undetermined species, perhaps new;—*Syringopora verticillata*, Goldf., *Cyathophyllum vermiculare* (?), Goldf., *C. turbinatum*, Goldf., *Strombodes astroides*, nobis, *Lunulites dactylioides*, nobis, *Astrea*, *Lingula*, *Orthoceratites*, *Conitites*, *Delphinula* (?).

Many beautiful and characteristic fossils of this group have been found at the Falls of the Ohio near Louisville, where some of its members form the bed of the stream. In the uppermost stratum, the one on which the water-limestone of the previous group rests (designated by Dr. Clapp as the "shell-stratum"), have been found *Strophomena euglypha*, *Cardium alæformis*, *Atrypa prisca* (the same species as occurs in the superincumbent water-limestone); a *Delthyris* with a very wide cardinal area; *D. gregaria*, Clapp, very abundant and characteristic, besides several other species; *Bellerophon* (species undetermined); a *Pentremite*, very different in form from any of the species found in the Pentremital limestone; *Favosites hemisphærica*, Troost; *Gorgonia*, *Retepora* ‡, and *Fenestella* (?). The stratum in which these fossils occur is, according to Clapp, sixteen feet thick.

Beneath it, in the 'Coralline strata' of Clapp, whose thickness is twenty feet, the fossils are mostly corals: viz. five or six species of *Favosites*, *Cyathophyllum gigas*, Clapp (some individuals two feet

* The fossils of this group are more apt than those of any other to occur in the form of casts.

† The difference I can perceive between this and the *Aulopora tubæformis* is, that the terminal orifice in the Iowa fossil is obscurely star-shaped, while that of the above coralline is not.

‡ This *Retepora* resembles the *R. fenestrata*, but is very much larger and the pores are more numerous. I have named it *Retepora Indianensis*.

long), *C. vermiculare*, and other undetermined species; *Stromatopora* and *Syringopora*; shells are rare in this stratum; and several Trilobites, including *Calymene bufo* and two or three undetermined species of *Calymene* and *Asaphus*.

These coralline strata rest on the 'Catenipora strata' of Clapp, characterized by *Catenipora escharoides*, and many of the other Iowa fossils already enumerated; also *Calymene senaria*, Conrad.

These rocks are best seen at Utica and Charleston landing, Clarke county, Indiana, the upper part only being visible on the Falls.

In the lower 100 feet of this group in Indiana there are not many fossils; the only one worthy of note is a coralline resembling a *Favosites*, but having star-shaped cells; it is known by the name of *Astræa favosites*.

The above list of organic remains supplies proof hardly contestable, that the rocks in which they occur are the equivalents of the "Wenlock formation" of Murchison, some of the Eifel rocks in Germany, those of Drummond Island, Lake Huron, and the Lockport, Niagara, and perhaps some of the Helderberg limestones of the state of New York.

The rich and important lead-mines of Iowa and Wisconsin occur in the lower 300 feet of the group I am now describing; they have yielded more lead than any other formation in the United States, and may be considered hardly second in productive capability to the lead regions of northern England. (See Report, *antè cit.* p. 37.)

The lead ore is remarkably free from adhering rock or spar, and is chiefly a very pure sulphuret; but the compact carbonate is not uncommon, and accompanying them are both sulphuret and carbonate of zinc in great abundance, and a very rich hydrated di-carbonate and sulphuret of copper, yielding by analysis from twenty-five to forty per cent. of pure copper.

The principal vein-stone of these mines is calcareous spar, while at a few localities sulphate of barytes also occurs. The ore occurs in fissures traversing the rock from east to west, rarely from north to south.

The most characteristic fossil of the true lead-bearing strata is the *Coscinopora*. The species from Iowa previously enumerated lie about 200 feet above the richest lead veins.

Hydrated brown oxide of iron is abundant in some localities in the upper 100 feet of the Iowa formation.

Some of the beds of magnesian limestones of Iowa will yield one of the most durable building-stones in the West: they are objectionable only on account of their hardness; but this is in a measure compensated by the great regularity of the blocks as they come out of the quarry.

Next in order follow the thin beds of shell limestone, alternating with marl and marlstone: these are the lowest rocks visible west of the Cumberland mountains and south of the Mekoqueta river in Iowa.

This shell limestone is usually of different shades of bluish grey; it rings when struck with a hammer, its fracture is conchoidal, and its structure is sometimes granular, but oftener of a subcrystalline aspect. It occurs in layers from half an inch to two feet thick, interposed between beds of marl more or less indurated, the relative proportion of rock and marl varying considerably at different localities.

The thickness of this group is greatest about the centre of the Ohio valley, where it is estimated at 1000 feet. In the N.W., at Prairie du Chien, it is but 100 feet, and near the Blue Mounds in Wisconsin only a few feet in thickness.

By referring to the map, it will be observed that two principal anticlinal axes bring this formation to view in the valley of the Ohio.

Cincinnati in the state of Ohio may be considered the centre of one of these axes, and Nashville, in Tennessee, of the other.

Visible (according to Troost) in some places in the Sequachee valley, between two spurs of the Cumberland Mountains, in Tennessee, it appears again at the base of the Caney Fork ridge, west of this range, and occupies the surface in Davidson county, Tennessee. Passing thence beneath superior rocks on the west side of the Cumberland river, it reappears in a N.E. direction in Fayette county, Kentucky, where it again occupies the surface for about 100 miles in a northern course, and is once more lost beneath overlying rocks near the national road both in Ohio and Indiana, not showing itself again on the surface for 300 miles. At Eagle Point, a few miles above Du Buque, on the Upper Mississippi, is the locality where it first emerges above the waters of that stream.

The superficial area occupied by the blue fossiliferous limestones and marls, at their principal outcrop, is about 10,000 square miles.

Strata of limestone, supposed by Dr. Troost to be the lowest members of the group in question, are seen, in some places, even east of the Cumberland range, resting unconformably on the upturned edges of the inferior stratified rocks of the valley of East Tennessee. But though this group emerges to the surface only over a limited area, there is every reason to believe that it is coextensive with the whole mass of superincumbent strata, for whereever the streams have cut sufficiently deep, or an axis of elevation has been sufficiently powerful, some members of the blue fossiliferous limestone come to light.

No rock can be more fossiliferous than this shell limestone: whole slabs of it may frequently be seen covered with fossil shells and corallines so closely set, that one cannot place the end of the little finger on a spot without touching some of these organic remains. It has yielded to the palæontologist more prolific subjects for contemplation and research than any other group of western rocks, and has enriched our cabinets with numerous interesting specimens of the marine inhabitants of our globe at almost the earliest period to which animal remains have been traced.

Some of the most remarkable and abundant of these are the *Isotelus gigas* and *Triarthrus Bechi*, which have been found, I believe, in the lower seventy-five or eighty feet of this group, sixty feet of which are below high water of the Ohio river at Cincinnati. The rest occur in the upper beds in the hills about Cincinnati and its vicinity.

One of the most remarkable fossils found in this formation in Iowa is a multilocular shell four feet in length, now in my collection, supposed to belong to the genus *Actinoceras* of Bronn.

It would exceed the limits of this paper to enumerate all the organic remains which have been found in the blue limestones and marls; but in addition to those already adverted to, the following must not be omitted, since they may be considered peculiar, and give character to this group: *Conotubularia Cuvieri*, *C. Goldfussi*, Troost, *C. Brongniarti*, Troost; *Bellerophon* (*acutus*?), *B. Nashvillensis*, Troost; *Maclurites magna*, Lesueur, and another species of *Maclurites* *; *Turbo bicarinatus*, Troost, *Isotelus planus*, *Cyathophyllum ceratites* (?); a *Favosites*, species undetermined; *Lingula Lewisi*, *Orthis excentricum*, *O. alternata* (?), *O. alatus*, Sowerby.

There is one circumstance connected with the palæontology of these rocks that deserves particular note; it is the occurrence in them of fossils belonging to the genus *Asterias*. The *Asterias antiqua* was found by Troost in the limestones of Middle Tennessee (members of this group), an account of which was published in the Transactions of the Geological Society of Pennsylvania for 1835, vol. ii. p. 232.

Besides this individual, Troost found five other species belonging to the same genus, all in rocks below the coal-measures. I have a fossil, somewhat imperfect, which appears to belong to the family, though I am not certain of its exact geological position, for I did not find it *in situ*. I have little doubt however, from the locality in which it was found, that it belongs to rocks below the coal-measures; so that it appears that this family existed before the deposition of our coal-measures and during the formation of the oldest rocks of the valley of the Ohio, forming a remarkable exception to observations hitherto made on European rocks, where, I believe, no fossils of the kind have been found in strata older than the Muschelkalk †.

These fundamental rocks of the Ohio valley I consider the equivalents of the Lower Silurian rocks of Murchison, the lower beds, for a thickness of from 75 to 100 feet, corresponding probably with the Llandeilo flags, and the rest with the Caradoc sandstone; while the corresponding formations of New York appear to be the Trenton limestones and shale, representing the former or older series, and the Salmon river and Pulaski sandstones and shale the latter.

The blue fossiliferous limestone is but little metalliferous. The

* I am not certain that this species occurs in the blue limestone; the genus *Maclurites* is found also, and more abundantly, in the upper beds of the inferior stratified rocks beneath this group, and is considered one of the most ancient shells of our formations, since few, if any, fossils occur beneath the strata containing it. The *Maclurites* is not multilocular.

† [Since the period when this paper was written, true starfishes of various kinds have been found in palæozoic rocks even so low down as the Silurian series.—Ed.]

rich veins of galena which traverse the thick beds of superincumbent magnesian limestones seem to shrink to insignificance when they reach the thin layers of shell limestone, and they have not hitherto, either in Iowa, Kentucky or Tennessee, been considered worth exploring.

In Dearborn county, Indiana, I noticed, in this formation, hydrated brown oxide of iron in considerable masses; almost the only instance that came under my eye, and how extensive I had not opportunity to ascertain.

Dr. Troost informs us that he observed in these rocks, in the vicinity of Nashville, veins of compact and crystallized sulphate of barytes, a beautiful blue sulphate of strontian, together with sulphate of lime.

Some of the beds afford a marble of considerable beauty, presenting sections and markings of organic remains.

Where these limestones and marls prevail, the soil is rich and productive, furnishing luxuriant pastures. The beautiful farms of Bourbon and Fayette counties, Kentucky, spoken of as the "Garden of the West," are based on this formation.

No inferior rocks are visible in a N.W. direction until the vicinity of the Wisconsin river; there the blue fossiliferous limestone is found resting conformably on a sandstone, sometimes of a deep red and sometimes of a white colour, and resembling loaf-sugar. Beneath this succeeds a magnesian limestone so like the lead-bearing rock, both in external appearance and chemical composition, as not to be distinguishable in hand specimens*; it alternates with and rests on sandstones similar to those above it.

The position of these rocks, in connexion with the previously described strata, is exhibited on the northern part of the map.

As I have never found any fossils in these sandstones, and only a few imperfect casts of shells in the magnesian limestone, I am not at present prepared to assign to them their proper place in the geological series.

To the S.E., beyond the Cumberland mountains, the blue limestone rests unconformably on the inferior stratified rocks of East Tennessee. These latter rocks dip south-easterly at a very high angle, in some places almost vertically, but their dip is towards, instead of away from, the granitic rocks. It is possibly the case that, since they show themselves in the Sequachee valley between the spurs of the Cumberland mountains, these rocks may have suffered dislocation somewhere in the vicinity of that range of mountains previously to the deposition of the superincumbent strata; but no hypogene rocks have yet been discovered in that vicinity. That disturbances however have taken place on the eastern side of that range, of date subsequent to the deposition of the coal, is certain; for the

* It differs however from this rock in several particulars when examined *in situ*; it is almost destitute of fossils; its lower members have sometimes a greenish tint, and the imbedded siliceous masses are more rugged and quartzose. Beautiful crystallized specimens of rose-coloured quartz are of frequent occurrence in its beds, and chert of an oolitic structure is also abundant.

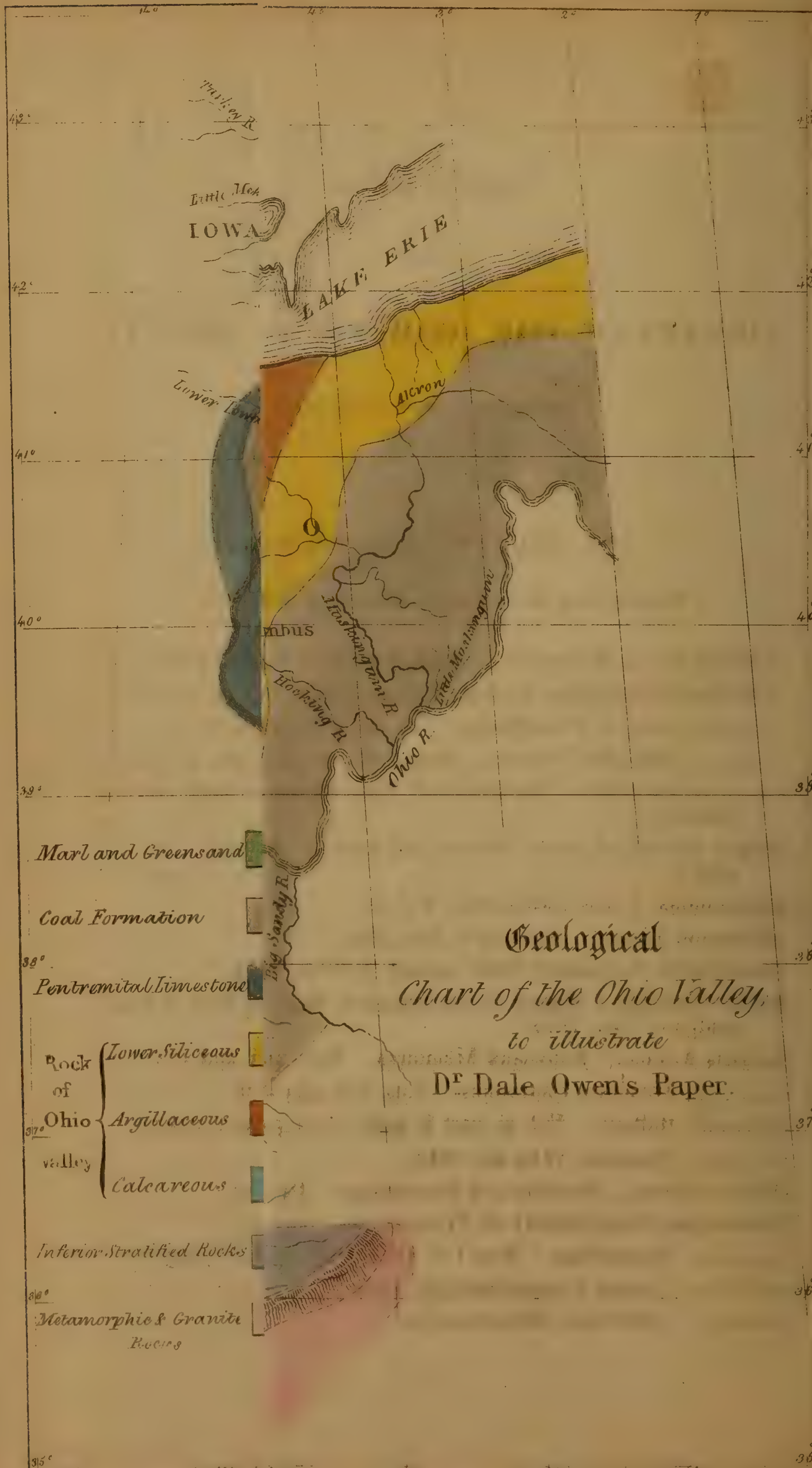
coal is found there twisted and contorted in a strange manner, although in the body of the mountain it is nearly horizontal.

Even high up on the flanks of the Alleghanies, near the Unaka mountain, the metamorphic rocks are seen preserving the same dip as the inferior strata of East Tennessee; that is, inclining towards the granitic rocks, with their elevated edges cropping out towards the Cumberland range.

I am not aware that any fossils have been found in the inclined strata of East Tennessee, except shells belonging to the genus *Maclurites*, and these are in a blackish grey limestone, one of its upper beds. The age of these rocks is a matter therefore which still demands investigation.

Such are the geological formations of the beautiful valley of the Ohio, projected by nature on a scale of grandeur commensurate with the vast territory, the mighty vegetation, the majestic rivers, the gigantic forests, and the wide expanse of trackless prairie that characterise this magnificent region of the West.

I regret that in this remote and secluded spot, cut off from access to public libraries and cabinets, and unable at all times to keep up with the current researches and discoveries of the day, I should not have been better able to do justice to such a subject.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Rock of Ohio valley
Lower Siliceous
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Inferior Stratified Rocks
Metamorphic & Granite Rocks
Geological
Chart of the Ohio Valley,
to illustrate
Dr. Dale Owen's Paper

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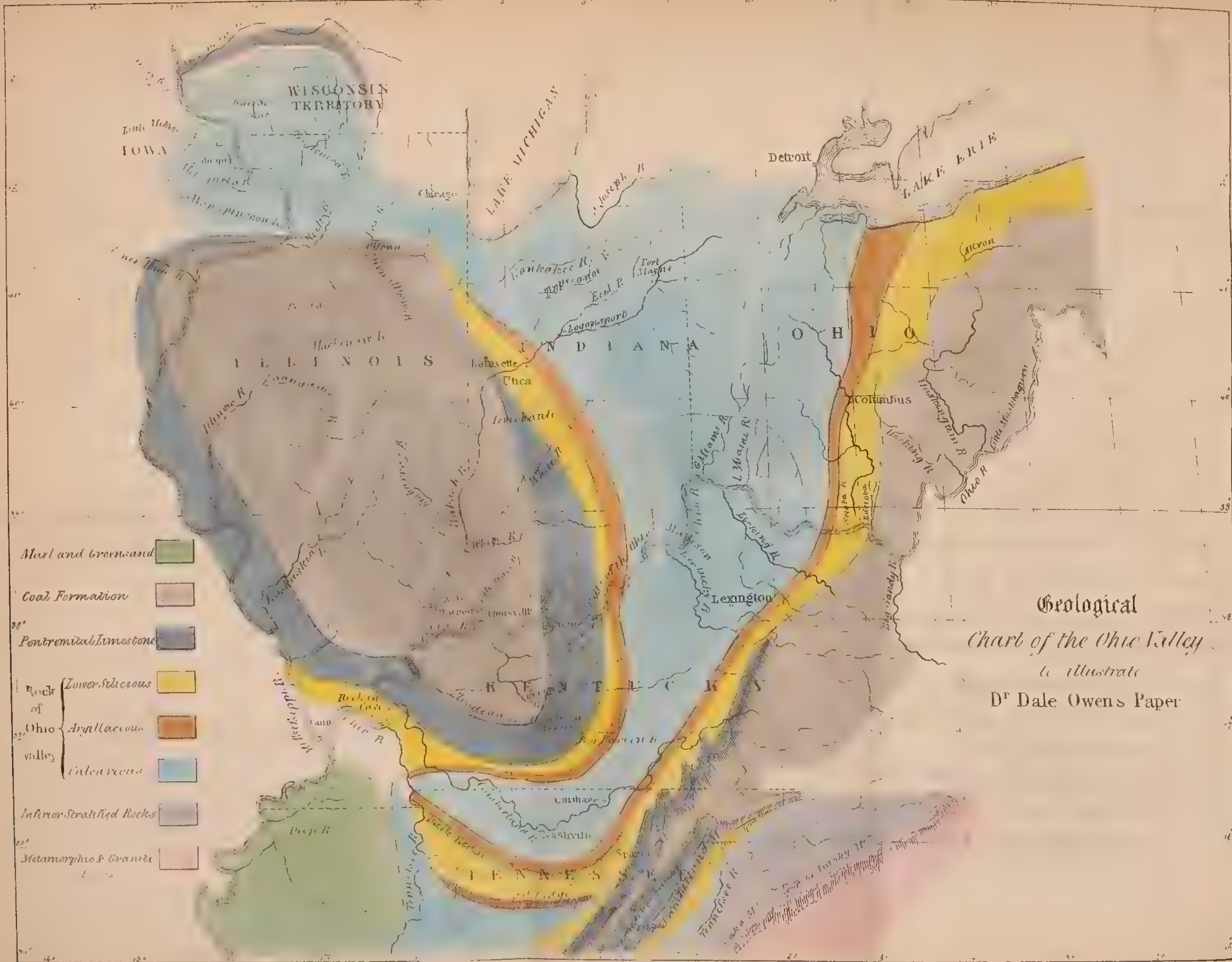
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1846.

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EXPLANATION OF THE PLATES.

CORRIGENDUM.

In the translation of the general view of the Palæozoic fauna of Russia, from the work on Russia in Europe by Sir R. Murchison, M. de Verneuil and M. de Keyserling, the heading of the article is throughout wrong, for the Editor, by a strange oversight, remembering the association of M. d'Archiac's name with that of M. de Verneuil in the determination of the Palæozoic fossils of Germany and the Rhine, has put "de Verneuil and d'Archiac" instead of "Murchison, de Verneuil and de Keyserling," and has again in p. 109, line 9 from the bottom, repeated the error, referring to Messrs. de Verneuil and d'Archiac as two of the authors, instead of saying "M. d'Archiac and one of the authors, M. de Verneuil." The reader is requested therefore to make these necessary corrections with a pen.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

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1. *Remarks on the* Molluscous Animals *of* South Italy, *in reference to the Mollusca of the Tertiary period.* By Dr. A. Philippi.

Continued from *Quart. Geol. Journ.* vol. i. p. 111.

(From 'Erichson's *Archiv für Naturgeschichte*,' 10ter Jahrgang, 1er Bd. p. 348.)

In the previous part of this memoir we have brought under comparison the Faunas of different seas with the marine molluscous fauna of South Italy, and have also grouped together those Mediterranean species which are most widely extended. If now, in the next place, we compare the existing fauna of the Sicilian seas with the inhabitants, during the tertiary period, of that sea whose elevated bed now forms the greater part of Sicily and Calabria, several problems of great interest and importance are suggested for investigation, and to these therefore we will next turn. The most important of these are:—1. Whether during the tertiary period the seas were greatly more or less rich in mollusca than they are at present? 2. How many species still met with were then in existence, having withstood the catastrophes which separated the former from the present condition of things? and how many species were destroyed by these catastrophes? 3. With regard to those species common to both periods, to what extent are these differences observable, whether as to relative abundance, difference of size, or other peculiarities? and how far are these differences important in themselves, although not sufficient to justify a specific distinction? 4. With regard to the localities of fossils, what relation have they to one another? Are the deposits all of the same age? or do the tertiary formations of South Italy admit of subdivisions? and 5. In what relation do the South Italian tertiary deposits stand with reference to the other tertiary formations? The last question I am unable, for want of necessary data, to answer distinctly; but with regard to the rest, my researches have brought out the following results:—

1. *Number of Molluscous species at present compared with the number during the Tertiary period.*

In the tertiary strata of South Italy we find scarcely any fossil remains but those of marine animals, and of these it is not to be expected that any indications of the naked mollusca should be preserved. Omitting, therefore, the latter, and also the land and freshwater shells, from the list of existing Mollusca, we have the following table of the numerical relations between the tertiary and existing period :—

	Existing period.	Tertiary period.
Conchifera	188 sp. or 35 per cent.	231 sp. or 40 per cent.
Brachiopoda	10 „ 2 „	13 „ 2½ „
Pteropoda	11 „ 2 „	5 „ 1 „
Gasteropoda (with shells) ...	313 „ 58 „	322 „ 56 „
Cirripeda	15 „ 3 „	5 „ 1 „
	537 species.	576 species.

The sea therefore was somewhat richer during the tertiary period than it is at present; and it must be remembered that the number of fossil species is likely to be increased by future researches to a much greater extent than that of existing species; but, on the other hand, it must also be borne in mind that the tertiary period involves a much longer lapse of time, during which many species have died out and new ones been introduced, and it is therefore not improbable that with respect to number of species there is no marked difference between the past and the present.

The relative proportion of the different groups was formerly somewhat different from that which now obtains, as will be observed by looking at the per-centage in the foregoing table, and it thence appears that the Conchifera and Brachiopoda formerly preponderated, while the Gasteropoda and Cirripedes are more abundant at present. I think we may hence conclude that the extent of coast was less during the tertiary period than it is at present, and that the bed of the sea recently elevated into land consisted chiefly of shallows.

2. *Proportion of extinct to existing species.*

Among the 537 existing species of marine shells, I have at present only met with the following in a fossil state. They amount to 169 in number, being somewhat less than one-third of the whole.

Conchifera.

Clavagella balanorum, *Scac.*
angulata, *Ph.*
Teredo navalis, *L.*
Bruguieri, *D. Ch.*
palmulata, *D. Ch.*
Pholas candida, *L.*
Solen legumen, *L.*
Panopæa Aldrovandi, *Men.*
Scrobicularia piperata, *Gm.*
Scrobicularia Cottardi, *Pay.*
Erycina ovata, *Ph.*
Bornia seminulum, *Ph.*
Solenomya mediterranea, *Lam.*
Corbula revoluta, *Broc.*
Pandora flexuosa, *Sow.*
Thracia ovalis, *Ph.*
fabula, *Ph.*
Galeomma Turtoni, *Sow.*

Venerupis decussata, *Ph.*
Tellina fabula, *Gm.*
Costæ, *Ph.*
baltica, *L.*
Lucina ? bipartita, *Ph.*
Scacchia elliptica, *Scac.*
ovata, *Ph.*
Venus geographica, *G.*
læta, *Poli.*
aurea, *Mat.*
Beudanti, *Pay.*
nitens, *Ph. et Sc.*
Cardium scabrum, *Ph.*
parvum, *Ph.*
Arca scabra, *Poli.*
imbricata, *Poli.*
Pectunculus lineatus, *Ph.*
Modiola costulata, *Riss.*

Pinna truncata, *Ph.*
rudis, *L.*
pectinata, *L.*
muricata, *Pol.*
marginata, *Lam.*
vitrea, *Gm.*
Lima inflata, *Lam.*
Pecten sulcatus, *Lam.*
Testæ, *Biron.*
gibbus, *Lam.*
Spondylus aculeatus, *Chemn.*
Anomia aspera, *Ph.*
scabrella, *Ph.*
pectiniformis, *Poli.*
elegans, *Ph.*
margaritacea, *Ph.*
aculeata, *Mont.*

Brachiopoda.

Orthis lunifera, *Ph.*
neapolitana, *Sc.*

Orthis anomioides, *Ph. et Sc.*
Thecidea mediterranea, *Riss.*

Pteropoda.

Hyalæa gibbosa, *Rang.*
vaginella, *Cant.*
Cleodora cuspidata, *Q. et G.*

Cleodora striata, *Rang.*
acicula, *Rang.*
zonata, *D. Ch.*

Gasteropoda.

Chiton pulchellus, *Ph.*
Polii, *Ph.*
Rissoi, *Pay.*
lævis, *Penn.*
variegatus, *Ph.*
cajetanus, *Poli.*
Patella Rouxii, *Pay.*
cærulea, *L.*
fragilis, *Ph.*
Emarginula Huzardi, *Pay.*
Fissurella rosea, *Lam.*
Pileopsis militaris, *Pult.*
Thyreus paradoxus, *Ph.*
Crepidula gibbosa, *Dfr.*
Bullæa planciana, *Ph.*
Bulla vestita, *Ph.*
ovulata, *Broc.*
ampulla, *L.*
diaphana, *Ar. et Mag.*
Rissoa elata, *Ph.*
violacea, *Desm.*
similis, *Scac.*
auriscalpium, *L.*
clathrata, *Ph.*
coronata, *Sc.*
radiata, *Ph.*
rudis, *Ph.*
gracilis, *Ph.*
cingulata, *Ph.*

Rissoa tenera, *Ph.*
subsulcata, *Ph.*
fulva, *Mich.*
labiata, *v. Mühlf.*
soluta, *Ph.*
Truncatella littorina, *Desh.*
? fusca, *Ph.*
atomus, *Ph.*
Chemnitzia scalaris, *Ph.*
obliquata, *Ph.*
†Nerita versicolor, *Lam.*
Natica marochiensis, *Lam.*
helicina, *Broc.* ?
Ianthina bicolor, *Mke.*
nitens, *Mke.*
patula, *Ph.*
Sigaretus haliotideus, *L.*
Vermetus semisurrectus, *Biv.*
Scalaria pulchella, *Biv.*
crenata, *L.*
Delphinula exilissima, *Ph.*
Solarium discus, *Ph.*
Trochus granulatus, *Born.*
dubius, *Ph.*
pumilio, *Ph.*
unidentatus, *Ph.*
villicus, *Ph.*
leucophæus, *Ph*
Racketti, *Pay.*

Trochus pygmæus, *Ph.*
† carneolus, *Lam.*
Turbo neritoides, *L.*
littoreus, *L.*
obtusatus, *L.*
muricatus, *L.*
Scissurella plicata, *Ph.*
striatula, *Ph.*
Cerithium lævigatum, *Ph.*
Pleurotoma purpureum, *Mont.*
costulatum, *Riss.*
multilineatum, *Desh.*
pusillum, *Scac.*
plicatum, *Lam.*
tæniatum, *Desh.*
Bertrandi, *Pay.*
lævigatum, *Ph.*
secalinum, *Ph.*
Laviæ, *Ph.*
Pyrula squamulata, *Ph.*
†Pyrula Santangeli, *Mar.*
Murex tetrapterus, *Bronn.*
Tritonium variegatum, *Lam.*
scrobiculator, *L.*
cutaceum, *L.*
Chenopus sirresianus, *Mich.*
Cassidaria depressa, *Ph.*
Dolium galea, *L.*
Buccinum Scacchianum, *Ph.*
candidissimum, *Ph.*
Tirei, *Mas.*
Lefebvrii, *Mas.*
Terebra aciculata, *Lam.*
Ovula carnea, *L.*
†Cypræa annulus, *L.*
† moneta, *L.*
erosa, *L.*
helvola, *L.*
Dentalium rubescens, *Desh.*

Cirripeda.

Balanus intermedius, *Ph.*
hemisphæricus, *Brg.*
galeatus, *L.*
Acasta spongites, *Poli.*
Chthalamus glaber, *Poli.*
Coronula bissexlobata, *Blain.*
Anatifa lævis, *Brg.*
striata, *Brg.*
Pollicipes scalpellum, *L.*

Since the tertiary period, therefore, there have been introduced as new species—

Of the	188	existing	Conchifera	35	species, or	19 per cent.
„	10	„	Brachiopoda	4	„	40 „
„	11	„	Pteropoda	6	„	58 „
„	313	„	Conchiferous Gasteropoda	97	„	31 „
„	15	„	Cirripeda	9	„	60 „

On the other hand, the following 193, or nearly one-third of the species found fossil, have disappeared and are now extinct:—

Conchifera.

Aspergillum maniculatum, *Ph.*
Clavagella bacillaris, *Desh.*
Clavagella sp.
Pholas vibonensis, *Ph.*
Solen tenuis, *Ph.*
Solecurtus multistriatus, *Scac.*
Panopæa Faujasii, *Men.*
Bivonæ, *Ph.*
Anatina oblonga, *Ph.*
pusilla, *Ph.*
Scrobicularia tenuis, *Ph.*
Erycina pusilla, *Ph.*
angulosa, *Bronn.*
longicallis, *Scac.*
similis, *Ph.*
Corbula crispata, *Scac.*
costellata, *Desh.*
Thracia ventricosa, *Ph.*
Thracia elongata, *Ph.*
Tellina pusilla, *Ph.*
pleurosticta, *Ph.*
ovata, *Sow.*
elliptica, *Broc.*
strigilata, *Ph.*
Diplodonta lupinus, *Broc.*
Lucina transversa, *Bronn.*
albella, *Lam.*
Scacchia inversa, *Ph.*
Astarte lævigata, *v. Münst.*
Cytherea fragilis, *Ph.*
Venus senilis, *Broc.*
vetula, *Bast.*
? miliaris, *Ph.*
Cardium multicostatum, *Broc.*
Hippagus acutecostatus, *Ph.*
Arca mytiloides, *Broc.*

Arca Breislaki, *Bast.*
aspera, *Ph.*
obliqua, *Ph.*
pectunculoides, *Scac.*
Pectunculus variabilis, *Sow.*
auritus, *Broc.*
minutus, *Ph.*
pygmæus, *Ph.*
Nucula placentina, *Lam.*
excisa, *Ph.*
striata, *Lam.*
pusio, *Ph.*
glabra, *Ph.*
cuspidata, *Ph.*
dilatata, *Ph.*
pellucida, *Ph.*
decipiens, *Ph.*
Chama dissimilis, *Bronn.*
Modiola grandis, *Ph.*
phaseolina, *Ph.*
sericea, *Bronn.*
Mytilus antiquorum, *Sow.* (?)
Arcinella lævis, *Ph.*
Perna Soldanii, *Desh.*
Pecten cristatus, *Bronn.*
Alessii, *Ph.*
latissimus, *Broc.*
palmatus, *Lam.*
scabrellus, *Lam.*
rimulosus, *Ph.*
antiquatus, *Ph.*
fimbriatus, *Ph.*
pygmæus, *v. Münst.*
semicostatus, *v. Münst.*
Hinnites læviusculus, *Ph.*
Plicatula mytilina, *Ph.*
Ostrea bellovacina, *Lam.*
prægrandis, *Ph.*
longirostris, *Lam.*
foliosa, *Broc.*
Anomia striata, *Broc.*

Brachiopoda.

Terebratula grandis, *Blum.*
bipartita, *Broc.*
biplicata, *Sow.*
sphenoidea, *Ph.*
Terebratula septata, *Ph.*
euthyra, *Ph.*
Orthis eusticta, *Ph.*

Gasteropoda.

Emarginula decussata, *Ph.*
Brocchia sinuosa, *Broc.*
Bulla convoluta, *Broc.*
lævis, *Ar. et Mag.*
Aplysia ? deperdita, *Ph.*
? grandis, *Ph.*
Melania ? soluta, *Ph.*
Valvata ? striata, *Ph.*
Rissoa sculpta, *Ph.*
reticulata, *Ph.*
textilis, *Ph.*
areolata, *Ph.*
substriata, *Ph.*
canaliculata, *Ph.*
Eulima Scillæ, *Scac.*
affinis, *Ph.*
bulimus, *Scac.*
Chemnitzia pusilla, *Ph.*
terebellum, *Ph.*
Natica undata, *Ph.*
tigrina, *Dfr.*
Scalaria trinacria, *Ph.*
plicosa, *Ph.*
crispa, *Lam.*
Delphinula nitens, *Ph.*
elegantula, *Ph.*
Bifrontia ? zanclæa, *Ph.*
Solarium reticulatum, *Ph.*
pseudoperspectivum, *Broc.*
Trochus crispus, *Kön.*
millegranus, *Ph.*
parvulus, *Ph.*
Trochus bullatus, *Ph.*
patulus, *Broc.*
gemmulatus, *Ph.*
filosus, *Ph.*
glabratus, *Ph.*
crispulus, *Ph.*
euomphalus, *Ph.*
strigosus, *Gm.*
suturalis, *Ph.*
marginulatus, *Ph.*
Ottoi, *Ph.*
cinctus, *Ph.*
Scissurella aspera, *Ph.*
Turritella tornata, *Broc.*
vermicularis, *Broc.*
subangulata, *Broc.*
Cerithium calabrum, *Ph.*
tricinctum, *Broc.*
Scæa stenogyra, *Ph.*
Pleurotoma cataphractum, *Broc.*
torquatum, *Ph.*
dimidiatum, *Broc.*
galeritum, *Ph.*
pygmæum, *Ph.*
noduliferum, *Ph.*
sigmoideum, *Bronn.*
harpula, *Broc.*
columnæ, *Scac.*
comma, *Sow.*
Imperati, *Scac.*
decussatum, *Ph.*
semiplicatum, *Bronn.*

Pleurotoma tarentini, *Ph.*
Payraudeaui, *Desh.*
Maggiori, *Ph.*
turricula, *Broc.*
Renieri, *Scac.*
carinatum, *Biv. fil.*
Cancellaria hirta, *Broc.*
coronata, *Scac.*
Fusus longiroster, *Broc.*
clavatus, *Broc.*
scalaris, *Broc.*
rudis, *Ph.*
politus, *Ren.*
Murex vaginatus, *De Cr. et J.*
multilamellosus, *Ph.*
Chenopus pes graculi, *Bronn.*
desciscens, *Ph.*
Strombus coronatus, *Dfr.*
Cassidaria striata, *Sow.*
Purpura cyclopum, *Ph.*
Buccinum serratum, *Broc.*
musivum, *Broc.*
Buccinum granulatum, *Ph.*
spinulosum, *Ph.*
acuticostatum, *Ph.*
pusillum, *Ph.*
exile, *Ph.*
Columbella Greci, *Ph.*
Mitra cupressina, *Broc.*
Voluta rarispina, *Lam.*
Ancillaria obsoleta, *Broc.*
Conus Brocchii, *Bronn.*
demissus, *Ph.*
Dentalium sexangulum, *Gm.*
multistriatum, *Desh.*
sulcatum, *Lam.*
substriatum, *Desh.*
tetragonum, *Broc.*
incertum, *Desh.*
coarctatum, *Lam.*
striatum, *Lam.*
triquetrum, *Broc.*
ovulum, *Ph.*

Cirripeda.

Chthalamus gigas.
Pollicipes carinatus.

We have therefore the following result:—

Of 231	tertiary	Conchifera ...	77, or 29 per cent. are extinct.
„ 13	„	Brachiopoda...	7, „ 54 „ „
„ 5	„	Pteropoda......	None.
„ 322	„	Gasteropoda...	107, or 31 per cent. are extinct.
„ 5	„	Cirripeda	2 „
Of 576	tertiary	Mollusca	193, or 33 per cent. are extinct.

Amongst the fossil species there are, however, several which exist in other seas, although they are no longer met with in the Mediterranean. The following is a list of these species:—

Mya truncata, L. Greenland, the whole of the North Atlantic Ocean, and, according to Brocchi, Tuscany.
Lutraria solenoides, Lam. The French coast, &c.
Tellina crassa, L. The North Sea.
Lucina columbella, Lam. Senegal.
L. pennsylvanica, L. The coast of America.
Cyprina islandica, L. The North Sea, Iceland, Canada.
Cardium hians, Broc. The warm seas—Algiers.
Lima bullata, Turton. The North Sea.
Pecten medius, Lam. The Red Sea.
Ostrea edulis, L. The North Sea.
Patella vulgata, L. The North Sea.
Niso terebellum, Chemn. The Nicobar Islands.
Vermetus intortus, Lamk. The Antilles.
Trochus strigosus, Gm. The Coast of Morocco.
Fusus contrarius, L. The North Atlantic Ocean.
Buccinum undatum, L. The North Atlantic Ocean.
Terebra fuscata, Broc. Senegal.
Dentalium elephantinum, L. The Indian Seas.
D. multistriatum, Desh. The Indian Seas?
D. coarctatum, Lamk. The English Channel.

Of the species common to the tertiary period and the present time, there are thus only 20 which do not inhabit that part of the Mediterranean which washes the coast of South Italy; and we may hence already conclude with some confidence that the climate at the period in question could not have been very different from what it is now.

But we have yet to consider the case of the 193 extinct species, since it is possible that these may either, on the one hand, indicate an arctic climate, corresponding with that assumed by the glacial theorists, or, on the other hand, they may have required a still warmer climate than we now find. It needs, however, merely a glance at the foregoing list to show that neither of these cases can be the true one.

The species *Aspergillum maniculatum*, *Perna Soldanii*, *Plicatula mytilina*, *Strombus coronatus*, *Terebra fusca*, *T. duplicata*, *Voluta rarispina*, *Ancillaria obsoleta*, will be especially and immediately recognised as indicating a warmer climate, since no species of any of these genera occur in the temperate zone of the northern hemisphere; and there is no doubt that *Cytherea lamellosa* has its nearest analogue in *C. cygnus*, whose habitat is in the neighbourhood of Canton, and not, as Deshayes has imagined, in the Mediterranean.

But, again, the number both of existing and extinct species that seem to point to a warmer climate is very inconsiderable compared with the whole number of species, and is counterbalanced by another group, such as *Mya truncata*, *Cyprina islandica*, *Fusus contrarius*, &c., confined at present to the colder seas; so that we may fairly assume as an incontrovertible fact, that *during the tertiary period in South Italy the climate was neither much warmer nor much colder than it is at present.* And it cannot be considered as a serious objection to this conclusion, that elephants, rhinoceroses and hippopotamuses have inhabited Sicily either during, or more recently than the tertiary period, since species of these animals, distinct from those which are now met with in warmer latitudes, might well exist in the present climate of Sicily. We shall see presently that the palæontological relations do not allow us to admit of any demarcation between the tertiary period and the periods of the diluvium and alluvium.

3. *Differences with regard to species common to both periods.*

If, in the next place, we consider the relative abundance of different species, in which the physiognomy, so to speak, of the molluscous fauna consists, we find that several species were equally common in the existing seas and during the tertiary period, but that a considerable number which were formerly very abundant are now rare, or have actually become extinct, while, on the other hand, many which were then rare, or had not been introduced, are now common. In the following lists, the species printed in italics belong to the former group,—that which includes those once abundant, but now extinct.

The following species were common during the two periods :—

Cardium echinatum.
tuberculatum.
edule.
papillosum.
Pectunculus violascens.
Nucula margaritacea.
Pecten Jacobæus.
opercularis.
varius.
Natica millepunctata.
Trochus conulus.
crenulatus.
rugosus.
magus.
Turritella communis.
Cerithium vulgatum.
lima.
Buccinum mutabile.
Dentalium dentalis.
entalis.

The following were common during the tertiary period, but are now rare or extinct :—

Solen coarctatus.
Psammobia feroensis.
Diplodonta rotundata.
Lucina radula.
Venus radiata.
vetula.
Pectunculus *minutus.*
Natica sordida.
Trochus *crispus.*
Trochus *millegranus.*
Fusus rostratus.
Pleurotoma *dimidiatum*, &c.
Murex *vaginatus.*
Buccinum *semistriatum.*
Marginella auriculata.
Dentalium *striatum.*
elephantinum.
strangulatum.

The following are now abundant, but either did not exist, or were extremely rare during the tertiary period. The species marked with an asterisk in the succeeding list are not known in a fossil state :—

Pholas dactylus.
Solen legumen.
Mactra stultorum.
*Pandora flexuosa.
Psammobia florida.
Tellina planata.
tenuis.
Lucina lactea.
Donax trunculus.
semistriata.
venusta.
complanata.
Venus gallina.
decussata.
*geographica.
*læta, *Poli.*
Cardita calyculata.
trapezia.
Chama gryphoides.
Modiola barbata.
Mytilus minimus.
Lima inflata.
squamosa.
Pecten hyalinus.
Spondylus gæderopus.
Patella scutellaris, *Blainv.*
cærulea, *L.*
tarentina, *O.*
Gadinia Garnoti.
*Fissurella rosea.
gibba.
Bulla striata.
*Rissoa violacea.
*auriscalpium.
*fulva.
Haliotis tuberculata.
*Ianthina bicolor.
*nitens.
*Trochus granulatus.
fragarioides.
fanulum.
canaliculatus.
Richardi.
Adansoni.
umbilicaris.
*Turbo neritoides, *L.*
Pleurotoma purpureum.
*tæniatum, &c.
Fasciolaria lignaria.
Tritonium nodiferum.
*cutaceum.
Buccinum variabile.
Pusio.
d'Orbignyi.
Columbella rustica.
*Cypræa lurida.
rufa.
*pulex.

Concerning these, we may remark that the most abundant, as

Venus geographica, *V. læta*, Poli, *Turbo neritoides*, &c., did not exist during the tertiary period.

It may be stated as a general rule, that the differences observable between recent and fossil individuals of the same species are not greater than we find in the case of recent specimens, so that we may often be in doubt whether a particular specimen is fossil or not. This is especially the case with shells obtained from the clay of Abbate, near Palermo, which are washed out by the sea, and are often taken to serve as the temporary habitation of the hermit crabs. These species are often remarkably well preserved, and there is some excuse for their being occasionally mistaken for recent specimens. This has happened, for instance, to those conchologists who, with Linnæus, have described *Dentalium elephantinum* as a Sicilian species; and also in the case of M. Kiener, who represented *Murex vaginatus* as living; and it is a matter of serious complaint that he allowed himself to change its name.

It is notwithstanding worthy of note, that several species seem to have attained a larger size in former periods than at present, and this is especially the case with regard to *Lucina radula*, *L. fragilis*, *Cytherea rudis*, Poli, *Venus radiata*, *Cardium Deshayesii*, *C. papillosum*, *Mytilus edulis*, *Pileopsis ungarica*, *Turritella communis*, and *T. triplicata*. This list indeed I could increase still further, (in my 'Enumeratio' I have always given the dimensions of the fossil and living forms when they exhibited any marked difference,) but the greater number of the species agree accurately in point of size, while it is remarkable that some, though but few, were smaller during the tertiary period than they are at present. This is the case with *Bulla lignaria* and *Terebratula vitrea*, which formerly did not attain half the size that they do now; and next to them we may mention *Corbula nucleus*. One can hardly come to any other conclusions from these facts, than that formerly the conditions with regard to number, locality, sea-bottom, &c. were more favourable for the development and growth of some species, and less so with regard to another and much smaller group; but that in general these conditions were very similar to those that obtain at present.

4. *The Distribution of Species, and considerations with regard to Subdivisions of the Tertiary period.*

The fossils are for the most part principally abundant in clay, marl and shelly sand; but it is of no consequence in the present discussion what may be the lithological character of particular localities, since the same species occur in clay and shelly sand, and even in compact limestone,—as may be seen, for example, very clearly near Palermo,—just as at present we find, on the whole, the same species on a sandy and muddy part of the coast. Moreover, the geological relations, so far as Sicily is concerned, have been described most fully by the late M. Hoffmann*; and the relations of the tertiary

* See his 'Geognostische Beobachtungen gesammelt auf einer Reise durch Italien und Sicilien,' Berlin 1839.

strata of Calabria, I intend myself to describe in detail: meanwhile their extent may be judged of by an examination of the map given by M. von Tchihatcheff, which is copied with great accuracy from my original drawing†.

Commencing with Sicily, we may include in one group the neighbourhood of Buccheri, Caltagirone, Caltanissetta, Castrogiovanni, Girgenti, Piazza, Sortino, Melilli and Syracuse. The following fossils are found in these localities ‡.

	Buccheri.	Caltagirone.	Caltanissetta.	Castrogiovanni.	Girgenti.	Piazza.	Sortino.	Melilli.	Syracuse.
Solen siliqua	—								
coarctatus	—								
Solecurtus strigilatus	—								
Panopæa *Faujasii*			—			—	—		
Corbula nucleus	—		—		—		—		—
Mactra solida			—	—					
inflata		—							
triangula		—			—				
Tellina donacina									—
pulchella		—							
Lucina spinosa	—								
*columbella							—		
*pensylvanica	—								
transversa	—	—							
Donax semistriata				—					
Astarte incrassata					—				
*Cyprina islandica			—						
Cytherea exoleta					—		—		
rudis		—							
Cyrilli					—				
lincta	—		—		—				
multilamella		—	—		—				
Venus *senilis*	—		—						
verrucosa			—		—	—			
gallina			—		—				
radiata					—				—
Cardium tuberculatum	—		—						
rusticum			—						
ciliare	—	—	—				—		—
lævigatum					—				
echinatum			—		—	—			
Isocardia cor	—								—
Cardita sulcata	—		—		—	—			—
aculeata									—
Arca diluvii	—		—					—	
Noæ							—		
barbata							—		
mytiloides		—	—			—			

† See the 'Coup d'œil sur la Constitution Géologique des Provinces Méridionales du royaume de Naples,' par M. de Tchihatcheff.

‡ The species printed in *Italics* are extinct, and those not now met with in the neighbouring district of the Mediterranean are marked with an asterisk (*).

	Buccheri.	Caltagirone.	Caltanissetta.	Castrogiovanni.	Girgenti.	Piazza.	Sortino.	Melilli.	Syracuse.
Arca *Breislaki*			—						
Pectunculus glycimeris	—				—				
pilosus	—				—	—			
violascens		—	—		—	—			
auritus					—				
Nucula *placentina*					—				
sulcata					—				
emarginata	—								—
margaritacea	—		—		—				
Chama gryphoides	—								—
Avicula tarentina	—								
Modiola *incurvata*			—						
Pinna sp.			—			—			
Pinna sp.			—						
Pecten *latissimus*, hab. Asaro									
Alessii				—					
Jacobæus				—	—		—		—
opercularis			—		—	—			—
aspersus						—			—
varius	—								—
pusio	—								—
cristatus	—			—					—
Anomia ephippium			—						
polymorpha					—				
Ostrea plicatula					—				
cristata			—						
cochlear									—
lamellosa				—				—	
bellovacina							—		
longirostris									—
Terebratula *grandis*		—							—
bipartita									—
Bulla striata	—								
lævis		—							
Crepidula unguiformis					—				
Calyptræa vulgaris			—						
*Niso terebellum	—		—						
Natica millepunctata	—	—	—		—	—			
sordida	—		—		—	—	—		
Scalaria planicosta					—				
Trochus *patulus*							—		
magus							—		
rugosus	—					—			—
Monodonta corallina							—		
Turritella communis	—				—				—
triplicata		—							
tornata					—				
vermicularis					—				
subangulata	—								
Cerithium pulchellum							—		
Pleurotoma *cataphractum*	—								
turricula	—						—		
Cancellaria *hirta*			—						
Fusus syracusanus							—		

	Buccheri.	Caltagirone.	Caltanissetta.	Castrogiovanni.	Girgenti.	Piazza.	Sortino.	Melilli.	Syracuse.
Fusus *politus*	—								
lignarius	—						—		
Murex Brandaris	—		—		—	—			
trunculus			—						
Tritonium corrugatum	—								
Chenopus *pes graculi*	—								
pes pelicani					—				
Strombus *coronatus*	—								
Purpura *cyclopum*							—		
Buccinum gibbosulum			—						
semistriatum	—	—	—		—				
Ascanias	—					—			
prismaticum	—								
serratum			—			—			
reticulatum					—				
mutabile	—				—				
scriptum					—				
Terebra *duplicata*	—								
Mitra cornea							—		
Voluta *rarispina*	—								
Ringicula auriculata	—								
Ancillaria *obsoleta*							—		
Conus *Brocchii*	—								
demissus							—		
Dentalium *sexangulum*	—								
dentalis			—						
entalis									—
*elephantinum	—				—				
striatum									—
Balanus tulipa				—	—				
perforatus			—						
balanoides					—				—

From the localities above referred to, which for convenience sake I will designate as Central Sicily, there are on the whole 124 species, of which only 40 (32 per cent.) are unknown as Mediterranean species, and only 35 (28 per cent.) are absolutely extinct.

If we take the separate localities, we find at

	Total species.	Species not now in Mediterranean.	Species now extinct.
Buccheri	41	14, or 34 per cent.	12, or 30 per cent.
Caltagirone	14	5, or 38 „	4, or 30 „
Caltanissetta	36	12, or 33 „	10, or 29 „
Girgenti	40	8, or 20 „	6, or 15 „
Sortino	18	9, or 50 „	9, or 50 „
Syracuse	21	5, or 25 „	5, or 25 „

At Palermo there have been found 279 species fossil, the names of which there is not here space to record, but they will be seen in my 'Enumeratio,' vol. ii. pp. 258, 259. The following is a general statement of the result:—

	Species not now in Mediterranean.	Species now extinct.
135 Conchifera	39, or 29 per cent.	34, or 25 per cent.
4 Brachiopoda	2	2
5 Pteropoda	0	0
135 Gasteropoda	29, „ 21 „	27, „ 20 „
279 Mollusca	70, or 25 per cent.	63, or 23 per cent.

At Messina 166 species have been collected, chiefly by M. Otto (Enum. vol. ii. pp. 259, 260). The following is the result:—

	Species not now in Mediterranean.	Species now extinct.
56 Conchifera	9, or 16 per cent.	9, or 16 per cent.
6 Brachiopoda	2	2
100 Gasteropoda	16, „ 16 „	15, „ 15 „
4 Cirripeda...............	2	2
166 Mollusca...............	29, or 17 per cent.	28, or 17 per cent.

Near Militello, as well in the basaltic tufa as in the Cava di Foschega, Cava de' Monaci, between Militello and Palagonia, there are 132 species, whence we obtain the following table. (See Enumer. vol. ii. pp. 260, 261.)

	Species not now in Mediterranean.	Species now extinct.
61 Conchifera	8, or 13 per cent.	7, or 11 per cent.
2 Brachiopoda	2	2
69 Gasteropoda	10, „ 15 „	9, „ 13 „
132 Mollusca...............	20, or 15 per cent.	18, or 14 per cent.

Near Sciacca 65 species have been found (Enumer. vol. ii. p. 261), of which 7 (11 per cent.) are not now in the Mediterranean, and 4 (6 per cent.) are extinct.

From Cefali close to Catania we have 109 species (*l. c.* p. 262), of which 43 are Conchifera and 66 Gasteropoda. Three of the former (9 per cent.), and six of the latter, also 9 per cent., are absent in the neighbouring seas, while two of the former and all the latter six are extinct: we have therefore 9 per cent. locally and 8 per cent. absolutely extinct.

At Nizetti, not far from Aci Castello, 76 species have been collected (*l. c.* p. 262). The following is the result of comparison :—

	Species not now in Mediterranean.	Species now extinct.
26 Conchifera	1, or 4 per cent.	0, or 0 per cent.
50 Gasteropoda............	4, „ 8 „	4, „ 8 „
76 Mollusca	5, or 6 per cent.	4, or 5 per cent.

Near Melazzo, of 98 species (*l. c.* p. 263) we have 4 (4 per cent.) absent in the Mediterranean, and three totally extinct. Between Stilo and Monasterace in Calabria, and near the latter place, I hastily collected 22 species *, of which 17 (77 per cent.) are extinct; and in the district of Calabria between Catanzars and the ancient Crotona near Cutro, St. Mauro, Sta Severina, Scandali, and even Crotona, I collected 69 species (*l. c.* pp. 263, 264), of which 32 (46 per cent.) are not now Mediterranean species, and 30 (43 per cent.) are extinct.

In the upper part of Reggio near the spot 'ai Nasiti,' and near the village of Terreti, about two or three leagues from the shore, and at a height above the sea varying from 1500 to 1800 feet, I found 24 species (*l. c.* p. 264), of which 11 (50 per cent.) are absent from the Mediterranean, while 9 (40 per cent.) are extinct.

In the valley of Lamato, below Tiriolo and near the high road, we have 107 species, including in this group 28 marked by M. Scacchi only as from the Gulf of Euphemia (*l. c.* pp. 264, 265). Of these

	Species absent in the Mediterranean.	Species now extinct.
52 Conchifera	19, or 37 per cent.	19, or 37 per cent.
3 Brachiopoda	3	3
52 Gasteropoda	19, „ 37 „	18, „ 35 „
107 Mollusca..............	41, or 38 per cent.	40, or 38 per cent.

Near his native city of Gravina in Apulia, M. Scacchi has collected 173 species (*l. c.* p. 265). Of these

	Species absent in the Mediterranean.	Species now extinct.
91 Conchifera	19, or 20 per cent.	16, or 17 per cent.
82 Gasteropoda	24, „ 30 „	22, „ 27 „
173	43, or 25 per cent.	38, or 22½ per cent.

* Enum. vol. ii. p. 264.

Near Pezzo, a couple of leagues north of Reggio and opposite Messina, I have found 82 Mollusca (*l. c.* p. 266), and of these 15 are absent from the Mediterranean and totally extinct. This amounts to 18 per cent.

About a league and a half from Reggio, at a place called Carrubbare, I found 129 species (*l. c.* p. 266).

	Species not now in Mediterranean.	Species now extinct.
65 Conchifera	8, or $12\frac{1}{2}$ per cent.	7, or 10 per cent.
64 Gasteropoda	7, „ 11 „	7, „ 11 „
129 Mollusca	15, „ 12 „	14, or 11 per cent.

Near Monteleone, in the sand-pits east of the town, about 900 feet above the sea, have been obtained 59 species (*l. c.* p. 267), of which 6 (10 per cent.) are not now in the Mediterranean, and 5 ($8\frac{1}{2}$ per cent.) are extinct.

Near Tarento M. Scacchi and myself have found 162 species (*l. c.* pp. 267, 268); of these 9 species (about $5\frac{1}{2}$ per cent.) are not now in the Mediterranean, and are not known in other seas.

In the island of Ischia we found 156 species (*l. c.* pp. 268, 269), consisting of 60 Conchifera and 2 Pteropoda, all referable to existing species, one extinct Brachiopod, and 93 Gasteropoda, of which one is also extinct. Of the 156 therefore, two species (about $1\frac{1}{3}$rd per cent.) are extinct. All the existing species are found in the adjacent seas.

On the coast at Pozzuoli, not far from Monte Nuovo, at the height of 70 or 80 feet above the sea, a number of species have been obtained and described by M. Scacchi*, and to his list I am enabled to make several additions †.

Of the whole number thus obtained, which amounts to 99, not one species is extinct, and only one, *Pecten medius*, found in the Red Sea, is absent from the Mediterranean, even this being a doubtful case. Notwithstanding this, the condition of the sea must have been considerably different from its present state when these beds were deposited; for *Tellina striata* was then common but is now rare; *Lucina spinosa* was both more abundant and grew to a larger size; *Lucina fragilis*, now rare and hardly measuring 6 lines, then attained the enormous dimensions of 14 lines, and was extremely abundant; and *Ostrea lamellosa*, Broc., no longer obtained near Naples, existed at that time, and attained a size so large that one lower valve measures

* Autologia di Scienze Naturali, p. 46.
† Enumer. vol. ii. p. 269.

5 inches 9 lines in length, 4 inches in breadth, an inch and a half in thickness, and weighed $26\frac{1}{2}$ ounces.

Lastly, in the town of Pozzuoli itself, when the foundations for the hospital were dug in 1832 at the height of 25 feet above the sea and 22 feet below the present surface, 103 species were found (Enumer. vol. ii. p. 270), not one of which belongs to a species either entirely or locally extinct, although in this case also there was by no means an identity in the condition of the sea with that which exists at present, since *Corbula nucleus* and *Diplodonta rotundata* (the latter of which I have never found near Naples) were far more abundant than they are now, while *Venus læta*, Poli (non L.), *Donax trunculus*, *Mytilus minimus* and others appear to have been less abundant than they are now.

If now we place these different localities in the order of the proportion they exhibit between extinct and existing species, placing first those places which contain the greatest number of extinct species, we shall obtain them in the order of date of their deposit, since we may fairly conclude that those placed at the head of our list are of the earliest formation.

	Not now in the Mediterranean.	Now extinct.
Monasterace	77 per cent.	77 per cent.
Sortino	53 "	53 "
Cotrona, Cutro, &c.	46 "	43 "
Naseti	50 "	40 "
Lamato Valley	37 "	35 "
Caltagirone	38 "	30 "
Central Sicily	34 "	30 "
Buccheri	34 "	30 "
Caltanissetta	34 "	29 "
Syracuse	25 "	25 "
Palermo	25 "	23 "
Gravina	25 "	22 "
Pezzo	18 "	18 "
Messina	17 "	17 "
Girgenti	20 "	15 "
Militello	15 "	14 "
Carrubbare near Reggio	11 "	11 "
Monteleone	10 "	8 "
Cefali near Catania	9 "	8 "
Sciacca	11 "	6 "
Tarento	$5\frac{1}{2}$ "	$5\frac{1}{2}$ "
Nizzeti near Catania	6 "	5 "
Melazzo	4 "	3 "
Ischia	$1\frac{1}{3}$ "	$1\frac{1}{3}$ "
Coast near Monte Nuovo	1 "	0 "
Pozzuoli	0 "	0 "

It appears therefore manifest that the passage from the tertiary period to the present has been perfectly gradual, and that, without the intervention of any convulsion or abrupt change, certain species have from time to time died out, and others have been introduced, until at length the existing fauna was elaborated.

We are unable to make any subdivisions in the tertiary formations of South Italy, for we cannot trace the limits which separate the tertiary from the diluvial or the diluvial from the existing period; neither can we make use of the terms eocene, miocene and pliocene with reference to the South Italian deposits so far as these expressions refer to a per-centage of extinct to existing species, and we would suggest that such terms are also uncertain and arbitrary with regard to other districts.

Finally, we conclude with the greatest confidence, that the tertiary formations of South Italy were not elevated above the sea at any one time, but that they exhibit the result of numerous and repeated elevations which have been continued until the historical period.

D. T. A.

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2. *On the* Cretaceous Formation *of* Saxony *and* Bohemia. By Dr. Hans Bruno Geinitz.

The cretaceous deposits of Saxony and Bohemia include the beds known by the terms Plaener-kalk and Quader-sandstein. The discovery made a few years since by M. Naumann, that the intervention of the '*Pläner*' separated the '*Quader*' into two parts, is fully confirmed by observations in Saxony and Bohemia; and, according to M. Glocker, Moravia exhibits additional evidence to the same effect.

The word *Pläner* is commonly applied in Saxony to any laminated rock, but more especially to the one now designated by that name amongst geologists. In Bohemia it is called '*Opuka*.'

The *Pläner* being divisible into three parts, the upper, middle and lower, we thus have the cretaceous series in these countries made up of the following five members in order of superposition:—

5. Upper Quader-sandstone.
4. Upper Pläner (Pläner limestone).
3. Middle Pläner (Pläner sandstone and marl).
2. Lower Pläner.
1. Lower Quader-sandstone.

1. The *Lower Quader* is a coarse sandstone of loose texture, varying in colour from white through ochrey yellow to red or green. The cementing material is calcareous, and the bed is tolerably fossiliferous, especially in the lower parts; but its upper portion is of still looser texture, and contains few fossils. It extends from the neighbourhood of Dresden, where it is well-seen, chiefly on the left bank of the Elbe as far as Pirna, and supplies an admirable building material. The same bed probably extends from Pirna to Tetschen and Königstein, and occurs also at Tyssa. Parts of the Saxon Switzerland also belong to this formation, although on the right bank of the

Elbe the upper Quader is chiefly developed, and beyond Schandau the two members of the formation are both found. The following are the most common and characteristic fossils of the lower Quader:—

Serpula septemsulcata, *Reich.*
Ammonites Rhotomagensis, *Defr.*
Cardium Neptuni, *Goldf.*
dubium, *Gein.*
Hillanum, *Sow.*
Inoceramus concentricus, *Sow.*
striatus.
Pecten æquicostatus? *Lam.*
arcuatus, *Sow.*
Fungia coronula, *Gold.*
Scyphia subreticulata, *Müns.*

2. The *Lower Pläner* varies in appearance more than the other members of the formation, being affected by the underlying rocks; and it is thus sometimes a good deal like the marly sandstone of the lower Quader, from which it is chiefly distinguished by its finer texture and greater compactness. It is best characterized by a Hippurite schist associated with it, and besides the Hippurites the following fossils are very abundant:—

Spondylus striatus, *Sow.*
Pecten crispus, *Röm.*
notabilis, *Mün.*
Lima aspera, *Mant.*
Exogyra haliotoidea, *Sow.*
Terebratula gallina, *Brong.*
triangularis, *Nilss.*
ovoides, *Sow.*
Cidaris claviger, *Mant.*

3. The *Middle Pläner.*—This bed sometimes appears as *Pläner-sandstone*, and sometimes as *Pläner-marl*, according to the proportion of carbonate of lime which it contains, a proportion which occasionally amounts to as much as 45 per cent. Its lithological character likewise changes in the same way, exhibiting a variable admixture of limestone, sand and clay, and occasionally lignite and iron ochre. It is distinguished from the lower Quader by the fineness of its grain as a sandstone, and its frequent yellowish and bluish spots. It is generally poor in fossils, but in some places, as near Luschitz in Bohemia, contains a considerable number. The following is a list of those which are characteristic:—

Belemnites minimus, *List.*
Pectunculus lens, *Nilss.*
Inoceramus striatus, *Gold.*
concentricus, *Sow.*
Exogyra plicatula, *Lam.*
Ostrea lateralis, *Nilss.*
vesicularis, *Brong.*

4. The *Pläner-kalk* is a marly limestone of a clear gray colour, containing about 75 per cent. of carbonate of lime. It is chiefly limited in Saxony to two places—Weinböhla and Strehlen, but is more widely extended in Bohemia, where it is much used for burning. It abounds with the remains of fishes, of species found in the chalk, and with Cephalopoda of the chalk-marl, and besides these contains—

Inoceramus Brongniarti, *Park.*
annulatus, *Gold.*
Cuvieri, *Sow.*
Spondylus spinosus, *Gold.*
duplicatus, *Gold.*
Terebratula semi-globosa, *Sow.*
carnea, *Sow.*
Terebratula pisum, *Sow.*
mantelliana, *Sow.*
octoplicata, *Sow.*
ornata, *Röm.*
Spatangus cor-anguinum, *Lam.*
Cidarites granulosus, *Gold.*

5. The *Upper Quader* occurs, as has been said, on the right bank of the Elbe, in the Saxon Switzerland, but it is extremely poor in organic remains. Of those that are found, the *Pecten lens*, Lam., seems the only one peculiar to it, the rest being found also in the Pläner-kalk and lower Quader. Like this latter rock, it is a sandstone of tolerably good quality in some districts, but occasionally of very loose texture and little consolidated.

A comparison of the fossils shows, that of 370 species determined, there were 20 species of fishes, 2 of insects, 5 of Crustacea, 8 of Annelides, 37 Cephalopoda, 58 other univalves, 180 bivalves, 15 Radiaria, 14 Polyparia, 18 Amorphozoa and 17 plants. Of these there are—

	Species.	
In the Lower Quader	148	(56 sp. from Tyssa alone.)
„ Lower Pläner	120	
„ Middle Pläner	128	(51 „ from Luschitz.)
„ Upper Pläner	168	(148 „ from Strehlen.)
„ Upper Quader about	30	
Common to Lower Quader and Lower Pläner	54	
„ „ and Middle Pläner	40	
„ „ and Upper Pläner	35	
„ „ and Upper Quader	25	
„ Lower Pläner and Middle Pläner about	50	
„ „ and Upper Pläner	29	
„ „ and Upper Quader	15	
„ Middle Pläner and Upper Pläner	52	
„ „ and Upper Quader	6	
„ Upper Pläner and Upper Quader about	17	

The results of the investigations and comparisons at present made on this subject, as recorded in my 'Characteristik der Schichten und Petrifacten des sächsisch-böhmischen Kreidegebirges,' are these:—

That the Lower Quader represents the Lower Greensand, the Upper Pläner the lower division of the Upper Greensand, the Middle Pläner the upper division of the Upper Greensand, the Upper Pläner the Chalk, and the Upper Quader the Upper Chalk.

Such then are the relations of these cretaceous rocks of Saxony and Bohemia, interesting and important by their extent and thickness, as well as by the multitude of their imbedded fossils, with the greatly developed and carefully worked formations of the same period in England. They offer an additional proof, in the complete agreement of so many species of fossils with those from distant spots in Germany, Poland, France, England and Sweden, how uniformly and completely what is now an entire continent must have existed, at the date of these deposits, as the bed of an ocean.

D. T. A.

3. *On the* Cystidea (*a new family of radiated animals*), *introduced by an Account of the* Caryocrinus ornatus, Say. By Baron Leopold von Buch, For. Mem. G.S., &c.

[From the Transactions of the Royal Academy of Sciences of Berlin.]

(Plates III. and IV.)

In the year 1825, there appeared in the 'Journal of the Academy of Natural Science of Philadelphia' (vol. iv. p. 9), an account of a genus of Crinoidea, specimens of which had been obtained (through Dr. Bigsby) from Lockport, on the Lake of Ontario, in the state of New York, and which proved to be altogether distinct from all known crinoidal forms.

This description, prepared by Thomas Say, one of the most acute of the American naturalists, and accompanied by a figure, was republished in the autumn of the same year in the 'London Zoological Journal' for October, and the name Caryocrinite has since been admitted amongst the genera of Crinoidea, although the distinctive peculiarities of the genus have hardly attracted notice. De Blainville, in his 'Actinologie' (p. 263, Atlas, pl. 29. fig. 5), gives only a meagre and incomplete description of it, and refers to a figure (taken from a specimen in his possession) by no means equal in clearness to that given by Say. Bronn also, in his 'Lethæa Geognostica' (p. 64), gives a short description, and acknowledges that he has not even seen a figure of the fossil. Since then, Castelnau, in his 'Essai sur le Système Silurien de l'Amérique Septentrionale' (Paris, 1843), has given another representation (pl. 25. fig. 2), in which the plates and ambulacral pores are indeed shown better and more distinctly than in preceding figures; but the essential points are not given, for we neither find any trace of the insertion of the arms (the small upper plate appearing entirely to inclose the animal), nor can we discover in what part the aperture of the mouth is to be sought for. The accompanying description leaves the matter in the same state of obscurity; for although M. de Castelnau has established a multitude of new species, he has merely in each case given the name, not stating his reasons for putting forward these names, and still less accompanying them with a proper description.

To this incompleteness it must be attributed that so accurate and careful an observer as M. de Verneuil has thought it necessary to identify the *Caryocrinus ornatus* with a species from St. Petersburg, described by me under the name *Hemicosmites pyriformis* *; and he considers that as one of the two names must drop, that given by Say ought of course to be adopted with reference to the Petersburg fossil †.

The conviction that it was impossible to group together, not

* Beiträge sur Kenntniss der Gebirgsformationen in Russland, p. 32.

† In the 'Survey of the Fourth Geological District of New York,' by James Hall (Albany, 1843), received at the end of 1844, there is given the best and clearest figure of *Caryocrinus ornatus* hitherto published, exhibiting very correctly the arrangement of the plates; but this figure is not accompanied by a description, and many of the most remarkable points of symmetry in the distribu-

merely into one genus, but even into the same family, animals provided with numerous arms projecting from the upper part of a cup-like body, and those unprovided with arms and completely inclosed in a dome-shaped habitation, induced me to undertake a new and distinct investigation of these Caryocrinites, of which there are now many specimens in different collections. And in this, as in every case in which nature is examined, so many extraordinary phænomena have presented themselves, such strange and astonishing symmetry appears in the arrangement of the separate parts, and a law, applicable to allied forms, and teaching the mode of development in them, is set forth so clearly, that the statement of it cannot but excite our admiration, and induce a great desire to discover and develope its most minute peculiarities. For the object of natural history is not to multiply species, to make catalogues, and to fill collections with names; but rather an earnest endeavour so to unite the different forms into one whole, that we may obtain some insight into the mystery and the object of life. The determination of species, when properly undertaken, ought to teach us a knowledge of the characters in which the great book of nature is written, in order that we may read what is there laid open before us with reference to the whole subject.

Say has given a very clear description of *Caryocrinus ornatus*, and his diagnosis enables us to distinguish this species from all those which it most resembles. He examined the form of each separate plate; he described the position of each, and mentioned the tubercles and the striæ which cover the surface; and he even showed the place which his genus must occupy in the arrangement of Crinoidea proposed by Miller. But notwithstanding all this clearness of description, the naturalist finds but little that is satisfactory; the bearing of each part upon the whole, the necessary relation of one part to another, and what is called by Göthe "die Beherrschung des Ganzen in der Anschauung," these remain still hidden, and we are taught only the character in which this section of the book of nature is written, and not the meaning and the idea which the writing illustrates. We might as well, in the case of an historical picture, take into consideration the separate figures, describing each one with the most minute accuracy, and mark the differences that exist between adjacent ones with the most careful attention, in order at last to arrive at the conclusion that the picture belonged to a class in which each part consisted of so many figures grouped together.

The number of figures however is of no consequence in the picture, nor their individual peculiarities of form, but rather the mode of grouping, and the manner in which the whole series work together towards the attainment of one common object. Just so it is in the case before us; but these things the species-maker, poring

tion of the pores have escaped notice, and are inaccurately represented. Neither is shown in this figure the way in which a line drawn through the intersection of the pair of large basal plates, and commencing at the very bottom of the pelvis, may be continued through the angular point of one side plate to the mouth, thus proving distinctly that the whole animal had a bilateral arrangement of its parts.

over minute differences, does not consider; and valuable as his labours may be, and often are, with regard to such points of detail, it is not thus that the true and philosophical naturalist is enabled to advance his knowledge.

Say has stated quite correctly that the Caryocrinite was possessed of a round pedicle or stem [Pl. IV. fig. 1 (*a*)] attached to the ground. Upon this stem four plates (*p*) were developed as a pelvis; upon these four (which are called *basal*), six lateral plates (*q*) repose; and six others again (*r*), called *scapulars*, rest upon these; while on this last upper series the arms (*c*, *d*) were planted.

The general form is that of a large acorn, terminating below in a blunt point, cylindrical in the middle, and closed at the top with a flattened dome*. The four plates of the pelvis (*p* 1, *p* 2), although of unequal size, are notwithstanding so regularly constructed that the pairs of adjacent ones are exactly alike, and exhibit a striking symmetry of form. If however the two larger plates (*p* 1) were divided in the middle, they would be found to differ in no respect from the smaller ones (*p* 2); and in this case all the sides would be alike, and instead of four, the pelvis would consist of six plates. This separation of the larger plates is most clearly exhibited in the distribution of the ambulacral pores on the surface, although the confluence of the two plates—which is carried so far that the retiring angle which ought to be formed on their upper side has become a straight line (see Plate IV. fig. 1)—can only arise from the distribution of the internal organs; and the mouth is invariably found upon the upper surface, exactly in the direction of the intersection of the larger plates, this line of intersection being continued through the middle of one of the lateral plates. The position of the mouth —not placed in the centre, but on one side of the summit—is an important point, and affects the lateral plate which conducts to it; since, although its form is not altered, this plate is notably deeper towards the base than the similarly formed lateral plate corresponding to it on the other side of the cup; and in conformity with this modification, the scapular plate is also more extended, and descends deeper than the similar plate on the opposite side (see figure). It seems as if the excentrical position of the mouth had pushed down the whole cup towards the base and pressed together the plates on this side; and, singularly enough, the side plates are found, in some abnormal instances, to be sometimes altogether pressed down, so that the scapulars repose immediately on the basal plates, while on the other side an additional plate is inserted between those regularly developed. This influence of the mouth upon the form and distribution of the plates is universal in all the Crinoidea; for where the basal plates are not exactly similar in form and arrangement, there the mouth is found invariably upon the side, an interradial or intercostal plate conducting to it. In the *Actinocrinites*, for example, the base of the cup consists of three small plates, of which two are considerably larger than the third. Exactly where the two larger ones intersect is placed that interradial so remarkable in the genus in question,

* See Pl. III. fig. 1, 2.

and on the side of the upper surface, exactly in this direction, is found the mouth. This is well exemplified in the figure of *A. amphora* given in Portlock's 'Geology of Londonderry' (pl. 15. fig. 4. *a*); and in *A. triacontadactylus* and *A. tessellatus*, in the same work, these relations are also indicated with the greatest clearness. Was it from inadvertence that Miller (p. 98, pl. 2) described this Actinocrinite as having the mouth central? The same relation between the basal plates and the position of the mouth upon the side appears in *Platycrinus*, and is admirably shown by the author (see *Pentacrinus*, tab. 6); and since the mouth is only central in those cases in which the cup is based upon perfectly regular five-sided plates, it is possible that Miller was not describing a true *Actinocrinite*, but a *Carpocrinite*, first separated by M. Müller (*Pentacrinus*, p. 32). I doubt also very much whether *Melocrinus* has ever been seen with the mouth central, as it is generally on one side in the direction of the smallest of the four basal plates.

The lateral plates of *Caryocrinites* (*costales* of Miller), six in number, and forming a perfect cylindrical inclosure, give to the general contour considerable elegance. They are higher than they are broad by about one-half, and they form more than half of the absolute height of the cup. They rise from the intersection of the basal plates, alternating therefore with these latter; and in the case of the larger plates, which, as I have already mentioned, are formed of the confluence of two, without a retiring angle being traceable on their upper line, they rest on the longer sides of each of the large pentagonal plates formed by the soldering together of two smaller ones.

These two inclose that one of the lateral plates which conducts directly to the mouth, and form a very regular six-sided figure, elongated and pointing in one direction towards the apex, and in another to the base. Of the other three lateral plates, only one, that namely exactly opposite this mouth-plate, is regularly hexagonal, since of the remaining two the angles pointing towards the summit of the cup are truncated, so that the figure is in each case changed to a heptagon.

Six scapular plates (*radialia axillaria* of Müller) form the upper portion of the cylindrical cup. Above the middle they are pierced through, and their further development prevented by the arms which rise from this part, so that only somewhat more than one-half of them appears in sight. Two small plates are inserted on the truncated angle of each of the two heptagonal plates on the side opposite the mouth, and are concealed under the bases of the arms, so that the rim of the cup properly consists of eight plates, six of them large, with two smaller ones between them.

This complete and perfectly symmetrical arrangement, and the relation of the different parts to one another, is extremely well shown in the appearance of the general form as seen from above (see Pl. III. fig. 2). Thus looking upon the fossil, we may see distinctly how the whole of the upper part is compressed into a spherical triangle, from each of the angles of which rise a pair of arms, while near every pair and on each side is placed another single arm. It is clear that these pairs of arms and their protrusion have distorted the upper surface of the triangle. Without them the scapular plates would have been continued without interruption to the middle point or apex, and instead of lateral plates, as they now are, would have become vertical plates, as in *Hemicosmites*. So essential is the change that has been effected throughout by the introduction of these arms! The number of arms is nine or six, according as those proceeding from the angles are to be considered in each case as two arms, or (as in *Platycrinite* and allied forms) as each consisting of one arm which has branched off immediately into a pair; but with regard to this point we have at present no knowledge, since not one of the specimens hitherto described exhibits the arms at their attachment.

This very remarkable triangular form of the upper surface of the *Caryocrinites*, marking like a roof the general contour of the cup, determines also the form and the arrangement of all the separate parts; and of these we may first mention the mouth, which is placed on the edge, on the right half of one of the sides of the triangular summit.

The mouth is a large opening, its diameter being generally at least a fourth part of the whole breadth of the upper surface, and it is closed by five, or, more commonly, six convex valves, which form a small cone, and are moveable, as if on hinges, being set in little grooves or depressions round the edge of the mouth. Of the other two sides of the triangle, the central part is exactly determined by the middle of the heptagonal plates of the side; and hence these are readily made out in cases where from injury or the presence of extraneous matter they might otherwise be concealed. The middle point of the triangle, and therefore of the whole upper surface, is marked by a small, very delicate, little elevated, and sharply defined plate, surrounded by others somewhat smaller, but of exactly similar shape, arranged in a circular group, and with the greatest regularity. The central plate would be a complete and regular hexagon, as the surrounding ones really are, were it not for the interference of the mouth, one of the very small plates surrounding which is pushed in on that side between the regular series of plates circularly arranged, so that the number of these latter is increased to seven, and the central plate itself receives an addition of a small seventh side. This arrangement of the summit, as well-defined as it is elegant, is common to all those genera of Crinoidea in which the mouth is excentrical. It is strikingly exhibited in all the species of *Platycrinus*, since in most of these the ranges of central plates terminate in pointed summits, and like a circle of little turrets they surround a higher central tower. In *Rhodocrinites* also (described by Phillips as *Gilbertsocrinite* in the Annals of Nat. Hist. vol. xi. p. 202) this peculiarity of arrangement may be well observed, although the plates themselves are but little pointed. In the drawing by Phillips, which in other respects is good, this arrangement is not shown, and the upper surface exhibits only confusion and irregularity, but it is admirably represented by M. Müller (*Pentacrinus*, tab. 6. f. 1. *c*).

Plications, Striæ and Pores of the Plates.—These markings are not only in the highest degree instructive in the whole family of Crinoidea, but a close investigation teaches us also, that there exists with regard to them a law of arrangement and a regularity which one could hardly have anticipated in characters apparently so superficial. In the first place, the striæ of growth, distinctly parallel to the bodies of each plate, repeat the form of the plate quite up to a central nucleus, and hence clearly distinguish each plate from those which are adjacent. These striæ, so distinctly marked and projecting so strongly, show the way in which each plate was surrounded on all sides by an organized membrane from which the calcareous matter was periodically deposited, thus enlarging the whole body of the animal by increments applied at each edge of every plate.

From the centre of each plate there proceed rows of pores, probably the remains of ambulacra, to all the angular points of the polygon, each row generally consisting of six pores. Towards those angular points on the side of the polygon the row of pores is single, while in those two directed vertically upwards and downwards the row is double. It is worthy of notice, that with regard to the side plates, only the upper half is decorated with these rows of pores, the lower part having them sparingly or not all distributed; but on the scapular plates a contrary arrangement takes place, the rows of pores being there most regularly developed on the lower half, and uniting with those from the side plates to form a complete encircling festoon on the upper part of the cup. This is also a very striking peculiarity in *Hemicosmites*, but such similarity is produced by the uniform action of a general law, and does not prove any identity of specific character. When the rows of pores of the scapular plates are examined minutely with the aid of a powerful magnifier, a very remarkable structure is observed, characterizing them and almost peculiar to them, the isolated pores not being hollow, but covered with very minute vesicles, one in the middle and six smaller ones around it. These little vesicles are larger and more abundant the nearer we approach the middle of the plate, and quite in the middle there are about a score of them close together, so minute as only to be visible under the microscope.

Not a trace of these vesicles can be discovered on the rows of pores on the lateral plates, and thus the scapular plates may be distinguished very easily from the others, even when only the smallest fragments remain; and by taking advantage of this structure we may readily discover those monstrosities in which the scapular plates entirely conceal some of the lateral plates and rest immediately on the pelvis, producing indeed a remarkable distortion and compression of the general form, but only on that side on which the mouth is placed. This compression probably has some reference to the effort made by the animal to bring the mouth near the ground in order to obtain food. The pores penetrate the entire thickness of the plates, and are as distinctly marked on the under as on the upper surface. There was doubtless some organ projected through them from the animal.

In these lateral plates, in which the angle pointing towards the vertex is truncated, each of the two angles thus formed seems to represent those pointing vertically upwards, and is marked by a corresponding double row of pores proceeding from the centre of the plate.

The basal or pelvic plates are decorated with pores after a manner precisely similar to that just described. Here also a double row proceeds towards the vertical angle of the two smaller four-sided plates, but in the case of the larger six-sided ones, two double rows proceed, diverging from the base towards the two angles pointing upwards, thus showing distinctly the compound nature of these plates, which evidently consist of a pair, exactly similar to the smaller ones, but fastened together. In the basal plates many of the pores towards the stem are covered with vesicles, but not so invariably as the plates under the arms.

Such is the decoration of the external surface of the Caryocrinus in the young and mature state, but with age it appears to exhibit a remarkable change. Along each row of pores there rise small oblong vesicles resembling the pores, but never piercing through and reaching the inner surface of the plate. These vesicles gradually lengthen, and at last unite into an elevated ridge, occurring between the rows of pores when they are double, but, when the row is single, under it, on the upper half of the plate, and above it, on the lower half--another very singular instance of symmetry of arrangement in this part. These ridges seem to have gradually risen in height while the rows of pores remained buried by their side, so that the whole plate at length puts on the appearance of a large six-rayed star, the surface being separated by that number of ridges proceeding from the centre; and this radiated appearance is exhibited very beautifully and distinctly even in the minute plates on the summit. The rays always proceed from the centre towards the angle of the plate, and never terminate upon the side; and this is an important point, because these radiating ridges differ essentially from the plications, often very strongly marked, which pass on from one plate to another, and frequently give to the surface a new polyhedral form, which a hasty examination attributes to the form of the plates, although, in fact, it is merely a modification of the external surface.

But neither is this latter modification absent in the Caryocrinites, which seem as it were to combine within themselves all the peculiarities of form occasionally met with, and so singularly characterising the various genera of Crinoidea. The striæ of growth on the surface of the *Caryocrinus* are distributed in a very distinct manner as little granulations placed in lines intersecting one another at right angles. However delicate these lines may be, their mutual parallelism may always be traced, and so may also their position perpendicular to the edges of the surface on which they exist. *They appear to pass without interruption from the middle of one plate to the middle of the next adjacent one.*

It is in this slight, and, for that very reason, instructive commencement of an appearance—exhibited in so remarkable a manner on the surface of the plates of all the tessellated Crinoidea and developed in almost all the Cystidea *—that we are enabled to determine accurately its true nature. Miller supposes, and I think with reason, that these striæ, folds or ridges were owing to a membrane projecting between the plates and coating their external surface—perhaps also producing the striæ of growth. The existence of such a membrane would at once explain the reason why the folds are invariably at right angles to the edge of the plate; it would also explain why they affect only that triangular area enclosed between the centre of the polygonal plate and two angular points towards the side and are prevented from extending to the adjacent triangles, and why they pass on from one plate to another, producing those singular striated rhombs on the external surface, and producing these only on the exterior without any trace of them existing on the inside. It may also possibly admit of a similar explanation, that when at last these folds seem to pass off into pores such apparent pores are by no means orifices for ambulacra, which is proved by their never penetrating the plate as those do which proceed towards the angular points, since they may be the extremities of hollow channels that are formed between these striæ or folds and the general surface of the plate.

If, notwithstanding the small claim which it has been shown that the Caryocrinites possess to be ranked among the Crinoidea, they may still seem to approach the *Poteriocrinites* in their cylindrical form, their tall lateral plates, and the scapular plates alternating with them, yet will a closer investigation soon show that these two cannot be classed together, the former group remaining separate and detached, standing between but without absolutely uniting the families *Crinoidea* and *Cystidea*.

The settled dominion of the number *five*, which so singularly obtains in all organised nature, may be observed in all the Radiaria, but is especially exhibited in the *Crinoidea*; and the separate parts show, by reference to this number, the place to which they belong. However various species of *Actinocrinus* and *Pentacrinus* multiply themselves to an almost unlimited extent, this is merely effected by the continued doubling of five arms which are developed from the interior of a cup-shaped body; and if, on the other hand, *Platycrinus* or *Actinocrinus* seem to rise from only three basal plates, it is easy to show in what way two of these are combinations formed of a pair of plates, so that here also the basis of the cup must be considered as made up of five plates placed in contact.

Not so in the case of the Caryocrinites. In them we find no trace, no indication which can in any way lead to a grouping into five parts, for everything, even to the most minute point, shows that the number *six* is dominant, a number which cannot in any way connect itself with five. The base of the cup consists of four unequal plates,

* The same appearance is yet more prominently developed in the highly projecting ridges which divide the body of *Actinocrinites* 30-*dactylus* and *A. polydactylus* (Miller, p. 98–100) into deep compartments, from three to five in number.

which, as has been already shown, may be readily converted into six, exactly similar and identical. Six lateral plates and six scapulars form the cup, and six arms, three double and three single ones, rise from its rim. Everything is entirely at variance, therefore, in this respect, with what is seen in other Crinoidea; and in none of the latter is the base of the cup composed of four plates except in the singularly formed and anomalous *Melocrinus* (Goldfuss, tab. 60. fig. 1), while the number (*six*) of the arms, proceeding from the rim, is also peculiar and not met with elsewhere.

Everything which is determined by the number five is developed from within, and is directly connected with life; but wherever the number six dominates, the surface only is affected, the mere external coating or enclosure, which stands in no other relation to the internal organs than simply as protecting and sheltering them. When from a membrane at the surface a plate begins to be formed, a point or a little hard particle being detached, it will increase by the continued detachment of hard particles in all directions, and will assume a circular form. If during growth these circles touch one another, they will be limited in their progress at the points of contact, and will there be flattened, producing hexagonal plates only capable of increase of size by increments at the edges, so that everything afterwards formed at the surface, as the pores and striæ, must necessarily be disposed and determined according to this hexagonal form.

In the Crinoidea, however, the five arms extending far over the edge of the cup, are developed from the very basal plates, and the determination of the number six is entirely limited to the plates themselves. It does not however, in fact, affect their shape, for from the very base of the cup and long before they make their appearance, the arms press the lateral plates together, raise them in the middle, and give to the whole margin the prominent form of a pentagon. For this reason has M. Müller designated those plates which announce as it were the existence of the arms so long before they appear—*radialia*, calling those upon which the arm when developed actually rests, *radialia axillaria*. The arms also, when they are put forth, bring with them the ovaries so remarkable in these animals, which till then were concealed within the margin of the cup, but being now at liberty and attached far above the margin to the pinnules of the arms, they are no longer obliged to squeeze through a narrow opening. In this way a new peculiarity is introduced, and on it is based the essential difference between *Crinoidea* and *Cystidea*.

It will probably remain for a long time unknown what is the nature of the mystery that exists in this number five, by which it exercises so remarkable an influence over the whole of organic nature. I would not presume to venture more than lift up the edge of this dark veil; but the study of the Radiaria, in which the subject appears so manifestly in its simplest form, has induced me to suggest that the number five may be an augmentation of three in the effort fully to complete the circle, these three being wrought out of one main direction or tendency, combined and brought into action by two directions or tendencies opposed to another. In one species of *Pentremite* from Yorkshire, which is not yet named, but which has very flattened ambulacra, a species, it will be observed, of a genus whose very name is characteristic of the division into five parts, we may clearly observe one principal arm more especially elevating the plates, and two other arms at the side, each dividing itself to form the posterior pair which complete the five rows of ambulacra. Is not this the case also in *Spatangus*, *Clypeaster*, and even the regularly circular *Cidaris*? and may not possibly the study of man and other Vertebrata—the head being the main development, the arms the opposed tendencies, and the legs the posterior pair derived from the anterior but detached by the prolongation of the vertebral column,—may not, I say, this lead to the same conclusions as those derived by the investigations of the Invertebrata, which I believe have been already frequently put forth?

I turn now to the nearer consideration of the Cystidea.

The Cystidea were natural bodies supported on a stem or pedicle which was attached to the ground; their surface, more or less spherical, was covered by a great number of polyhedral plates accurately fitted to one another, and between these plates were certain openings necessary for the performance of the animal functions; but from none of these did arms proceed resembling those of the Crinoidea. The animal was completely without arms.

With regard to the openings on the surface, we find in all the Cystidea,—1st, that the mouth was planted in the central part of the upper surface, generally in a moveable proboscis covered with minute plates; 2nd, that besides this mouth, and close to it, there is generally, if not always, a small anal orifice penetrating the plate, but not itself surrounded with any plates peculiar to it; 3rd, that further towards the middle, but almost invariably on the upper half of the body on which the mouth is placed, there rises a round or oval aperture, not connected with the mouth, and often covered by a five or six-sided pyramid, which seems to be composed of as many little valves. This probably forms the ovarial orifice of the animal.

These openings, with the exception of the mouth, are not found to exist when arms begin to be developed from the upper surface; and we may easily understand this when we remember that in the latter case the ovaries are carried out with the arms beyond the rim of the cup-like body, so that a separate opening for them would be useless. In all the Cystidea the presence of these ovarial orifices is however manifestly essential.

Since scarcely anything appears of the interior of these animals, and one can only observe their external structure, it is not remarkable that the number *six* appears especially to predominate, while the quinary arrangement is rarely observed. The latter may, however, be traced in the stem, and in the internal nutritive canal running through the stem, which I have never seen other than five-sided. The stem itself is in almost all the genera remarkably slender, and appears hardly adapted to support so heavy a weight as is sometimes placed upon it: for this reason it would appear that its length was not great, and perhaps in most cases the body of the animal rested on the ground. In *Sphæronites aurantium* the diameter of the aperture for the stem is only $\frac{1}{40}$th part of that of the rim of the cup, but in *Caryocystites granatum*, Wahl., the proportion is only one to fifteen, and in *Cryptocrinites cerasus* one to seventeen.

The species of Cystidea at present distinctly known and described are the following:—

Genus SPHÆRONITES.

1. Sphæronites aurantium, Hisinger. [*Tilas*, Vet. Acad. Handl. 1740. tab. 11. fig. 18. *Gyllenhal*, Vet. Acad. Nya. Handl. 1772, p. 242. tab. 8. fig. 4, 5. *Wahlenberg*, Acta Acad. Ups. viii. 52. *Pander*, tab. 29. fig. 2, 3. *Herz. v. Leuchtenb.* tab. 2. fig. 17. *v. Buch*, Beitr. z. Best. d. Gebirgsform. in Russl. tab. 1. fig. 14.]

Plate III. fig. 3.

Form spherical, rising from a very thin round stem, with pentagonal nutritive canal; six small plates form the pelvis; these are surrounded by other plates of larger and smaller size, which alternate without any observable order and are very numerous, so that one can count at least twenty upwards in a row. Most of these plates are hexagonal, but many with seven, eight, nine or more sides might easily be found. The mouth (*a*), in a small proboscis surrounded with plates, is placed diametrically opposite the insertion of the stem (*c*). Lower down, but on the same hemisphere with the mouth, occurs a large pyramidal orifice, closed with five or, more rarely, six valves, which is the ovarial opening (*b*). On the top of each of these valves is a small orifice piercing quite through the valve, and possibly the eggs were extruded from these orifices, since the valves themselves are never found open. In a direct line between the mouth and this little pyramid, but quite close to the mouth, is a small round anal opening, not elevated above the surface.

The inequality of size and the minuteness of many of the plates, and the way in which they are strewed over the surface, render it probable that in this animal it was not only by additions to plates originally formed that the whole increased in dimensions, but that new plates were also constantly added, crowding in between the older ones.

The surface of each plate is covered with lines or striæ, which are at right angles to the edges of the plate. There are therefore as many directions of these striæ as there are sides of the plates, but all meet in the central point, and this has been very well and clearly described by Pander (tab. 29. fig. 3 *a.*). The striæ of one plate pass without any interruption or change of direction to the adjacent one, and the two seem then to form but one, whose shape is a rhomb, having well-defined striæ in the direction of the longer diagonal; and for this reason I shall describe such striæ under the name (rhombic) striæ, or plications. They terminate towards the middle of the plate by an aperture, which Pander considered to be a place whence ambulacra were protruded, a view in which I have coincided (Beitr. z. Best. d. Gebirgsform. in Russl. p. 27); and I have even ventured to throw out the conjecture, that these striæ may possibly have been the borders of channels by which ambulacra parallel to one another have been mutually conducted from one plate to the adjacent one. But when these external striæ are rubbed down, as in the state in which the *Sphæronites* are generally found, so that the true separating lines between adjacent plates can be distinctly traced, we find on the surface no mark whatever of orifices or holes by which they were pierced, as there must have been if these holes had served for the passage of ambulacra, which could of course only proceed from the interior. They are therefore entirely superficial, and are probably only the terminations of covered channels or hollow ridges along the length of the striæ. In the Sphæronites which are found at Christiania in Norway, the striæ are so prominent that the rhombs which they form are sharply detached from one another, and they completely conceal the line of intersection of the true plates. In this state they have been improperly described as belonging to *Echinosphærites granatum*. They are figured by Hisinger in the 'Lethæa Suecica' (tab. 25. fig. 8).

2. Sphæronites pomum, Hisinger. [*v. Buch*, Beitr. z. Best. d. Gebirgsform. in Russl. i. 15. 16. according to *Gyllenhal*. *Hisinger*, Leth. Suec. tab. 25. fig. 7.]

There is still considerable doubt with regard to this species. In shape and in the distribution of the openings it differs very little from *S. aurantium*; for notwithstanding Gyllenhal's statement, that the anal aperture is so near the mouth that the two are often confluent, this after all can only be an individual peculiarity, since other specimens exhibit the two openings perfectly distinct. The ovarial pyramid also, which Gyllenhal could not find, is not absent in this species, since the Duke of Leuchtenberg has described and figured it with perfect distinctness (Beschr. ein. Thierrestes d. Urw. p. 23. tab. 2. fig. 19). The essential difference between this species and the former is in the pores of the plates, two being observed on *S. pomum* which are connected by a small furrow, and which are not merely superficial, but penetrate the plates and may be distinguished on the stony nucleus. From ten to twelve little series of this kind occur on each plate, and these also have been noticed by the Duke of Leuchtenberg, who has described them as occurring on a specimen, perhaps the largest hitherto found, measuring three inches in diameter.

Sphæronites have not been found except in northern latitudes. They occur in Norway near Christiania; very abundantly at Westraplana near the Kinnekulle, in West Gothland, where, according to

Gyllenhal, *S. pomum* always occurs in lower beds than *S. aurantium*; at the Mösseberg; on the island of Oeland near Bödahamn (only *S. aurantium*); in Dalecarlia at Osmundsberg; and one of the species (*S. pomum*) occurs near Boda and Wikarby, and at Hallebråten in Nerike. In the Silurian strata of St. Petersburg both species have been obtained, according to the Duke of Leuchtenberg.

The Sphæronites may be looked upon as the type of the whole family of Cystidea, for they are in all respects the most widely removed from the crinoidal type. Most especially is there a total absence both of any attempt at the development of arms and of any law in the arrangement of the plates, while the spherical form permitted the increase of growth to take place almost uniformly in all directions from a central point, rather than confined it to a given direction from below upwards, as in the Crinoidéa.

Genus CARYOCISTITES.

Pelvis formed of four basal plates, two large and two small. Three ranges of lateral plates rising one above another.

3. Caryocistites granatum, Wahlenberg. [*Echinosphærites granatum*, Wahlenberg, Acta Soc. Ups. viii. 53. *Sphæronites testudinarius*, Hisinger, Lethæa Suecica, p. 92. tab. 25. fig. 9. *a.*]

Plate III. fig. 4. Plate IV. fig. 2.

In this genus the plates are much larger than in *Sphæronites*. It seldom happens that new plates are inserted between the old ones, and the consequence of this is a greater regularity in the relation of the separate parts.

The pelvis (Pl. IV. fig. 2. *p* 1, *p* 2) consists of four plates as in *Caryocrinites* (see fig. 1), two of the plates adjacent to one another (*p* 1) being larger than the rest and forming irregular pentagons, while the other two opposite to them (*p* 2) are four-sided. If however the larger plates are bisected we have six similar quadrilateral figures, so that here also we may consider these larger ones as nothing more than pairs of smaller plates united together. The ovarial opening (*b*) is placed in the prolongation of a line drawn from the stem through the intersection of the two larger plates.

Six lateral plates (*q*) are placed on the edges of the hexagonal base. In the intervals between them, and therefore alternating with them, a second row of lateral plates (*r*) occurs, and again alternating with these a third row (*s*). A fourth similar series (*t*) forms the summit.

The ovarial orifice (*b*) is pentagonal, and generally rises above the plates. The five valves with which it was closed are seldom preserved.

The mouth (*a*) in the middle of the summit, which is always somewhat depressed, is elevated above the surrounding plates, but not by a true proboscis. The round anal orifice is close by, and, as in the Sphæronite, is placed on the right side of the ovarial aperture.

It must be considered as a remarkable character of this species, that the plates are not only entirely covered by the rhombic striæ, but so completely hidden by them that the lines of division between the plates are only to be made out when the surface has been deeply worn and rubbed. As, however, almost all the plates are hexagonal, the rhombic striæ, which follow the same law in the Cystidea that they do in the Crinoidea, and are invariably at right angles to the edges of the plates, form thus six rhombs proceeding from the centre of each plate, this central point being sometimes considerably elevated.

The genus *Caryocystites*, which we are now considering, has only been found hitherto in Sweden, at Bödahamn in the northern part of Oeland, and at Wikarby and Furudal in Dalecarlia. There is little doubt however that it may also be found near St. Petersburg.

4. Caryocystites testudinarius, Hisinger. [*Sphæronites testudinarius*, Hisinger, Lethæa Suecica, tab. 25. fig. 9. *d.*]

Plate III. fig. 5.

A singular form, which can hardly be identified with the last species. The cylindrical cup is so greatly elongated towards the two extremities, that the body almost disappears in comparison. It is a Sphæronite whose stem and proboscis are swelled out to monstrous proportions.

The body itself consists of very large hexagonal plates: they are much larger than those which enclose the Sphæronite, and consist of three rows alternating with one another, each row comprising six plates. The rhombic striæ on the surface are delicate, and do not conceal the divisions of the plates. It is almost certainly the case, that here, as in the other species, the pelvis is composed of four basal plates of unequal size, but this is difficult to make out distinctly, and the more so because little plates continue to cover the thick stem quite to its extremity, where a minute projecting point proves that besides this there was also a very slender pedicle attached, which served to fasten the animal to the ground. Five sharp projecting edges, traces of concealed arms, which are lost in the upper part, may be distinctly seen indicated in both the stems. On the upper side of the principal body, opposite to the pedicle, the somewhat remarkable pentagonal ovarial opening may be clearly distinguished.

The proboscis is scarcely smaller than the cup itself, and large plates enclose it quite to the extremity. Its length exceeds that of the cup, and contributes very much to produce the monstrous appearance of the whole animal. Quite at the top the usual broad depressed mouth may be readily distinguished (*a*), but the anal orifice (*d*) is more difficult to find. On the plates are ambulacral pores arranged in rows, about six in each row, from the centre towards the angles of the plates, as in *Hemicosmites.* We are not at present acquainted with the details of the law of their distribution.

Hisinger has united this species with the former under the name *Sphæronites testudinarius*, but since he has not given the reasons which induced him to abandon the older name, *S. granulatum* (adopted by himself from Wahlenberg, and given from the resemblance of the fossil to crystals of garnet), I have thought it better to apply his name to this remarkable species which he has considered as a variety.

Locality, Bödahamn in Oeland.

Genus HEMICOSMITES.

5. HEMICOSMITES PYRIFORMIS, v. Buch. [*Echinosphærites malum*, Pander, tab. 29. fig. 1, 2, 3, where the position is inverted, the stem being above and the mouth below. *Hemicosmites pyriformis*, v. Buch, Beitr. z. Best. d. Gebirgsform. in Russl. tab. 1. figs. 1 to 3, 6 to 8, 11 and 13.]

PLATE III. fig. 6.

It cannot be denied that there is considerable resemblance between this genus and *Caryocrinites*, but the manifest absence of arms separates it entirely from the Crinoidea, while the large ovarial orifice at the side [Pl. III. fig. 6. (*b*)] brings it into close relation with the other Cystidea.

Here again the pelvis is composed of four plates, two of them pentagonal and two quadrilateral, which by the bisection of the larger ones form six similar plates. Six large long plates form the side of the cup, and so symmetrically that they divide the whole into two dissimilar halves, in each of which the plates have a distinct form. The three which rest upon and between the two pentagonal plates are hexagons, each terminating upwards in an angular point, and two of them include in their upper half the large ovarial orifice, which is closed with five valves. In the opposite half, however, each lateral plate has its upper angle truncated, and thus from a hexagon becomes a heptagon. An upper row of six plates, corresponding to scapulars, incline inwards to form a dome-shaped vault, and terminating in a wedge-like manner they embrace the mouth. On that side on which the plates are truncated, but not on the other, there are three additional smaller plates inserted above the truncated angles in a direction towards the mouth.

The mouth is placed in the middle of the summit on a somewhat projecting proboscis covered with small plates. It appears as if this proboscis separated itself into three parts, which must have been surrounded with small plates since they do not remind one in the least of arms. All the plates are distinctly marked with concentric striæ of growth, but it is a remarkable and striking fact that there is no trace whatever of rhombic striæ.

Yet more striking however is the symmetrical and beautiful arrangement of the ambulacral pores upon the surface. From the middle of each lateral plate a double row of pores proceeds towards the vertical angle, and a single row towards the angles on each side of it, but on the lower half of the plate there are no distinct rows, but merely detached pores irregularly distributed. With regard however to the plates which form the summit, the case is just reversed, the lower half having rows and the upper half being without them, while here also, as in the lateral plates, the middle row is double and the others single. The upper part of the cup is thus decorated with a festoon of these pores, as we have already seen was the case in *Caryocrinites*, and the rows on the upper plates are in the same way covered by small vesicles which conceal the orifices. There is this difference however to be observed, that in the species we are now describing none of these vesicles and ledges can be seen between the rows of pores, which in the Caryocrinite ultimately divide the whole plate into six deeply-marked triangles.

The pores on the basal plates are hardly arranged in perceptible rows, but there are many irregularly distributed over the surface.

This remarkable and beautiful species appears not to be very common. It has been found at Pulcowa. M. Blasius has obtained it from Narowa near Narwa, and M. Eichwald mentions it also as occurring near Reval.

Genus SYCOCYSTITES.

6. Sycocystites angulosus *vel* Senckenbergii, H. v. Meyer. [*Echino-encrinus Senckenbergii*, Herm. v. Meyer. Kastner, Archiv für die Naturlehre, Bd. vii. S. 185. tab. 2. fig. 1–5. Bronn, Lethæa, tab. 4. fig. 1. *Echinosphærites angulosa* et *striata*, Pander, tab. 2. fig. 27–31. Vollborth, Bulletin Scientifique de l'Acad. de Pétersb. x. n. 19. tab. 1. 7–12. tab. 2. Bullet. de l'Acad. 1844. t. 3. n. 6.]

Plate III. fig. 7. Plate IV. fig. 3, 4.

The determination of this genus long rested upon the evidence of a single specimen, which has since disappeared and cannot now be referred to. M. v. Meyer has however described it so well and so distinctly that no doubt is left as to its peculiarities, and a specimen has been since clearly and well figured by M. Vollborth of St. Petersburg. Through the efforts of M. Kranz also, several specimens have at length (November 1844) been received at Berlin, so that now everything is obtained that can throw light on the investigation of this very remarkable species.

From all the Cystidea hitherto met with, the present is at once distinguished, first, by the unusually large dimensions of the stem; secondly, by the very large and projecting ovarial aperture, which is situated in the lower instead of, as in other cases, the upper half of the cup; thirdly, by the elongated form of the mouth; fourthly, by the very strikingly prominent rhombic striæ passing from one plate to another, and rendering the actual line of demarcation between the plates generally very difficult to find; and lastly, by a singular and finely striated basal plate, and a similar finely striated segment of a plate placed diametrically opposite, between the ovarial orifice and the mouth.

The stem is very slender at its further extremity, and is provided with articulations whose length is three or four times greater than their diameter. Towards the cup the diameter, however, increases, the articulations approach one another and become rings, and at length when they reach the basal plate and pass into it, this diameter is as much as one-third of the whole diameter of the cup (Vollborth, Bulletin de l'Acad. de Pétersb. x. tab. 2).

The base of the cup into which the stem passes is a nearly perfect square, which may become changed into a rhomb, the angles of which are blunted by the compression of the entire form. The basal plates are deeply depressed near where the stem is attached.

Four basal plates surround the depressed square in such a manner that each plate encloses one angle of the square, and its edges reach the middle points of the two enclosing sides. Three of the plates are terminated by similar triangles having the vertical angle directed upwards, but the fourth, in the direction of the ovarial orifice, has this vertical angle truncated. Hence it becomes possible that these four plates may support five *parabasalia* (corresponding to lateral plates), namely four alternating with and occupying the spaces between the triangular ones, and the fifth placed on the truncated angle towards the ovarial opening. A group of five parabasalia of the second order is placed alternating with and above these, and lastly, another group of five of smaller size and of the third order surround the mouth. All these plates are covered with very prominent striæ, which project like ridges and are at right angles to the edges of each plate, continuing without interruption from one plate to another, as in most of the Crinoidea and Cystidea. Only three ridges proceed to each edge, and two smaller ones pass into these to form a prominent triangle where three plates meet. Since therefore every plate is properly a hexagon, we have rhombs proceeding from each of the six edges, their longer diameters and acute angles meeting in the central points of two adjacent plates. Striæ of growth parallel to the edges of the plates fill up the space between the other striæ and at right angles to them, but are by no means so prominent.

It is yet more remarkable, but still common to all the individuals of this species, that one of the basal plates exhibits much more delicate perpendicular striæ than the rest, and that these fine striæ proceed to the adjacent plate. Instead of three of such striæ, also, there are no less than ten, and they appear at first sight to form two rhombic plates, while the striation of the edges of the plate through the middle of the smaller diagonal is entirely concealed. The plate so delicately striated is generally somewhat elevated above the adjacent ones, and in a line drawn from the pelvis upwards through this vertical point and between the two finely striated rhombs we find the mouth, which is distinctly elongated in this direction. On each side of the mouth and still in the same direction, there is also a very similar finely striated rhomb, which is formed from the lower triangle of the hexagonal plate of the third order and the upper plate of the second order, and is situated rather on one side between the ovarial opening and the mouth. These five striæ always terminate with an opening which penetrates through the plate, and from which doubtless ambulacra may have proceeded.

It is worthy of notice, that a section made through the finely-striated basal plate, the longer direction of the mouth, the ovarial orifice and the longer diagonal of the basal rhomb, would divide the entire animal into two symmetrical halves, which are always distinctly compressed parallel to this direction, to which indeed the singularly strong projection of the ovarial orifice may not a little contribute.

The elongated aperture which forms the mouth, and which is in the direction of the ovarial orifice, is surrounded by what may be called *lips*, consisting of a pouting forward of the plates which project outwards near the mouth. Upon these lips and around them may be seen five or six holes hardly larger than those upon the lateral plates, whence ambulacra appear to have proceeded; but sometimes these holes are open towards the interior, the side or wall in that direction being absent, and the appearance is then rather as if the lips were bent forward towards one another. It is highly probable that here also tentacula were protruded. M. Vollborth has noticed and drawn these, and believes that he recognises in them indications of arms as in Crinoidea; but it would indeed be strange, if, while everything else is so opposed to the Crinoidal type, there should thus be a spot at which arms were inserted. But even if this were so, we should not be justified in considering the present genus as Crinoidean, were it only for the large ovarial aperture on the side, which is not met with in the members of this latter family. These tentacula may possibly have been covered with small plates, like the proboscis of *Hemicosmites* and *Sphæronites*, and this Vollborth's drawing induces us to conjecture.

The large ovarial orifice occurs at the junction of four of the lateral plates, two of them being of the first and the other two of the second order. The middle striæ of each plate are elevated and swelled out almost to a cylindrical form, so that the junction of these four semi-cylinders forms the edge of the aperture and renders it quadrangular; but it happens occasionally, though seldom, that one of the plates is absent and only three surround the opening. It is quite peculiar to this genus, that the aperture in question is not, as in all the other Cystidea, placed in the same (the upper) hemisphere as the mouth, but in the lower half of the cup, nearly over the opening on which the stem is placed, and diametrically opposite the diamond-shaped set of pores on the basal plate.

The ridges which surround the opening very often rise so high that they project far above the side, in the manner of a proboscis; but that it is a true ovarial opening and not an anus, as it has been often considered, appears clear from what is observed in the Sphæronite and Caryocystite, where the mouth is always accompanied by an exactly similar smaller aperture adjacent, invariably acknowledged as the anus, and in the allied forms this aperture is in no case far removed from the mouth, while sometimes, as in *Pentremites*, it is actually placed within that cavity. Such may also be the case in *Sycocystites*.

It is a question whether *Sycocystites striatus* (Pander, tab. 2. fig. 30, 31. tab. 28. fig. 12) ought to be considered a distinct species or merely a variety of the foregoing. It is of the form described and figured by M. von Meyer, and in all essential points the two are identical, even with regard to the remarkable and striking diamond-shaped rows of pores, but the plates are covered with a larger number of striæ at right angles to the edges, and these striæ are not so prominent. In this so-called *S. striatus*, which attains a larger size than the species above described, there are ten or twelve striæ on every rhomb, and as many as fifteen in that marked by pores. The larger species is evidently the same as that described and badly figured by Schlottheim in the "Isis" for 1826 (Heft iii. tab. 1. fig. 1), the identical specimen having been before described by Von Meyer in January 1825. Schlottheim erroneously calls it *Echinosphærites granatum*, Wahl., and others have without examination repeated this mistake.

Both species have been found hitherto only at Pulcowa near St. Petersburg.

Genus CRYPTOCRINITES.

7. Cryptocrinites cerasus, Von Buch. [*Echinosphærites lævis*, Pander, p. 147. tab. 2. fig. 24–26. V. Buch, Beitr. z. Best. d. Gebirgsform. in Russl. p. 36. tab. 1. fig. 4, 5, 9, 10, 12. *Sycocrinites Jacksoni* et *anapeptamenus*, Austen, Annals of Nat. Hist. 1843, vol. xi. p. 206.]

Plate III. fig. 8.

Form nearly spherical, but somewhat swelled out in the lower hemisphere. Three plates surmount the slender pedicle, two larger, pentagonal, and one smaller, rhomboidal. As is the case invariably in the *Cystidea*, the two pentagonal plates bisected become each of them a pair of equal and similar rhomboidal plates.

Of lateral plates there are, first, a row of five, two of them placed on the bases of the two pentagons and the others touching two sides of adjacent plates. Five other plates alternating with these complete the cup. The mouth is in the centre of the summit, slightly prominent or probosciform, and covered with very small plates. The ovarial orifice is covered with five small valves, rarely preserved, arranged like a star; and in each of the valves is a small orifice open to the interior of the plate, as in *Sphæronites*, but situated exactly in the middle of the valve, and probably serving for the protrusion of the eggs. There is a remarkable arrangement admirably shown in a specimen in the Royal Collection of Minerals at Berlin, which clearly proves that this opening cannot be looked upon as an anal aperture. The aperture is placed at the junction of two lateral and one summit plate, and the lateral plate on the left side, which reposes on the intersection of the two basal pentagons, is divided throughout into two smaller plates which are attached at the broader sides of each; appearances which must manifestly stand in close relation to the arrangement of the internal organs. The anal opening is placed a little to the right, between the ovarial orifice and the mouth, but it is often hardly visible.

Five blunted corners may very distinctly be traced on this species, reaching from the pelvis quite up to the summit. They are unquestionably indications of arms which have vainly endeavoured to become liberated towards the summit and extend themselves upwards.

Although the specimens described exhibit no traces of rhombic striæ, this may in all probability have arisen from the worn condition of their surface.

Locality:—Pulcowa, and also Narwa on the Narowa, according to M. Blasius.

Mr. Austen states that *Sycocrinites* exhibits three dorso-central (pelvic) plates, which form a pentagon, and supporting five perisomic (lateral) plates, while five other plates rise in a dome-like form to the central mouth. He adds that an anal (ovarial) orifice is found at the side, and that there are no arms. This is manifestly the description of a *Cryptocrinite* (so named in 1840); but this author does not state the locality of his specimen, and not even whether it is English; and this is so much the more to be lamented, since it is important to know, in case of this locality being, as it probably is, in England, with what Crinoidea it was found associated. The *Sycocrinites clausus* has however an additional row of lateral plates, and would properly form a distinct genus.

The so-called *Asterocrinus* of Austen, provided with ambulacra, evidently belongs to the *Blastoidea* of Say, and approximates closely to the *Pentremites*.

Some fossils described by M. Eichwald and named *Cyclocrinites Spaskii* (Urw. Russl. p. 48. tab. 1. fig. 8) and *Heliocrinites echinoides* (Duke of Leutchenberg, p. 18. tab. 2. fig. 11, 12) are too indistinctly known to be identified. They are round bodies not having any visible place of attachment for a stem, and neither mouth nor ovarial orifice, and therefore nothing that can mark them as belonging to the *Cystidea*. M. Eichwald conjectures, and with some probability, that they may be coralline bodies, perhaps *Favosites* (*Calamopora*) resembling the specimens described by M. Pander (tab. 29 of his book, fig. 4, 5, 6).

The Cystidea belong unquestionably to the most ancient formations of the earth's surface, to the Silurian strata of the Palæozoic period. In more recent formations nothing analogous to them has hitherto been met with, and still less do they appear in the existing creation. That they form the extreme verge of an entire group of *Radiaria*, is shown by these ancient and isolated examples; and the *Caryocrinite* indicates in a most singular manner in what way the passage from *Cystidea* to *Crinoidea* may have taken place. As soon as this happened and arms were developed, this group of animals multiplied itself immediately into a vast variety of forms, and during the carboniferous period appears to have attained its maximum.

The closed cup which in *Cystidea* enwrapped and concealed the whole animal then gradually disappeared, and at length, as in *Pentacrinus*, is hardly more than a basis upon which the soft parts were supported.

In the rocks of the Oolitic series, the multitude of genera diminished rapidly, while the distribution of the separate species increased in almost the same proportion; and at length, in the upper oolites, we find that the animal had broken loose from its pedicle, and, in the form of *Comatula*, appears as a free swimming animal.

Apiocrinites ellipticus is almost the only true Crinoid of the chalk which connects itself with the older forms, and *Pentacrinus Caput Medusæ*, which still remains, offers but a faint shadow of the noble and beautiful sea-lilies of the ancient seas. But in the *Pentacrinus europæus* (*Comatula rosacea*), discovered in 1827, we seem to have this whole change brought about in the transmutations of a single species. Müller (*Pentacrinus*, p. 7) thus expresses the modification:—" The younger specimens appear like little clubs (*Cystidea*) fixed by a spreading base, and send out from their summits a few pellucid tentacula. No portion of the hard part is visible, except an indistinct appearance of the cup. At a more advanced stage the arms begin to appear, at the same time with the prolongation of the stem, and the pinnules are more prominent and become visible as cirrhi, on which the arms elongate. It is then a Crinoid. When full-grown the animal disengages itself entirely from its stem, becoming a *Comatula*, and now swims freely in the sea without being interfered with in its further development."

Note.—*Pseudocrinites bicopuladigiti*, figured by Mr. R. Garnet in the 'Natural History of Staffordshire' (fig. A. 8–13), copied in the 'Athenæum,' No. 803, fig. 10, and described by Messrs. Bennett and Pearce, is manifestly a *Cystidea* resembling *Caryocystites*. An ovarial orifice may be observed in the upper part, and beyond the basal plates three rows of hexagonal plates rise one above another to the completely enclosed summit. The specimen is in the Dudley Museum, but the locality is not given.

A species figured and described by Mr. J. Sowerby in the 'Zoological Journal' (ii. 318) also probably belongs to this family. Five long tentacula proceed from the mouth. A large ovarial orifice may be observed at no great distance from the mouth, and a considerable number of irregular plates surround, as in *Sphæronites*, the spheroidal figure. It was discovered by Mr. Bigsby not far from the falls of La Chaudière on the Ottawa river in Lower Canada.

D. T. A.

DESCRIPTION OF THE PLATES.

Plate III.

Figure 1. *Caryocrinus ornatus*, natural size, viewed from the side.

a. Mouth.
c. Base, and attachment of the stem.
e, *e*. Single arms.
f, *f*. Pairs of arms.

2. Ditto, seen from above.
3. *Sphæronites aurantium*, natural size, viewed from the side.

a. Mouth and proboscis, with the small anal orifice (*d*) adjoining.
b. Ovarial orifice closed with valves.
c. Attachment of the stem.
d. Anal orifice*.

4. *Caryocystites granatum*, natural size, viewed from the side.
5. *Caryocystites testudinarius*, ditto.
6. *Hemicosmites pyriformis*, ditto.
7. *Sycocystites angulosus* vel *Senckenbergii*, ditto.
8. *Cryptocrinites cerasus*, ditto.
9. Ditto, seen from above.

* The same letters of reference apply to the remaining figures in this plate.

Plate IV.

Figure 1. *Caryocrinites ornatus.* The separate plates detached to exhibit the law of their arrangement.

a. Mouth.
c. Attachment of the stem.
e. Single arms.
f. Pairs of arms.
p. Basal plates.

p_1. Small four-sided plates.
p_2. Large five-sided compound plates.

q. Lateral plates.

q_1. Hexagonal plates leading to, and opposite, the mouth.
q_2. Pentagonal plates.
q_3. Heptagonal plates.

r. Scapular plates.

r_1. Plates terminating downwards in an angle.
r_2. Plates resting on a truncated angle.

2. *Caryocystites granatum.* Plates detached.—The whole of the pelvic plates and the lateral plates on one side exhibiting the position of the mouth and ovarian orifice.

p. Pelvic plates.

p_1. Pentagonal plates.
p_2. Quadrangular plates.

q. Lateral plates, first row.
r. Ditto, second row.
s. Ditto, third row.

s_1. Pentagonal.
s_2. Hexagonal.

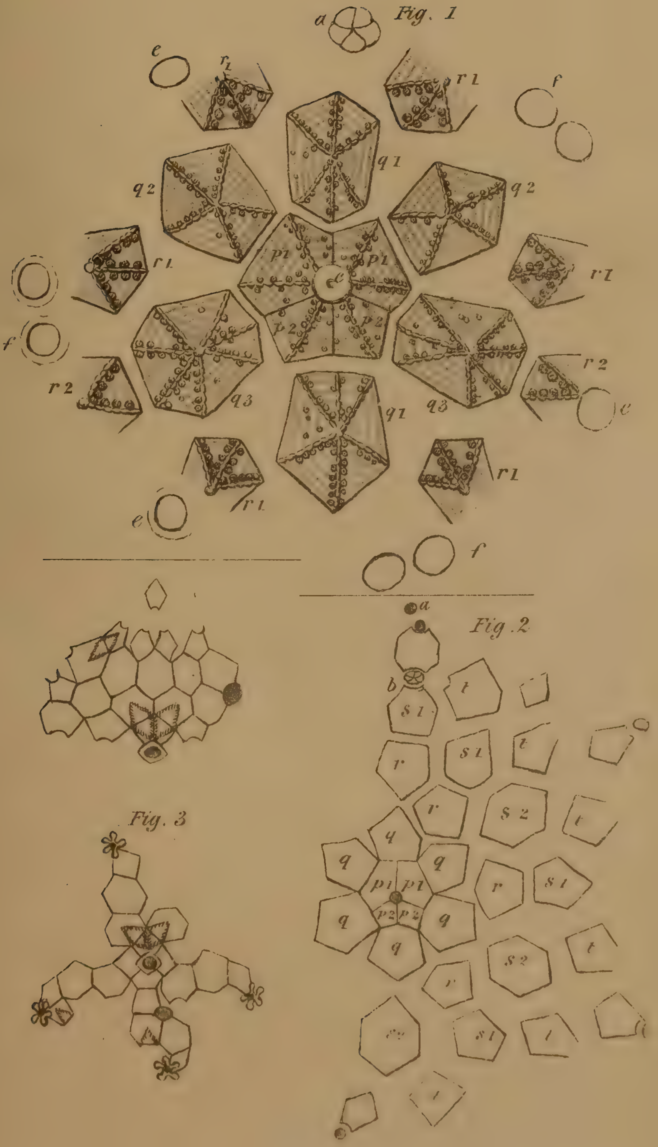
t. Ditto, fourth row.

3. *Sycocystites Senckenbergii.* The development of the separate plates.

W. H. Baily, Zinc.

Day & Haghe Lith. [illegible] the Queen

CYSTIDEÆ VON BUCH



W. H. Baily. Zinc

Day & Haghe

II. NOTICES OF NEW BOOKS.

Traité élémentaire de Paléontologie, *ou Histoire Naturelle des Animaux Fossiles*. Par F. J. Pictet, Prof. de Zool. et d'Anat. Comp. à l'Acad. de Genève*. 4 vols. 8°. Paris, 1844–45.

Of this work, which has been very favourably noticed by M. Agassiz, the friend of the author, three volumes only have hitherto appeared; the fourth, which is to contain a general *résumé*, and a sketch of the history of organization, founded on the principal data which geology furnishes concerning the various phases through which our globe has passed, will be published, it is believed, very shortly.

The plan of the work is simple and convenient. The author commences with some general considerations on Palæontology as a science, on the nature of fossilization, the geological distribution of fossils, the zoological principles of classification, and the determination of fossils. Assuming that his readers possess some knowledge of natural history and comparative anatomy, without which, indeed, any useful knowledge of palæontology is impossible, he then describes the various genera found fossil, merely enumerating the principal extinct species, and only dwelling at length on generic forms when the genus is no longer met with on the earth. The first volume includes an account of the Mammals and Birds; the second, the Reptiles, Fishes and Cephalopodous Mollusks; and the third and fourth include the remainder of the Invertebrata. These volumes being to a certain extent elementary, cannot be expected to present in the body of the work any points which admit of special notice; but the views of the author, as expressed in his chapter on the geological distribution of fossils and the succession of extinct species on the globe, and also on the theories which have been suggested to account for palæontological phænomena, it may be useful to put before English geological readers, since, though they do not in all cases agree with the prevalent opinion on such subjects in our own country, they are systematically expressed, and illustrate views held by an important section of continental naturalists.

It is one of the most elementary facts of geology, that there are certain groups of species found fossil in the various sets of strata of which the earth's crust is made up, and that these demonstrate the

* Elementary Treatise on Palæontology, or Natural History of Fossil Animals. By F. J. Pictet, Prof. of Zool. and Nat. Hist. in the University of Geneva. 4 vols. 8vo. Paris, 1844–45.

existence of something like a series of distinct faunas. "The comparison of such faunas sometimes presents very important results, by generalising from which certain supposed laws have been arrived at, which it is assumed have governed the succession of organized beings. Possibly these have been too hastily assumed, and the importance of some phænomena overrated; but at any rate such generalizations have been useful, and they have greatly tended to advance palæontological science. It will be useful to consider what these supposed laws are, and how far they are well-grounded. The number of the principal ones may be reduced to five, and we will examine them successively."—Vol. i. p. 57.

Law 1. "*The species of animals belonging to one geological epoch have not existed either before or after this epoch, so that each formation has special fossils, and identical species are not found in two formations of different age**.

"Concerning this law, I believe that the progressive advance of science will every day demonstrate more clearly its certainty and generality; but it is one not equally admitted by all geologists; and many, whose authority possesses great weight, consider that although true with regard to the greater number of the species of each epoch, yet that it is not generally true, since many species, as they suppose, have been carried through, and are the same, from one epoch to another.

"The determination of the question thus at issue is a matter of great interest in palæontology, for upon the degree to which our supposed law is admitted, depends entirely the opinion that will be had of the application of this science to geology. If fossils are peculiar to certain formations, they characterise them absolutely; but if, on the contrary, some are peculiar, while others are common to several groups of strata, a portion only of the whole number can furnish us with results, and thence is introduced a source of considerable uncertainty and great chance of error. Those geologists who have not admitted what may be termed the speciality of fossils, but who at the same time are aware that these bodies must exercise an inportant influence on the determination of formations, have made a distinction between *characteristic fossils*,—those namely whose presence is looked upon as a certain criterion by which to mark the age of a bed, and those, on the other hand, which are not characteristic, or, in other words, are not capable of being made use of for such purpose. But those naturalists who admit the speciality of fossils regard them all as characteristic and as furnishing equally certain results, provided only that they are distinctly made out.

"In the discussion of this important law, palæontologists do not all start with the same data. M. Defrance indeed has assumed a sort of special position in the study of fossil shells. In comparing them,

* [This being a view altogether different from that taken by most English palæontologists, I have thought it better to translate literally the illustration of the supposed law as given by the author.—Ed.]

he distinguishes three degrees of resemblance, denominating those *identical* of which the individuals compared present not the smallest difference; describing as *analogous species* those which differ by such peculiarities as in existing species would mark varieties, and which may be attributed to local or climatal influence; and recognising as *subanalogous* those which have but an imperfect analogy, passing beyond the limits assigned to varieties of the same species. He only considers as *extinct species* those which have none of these degrees of resemblance with existing forms.

"This method of comparison has been favourably received by many geologists and conchologists, nor would I deny that it has exercised a happy influence, by directing attention to the various degrees of resemblance that exist between fossil and living shells. But it seems to me that it introduces unnecessary complication into the question now under discussion*; and that instead of four kinds of difference and resemblance, it is more simple, more logical and more natural to admit but two. I think that the point is, not to determine whether shells are *identical*, *analogous*, *subanalogous* or *extinct*, but to settle whether or not they are of the *same species*.

"If we, in fact, consider attentively the distinctions established by M. Defrance, we shall see that the group of *analogous shells* is by no means brought within clear and well-defined limits. If this skilful naturalist only considers as analogous those forms, between which the differences are such as would allow us to unite them as varieties of the same species, if they were both recent, there is in fact no real distinction between identical and analogous species, since absolute identity never exists, and the difference is confined to unimportant characters, not sufficient to prevent our recognising the two forms as resulting from the same stock. Between the minute variations which the naturalist entirely neglects and those which induce him to designate a certain form as a variety, there are insensible gradations, which entirely disappear in comparison with the important fact of identity of specific character in the species which exhibit them.

"But if M. Defrance understands by *analogous species* those which differ by characters *a little more considerable* than such as are met with in the varieties of recent species, and admits at the same time that such differences may have been produced by the influence of climatal changes or by geological causes, his distinction becomes more suspicious, for he prejudges a doubtful question, assuming the agency of causes, the extent of whose action is unknown and ill-defined. For the determination of so nice a question, we are only at liberty to reason from positive data, which the study of existing nature can alone furnish; and to admit other influences is in fact to give up gratuitously positive facts for hypotheses. If two species differ by characters which cannot be explained by the influence of external agents, limited as we know them to be at present, the pa-

* "I speak here only of the main question. There are others secondary and of smaller importance, where the degree of resemblance between different shells is a matter of considerable interest."

læontologist is bound to consider them as distinct species in the present state of science. He will in this way bring together facts that may be compared; and the limits of species will possess for him a clearness which they cannot have if it is admitted that they may vary in a manner not admitting of strict definition, and from the influence of causes which escape detection for the very reason that they are supposed to be different from those which act at present*.

" The group of *subanalogous species* seems to me no better established than the analogous ones; for if the shells so designated differ by characters too important to allow of their being referred to the same species, it is clear that in the view of the question we are now taking, this word is synonymous with *different* or *extinct* species.

" I think therefore that it is more proper and more conformable to facts, not to take account at present of these intermediate degrees of analogy; but in discussing the law of the speciality of fossils, to apply to the investigation of these remains of ancient animals the same laws which guide the naturalist in the establishment of existing species. The distinctions established by M. Defrance will still be useful in the comparison of the extinct species of different geological faunas, since it may often be a matter of interest to know the greater or less degree of resemblance that exists between such species and those which preceded or succeeded them.

" This point being established, the question is simplified, and its solution depends entirely on the examination of facts under the guidance of zoological principles properly so called. It may seem then that we have only to compare the lists of the fossils of each formation as established by palæontologists, in order to see whether the same names are repeated; but unfortunately these lists, often prepared hastily, and sometimes by superficial observers, or by those little versed in zoology, are not always such as to inspire confidence, and indeed most of them abound with errors. The result of the comparison, if these lists are taken, is, that many species occur in more than one formation; but the more carefully fossils are studied,

* "These strict limitations in laying the foundation of our argument by no means prevent subsequent discussion concerning the prolonged influence of external agents; and I think that the partisans of the theory of the passage of species from one formation to another must necessarily grant so much as a point of departure. Logically there are for them but two courses to take; namely, either to limit, as we have done, the determination of fossil species by the same principles as those which are introduced with regard to existing nature, or else to reunite as the same species all those animals which they consider to have proceeded from the same type. Now if this last method is followed, a mischievous variability is introduced with regard to the limits of specific character. One naturalist will group together only certain animals which seem to him to possess resemblances too considerable to admit of other than a common origin. Others, adopting to a greater extent the theory of gradual development, will associate under a common specific name, genera and even whole families which they look upon as forming a series of modifications of a primitive type. There is no longer either fixed rule or unity. I am indeed well-aware that these extreme results are far from according with the views of the learned conchologist whose opinions I am combating, but it is dangerous to advance even a single step in a wrong direction, lest we should be obliged to follow out such a mistaken route to extremity."

the more do these supposed identifications disappear; and I firmly believe that as the science advances, it will be found to have been only by mistaken resemblances that the same name has been applied in the catalogues to fossils of different formations. The present state of palæontology does not perhaps permit us to affirm this, but every probability is in favour of the speciality of fossils. All the investigations properly made by careful zoologists, and with the precision which is now demanded of the palæontologist, have invariably terminated in the result, that the fossils of each formation are different. The most eminent palæontologists are now agreed with regard to this fundamental fact; and I am perfectly satisfied that we may fully expect its confirmation as time advances. It was indeed natural that the first observers should have been more struck with analogies than differences, for a slight and superficial examination is sufficient to exhibit the former, but it requires more labour to make out the latter; and this indeed has been the case even with recent species, ancient authors having often grouped under one name several allied species, which have been since separated. With regard also to fossils at one time identified, we find that afterwards more accurate or less hurried observers have found differences where they had not before been seen; and hundreds of cases might be quoted in which species at one time united have required separation, and have thus served to demonstrate the truth of a law which they before seemed to contravene.

"From future investigations, we shall one day learn how far this law extends; but most palæontologists have already admitted it with reference to the four great geological periods, and even for the principal formations into which these have been subdivided*. Thus it will hardly now be denied, that in the secondary period, the fossils of the triassic, jurassic and cretaceous formations are completely distinct, but it is probable that we may go still further, and that the groups of strata of which these larger divisions are made up also possess peculiar faunas. The best recent investigations seem, for instance, to show, that in the cretaceous series none

* These are, according to our author,—
4. Diluvial period.
3. Tertiary period (upper, middle and lower).
2. Secondary period (cretaceous, jurassic, triassic and Permian).
1. Primary period (Carboniferous, Devonian and Silurian).

[It may not be amiss here to refer to the recent investigations of Dr. Philippi, on the Tertiaries of South Italy, translated in the present number of this Journal (Part ii. p. 1); to the discovery by Professor Owen of the remains of existing species of Mammalia in the middle tertiary deposits (see his work, now in course of publication, on the British Fossil Mammalia and Birds); to the identification by M. Deshayes of at least two species of shells common to the tertiaries and the chalk (Bul. de la Soc. Géol. de Fr., 2nd Ser., vol. for 1844, June 17); to the probable identity of the Ichthyosaurus found in the lower chalk with a common species (*I. communis*) in the lias (Owen, Rep. of Brit. Assoc., 11th Meeting, p. 193); and to the statement by M. de Verneuil, that of the Russian Palæozoic fossils, as many as *eighteen* species are common to the Permian and older formations; or, in other words, to the secondary and primary periods of M. Pictet (Geol. Journ. vol. i. p. 87).—Ed.]

of those species found in the neocomian (lower greensand), albian (gault and upper greensand) and chalk groups are common to either of the others. M. d'Orbigny goes yet further, and states that he has not found any species common to the *turonian* and *senonian* portions of the chalk*, or to the *neocomian* and *aptian* divisions (the lower greensands and gault) of the neocomian group. These results arrived at by M. d'Orbigny inspire great confidence; and it is left to future investigators first to demonstrate where the universality of these differences stops, and then to modify from these considerations the classification of the strata.

"I must not quit the discussion of so important a law without one more observation. I have said that the demonstration of the law must be effected by a knowledge of facts; but there occur, though rarely, cases in which these facts may be interpreted differently, according as the preconceived opinion of the palæontologist who describes them is favourable or otherwise to the truth of the law. Such cases may seem to serve for arguments on both sides; and a simple reference to some well-marked genus will exemplify the meaning and truth of this. If, for instance, we compare the skeletons of existing species of hares, we can scarcely, with regard to some of them, find any distinctive characters. If then a fossil hare is discovered, especially if we only obtain a few fragments, it may happen that these may seem identical with some of the recent species. The palæontologist who examines these remains may therefore either declare that the species is identical with those now living, or that it is an extinct species, of which the distinctive characters probably existed in the soft parts and were not sufficient to be indicated in the skeleton. The rarity of such instances, and their small importance for the determination of strata, prevent any real confusion from being introduced by this cause."—Vol. i. pp. 58–66.

LAW 2. "*The differences which exist between extinct and existing groups of species are greater in proportion as the faunas are more ancient*; or, in other words, *the more ancient the formation, the more widely do its fossil contents depart from the existing type.*"—P. 67.

The author states that this law is distinctly exemplified whenever we compare the fossils of different periods; and people are not unfrequently inclined to designate new forms as strange and anomalous when they differ widely from those with which we are familiar.

It appears, if we attempt to express the amount of this difference, that in the most recent beds the species are generally referable to existing genera; that descending to those at somewhat greater depths we must group them into new genera; and that in the older formations additional orders and families require to be introduced.

* [These two names have been assumed by some French geologists to designate the lower and upper portions of the chalk; the former including a portion of the upper greensand, the *craie tufau*, the *glauconie crayeuse*, and the *craie chloritée*; and the latter the chalk with flints.—ED.]

This law is true for all classes of animals, but is differently exhibited in each, the groups first introduced having, it would seem, undergone the smallest amount of change and the converse. Thus, if we compare the mollusca and mammalia, we shall find that the former, which existed at the earliest period, have hardly changed their form since the close of the cretaceous epoch, and that the shells of the tertiary period are generically the same as those now existing; while the mammalia, though only recently introduced, have been subject to many changes, and have required the introduction of new and important groups.

But this law, though sound as a general expression of results, must not be applied too minutely. The nautilus and the terebratula, the companions of the most ancient form of cephalopodous and brachiopodous mollusca, are still represented by existing species; and associated with the pachyderms of the earliest tertiary period we find bats and small carnivora, which can hardly be distinguished from animals of the same kind now living.*

LAW 3. "*The comparison of the faunas of different epochs shows that the temperature of the earth's surface has undergone change.*" —Page 69.

This appears from the discovery of the remains of animals in parts of the world where the nearest allied species could not now exist; and it has also been supposed that the extinct faunas of northern Europe indicate a climate nearly tropical. It is probable however that this law has been the result of a generalization somewhat too hasty, the most that we can safely assert at present being, that there have existed different climates at the same spot at different geological epochs, and that the changes in the cases we are best acquainted with were sometimes, and most frequently, from a higher temperature to a lower, but sometimes also from a lower to a higher.

LAW 4. "*That the species belonging to the more ancient periods had a wider geographical distribution than the species now living.*"—Page 73.

This is a law rather indicated than demonstrated, and it is clear can only be definitively admitted when the numerous localities still unexamined have given evidence on the subject. There appear to have been certain species now extinct which were formerly common to Europe and America; while others, and those too of no ancient date, were spread over Europe and northern Asia as far as the frigid zone. This would seem to show that the temperature of the earth was formerly more uniform than it is now; and it may perhaps also appear that the sea was more shallow than at present, and admitted a wider extension of the marine mollusca.

* [With regard to the evidence for this and the two succeeding laws, the substance of the author's opinion has been given without actual quotation.—ED.]

"The preceding laws may be considered as established on something like a solid basis: that which follows can however only be admitted with great restrictions."

Law 5. "*The faunas of the most ancient formations are made up of the less perfectly organized animals, and the degree of perfection increases as we approach the more recent epochs.*"

"This is a law which has long been considered as demonstrated, and it has served as a point of departure for many theoretical views. A more strict and rigorous analysis has however of late years considerably shaken it, and we are now in a condition to affirm that it has at least been greatly exaggerated. Its importance both in itself and with reference to the consequences deduced from it, requires that it should be discussed at some length."—*Page* 75.

The author, after some further remarks, proceeds to state that those who attribute the present state of organization at the surface of the globe to a gradual perfecting of the lower forms of organization during the lapse of a series of ages, who believe in spontaneous generation, and who admit the possibility that species may pass from one form to another by the varying influence of external agents and a change in the media in which they live, readily embrace a view which seems to recall in the actual monuments of past ages the different phases of this organic development.

"It is then not to be wondered at, if, under the influence of this accordance, the idea of the gradual advance of animal organization towards perfection has struck deep root, and that in the infancy of palæontology men have hastened to group around it the facts with which they became acquainted. But now, when accurate observations are more multiplied, if we endeavour calmly and conscientiously to discuss these theories without allowing ourselves to be dazzled by their brilliancy, we shall find ourselves obliged to strip them of almost all their value as generalizations and reduce them to very scanty proportions. It will soon appear that the law as expressed above can only give a false and incomplete idea of the facts which it distorts or exaggerates.

"To demonstrate this, we must first of all obtain accurate notions concerning those circumstances and conditions which induce us to consider one kind of organization as superior to another; we must also satisfy ourselves as to the way in which animals now living present themselves under this point of view.

"The idea of the gradual advance of organized beings towards perfection is connected more or less with the theory of a *scale of beings*; that is, with the opinion that all animals together form a series, of which man is the crowning point, and that in this series each species is less perfect than that which precedes it, and more perfect than that which succeeds it, thus forming as it were a link of an unbroken chain. This idea of a scale of beings is based on the evident fact that there are different degrees of perfection (or complication of organization) in the animal kingdom; it is consequently true in a very vague sense, but I believe totally inadmissible if we give it a distinct meaning, and assume that all created beings are connected by any single or continued series. It is indeed impossible to place all existing animals in such an order that we can successively pass from one species to another, each gradually decreasing in perfection; but as we cannot here enter fully into the consideration of this theory, which is one familiar to all zoologists, I will content myself with quoting two groups of numerous facts which are opposed to it. On the one hand there are classes of animals so completely detached, that they have nothing to connect them with the rest, thus creating in this imaginary series very important breaks of continuity; and on the other hand, there are types of organization which are absolutely indivisible, and such, that while their more perfect forms are superior to those of another class, the less perfect are inferior, as is the case with regard to the Mollusca and Articulata, the former being superior to the latter in the *Cephalopoda* but inferior in the *Acephala*, so that we cannot arrange the mollusca and articulata in any continuous series. It is also the case that these types have different kinds of perfection according as the conditions of a certain kind of organization are realized, so that it is extremely difficult to bring them into comparison. The highest molluscous, articulated, or radiated animal is each characterized by a different sort of perfection, which precludes us from deciding on its relative superiority to the others.

"We do not therefore admit the *scale of beings* as the starting-point in the discussion of this law, and it appears to us that the true idea of the relative perfection of the organization of different animals is the following:—These beings are divided into a certain number of groups, each of which exhibits a peculiar type; but while some of the groups are manifestly superior to others when we consider their organization generally, it happens also that the result of a comparison sometimes fails to establish any real superiority. The most perfect type is that of the *Vertebrata*, which must evidently be placed far at the head of all the inferior groups. It is itself divided into four other types exhibiting very unequal degrees of perfection of organization. The mammalia are more perfect than the birds, and the birds than the reptiles, while the fishes are in this view the most imperfect. But in the invertebrata the distribution is by no means the same, and the principal classes, the *Mollusca*, the *Articulata* and the *Radiata*, are superior or inferior to one another according to the point of view under which we regard them and the species which we compare, so that we are no longer able with them, as with the vertebrata, to arrange them in a series, where the most imperfect of the first group is superior to the most perfect of the second. Each type again of the invertebrata subdivides itself unequally, although these subdivisions might, more properly than the principal group, be arranged in continuous series.

"If now, in comparing different creations, we apply these views, less simple it may seem and perhaps more vague, but probably also more correct than the others, we shall find, in the first place, that the faunas of the more ancient formations are far less imperfect than has been often supposed. The vertebrate type is already represented in them by the fishes, and the different classes of the invertebrata are by no means reduced to their less complex forms of organization, since, among the mollusca for example, we find numerous examples of gasteropoda and cephalopoda, the most perfect orders of the class. It cannot be said therefore with regard to the invertebrata, that the faunas of the more ancient formations exhibited organization inferior to that presented in newer deposits; and the most that can be asserted is, that among the vertebrata the most highly organized animals of the oldest period seem to have been fishes. If then we would deduce the true character of most ancient faunas, we shall find that they bear comparison with the groups of existing animals, excluding reptiles, birds and mammalia, and that all the types, including those of fishes, were then represented by animals as perfect as those of the present day.

"The intermediate faunas, such as that of the Oolitic period, differed from those of the earlier and later periods by analogous characters. The fishes, the mollusca, the articulata and the radiata, compared with the preceding and succeeding forms, exhibit similar organization neither more nor less perfect. But these intermediate faunas differed from the earlier ones yet further, since the vertebrata in them included reptiles and didelphine mammals, while they differed from the more modern ones by the absence of the monodelphous mammals.

"We shall find then that neither the radiata, nor the articulata, nor the mollusca, nor the fishes, were imperfectly developed in ancient times, and that ever since their first appearance the species belonging to these classes of animals have possessed the same degree of perfection as those that live now. It is therefore a mistake to suppose that the early faunas generally were composed of animals less perfect than the recent ones, although indeed we find that the highest point to which organization reached has risen during successive geological periods; so that while fishes at first formed the superior limit of organization, they were afterwards surpassed by the reptiles, and these also, after an interval, by the mammals.

"To such greatly narrowed limits therefore, the law we are discussing must now be reduced. It is not true when applied to organization generally, but it expresses a fact when so limited as to mean only 'the appearance of the higher forms of organization'; and thus limited, it will even, according to the present state of our knowledge, hardly serve to establish the notion of a marked superiority in the existing faunas. With reference to this point however I will conclude with two observations.

"The first is, that we ought not to be too hasty in assuming the absence of certain more perfect types in the older faunas merely because we have not yet discovered any remains of them. We hardly know anything of these faunas, except with regard to some of the inhabitants of the sea, and it is well known that in the present condition of the globe, those animals living on land exhibit the higher forms of structure. Is it not possible that in these first ages of the world, terrestrial animals also existed more highly organized than their marine contemporaries, although their remains either have not been preserved or are still to be discovered? The existence of didelphine mammals in the oolites has been made out by the discovery of a very small number of fragments; and the remains of land animals generally are hardly fossilized, except by sudden deluges and inundations, which are always trifling in their results compared with the slow but unceasing deposits from the water of the sea. May we not yet expect new discoveries in these ancient strata, revealing to us the existence of primæval animals at present little suspected?

"A second observation I would offer is, that when we endeavour to compare the actual state of the globe with the various former creations, we shall find that the highest degree of perfection of organization will not always furnish conclusive results with regard to the perfection of the faunas.

"Putting out of the question the presence of man, should we, for instance, assert that the fauna of Asia is superior to that of Europe because its highest point is the orang-outang; and should we place the fauna of New Holland much below the rest because its mammals are almost all didelphine? Such conclusions would however be nearly as legitimate as some of those which have been established by the comparison of geological faunas."—Vol. i. pp. 76–83.

Having thus discussed the laws which have been supposed to regulate the distribution of fossils, the author proceeds to compare the different theories most in vogue by which it is endeavoured to explain the phænomena observed.

"Of these theories there are only two which require to be considered in any detail. But M. Pictet states his own opinion to be that neither of them is satisfactory, and that he looks forward to a better explanation being furnished by the progressive march of palæontology.

"The succession of organic beings is explained by some theorists by the *transformation of species*, assuming that the animals of the ancient formations have become modified by the influence of atmospheric and climatal changes, &c. which the globe has undergone, so that the original forms have insensibly become metamorphosed into others, of which the different strata have preserved and handed down the indications, and these forms have at length by successive changes attained their present condition.

"The other theory supposes a complete destruction of all the species by each catastrophe which has terminated an epoch, and a new creation at the dawn of the next succeeding epoch.

"The theory of the transformation of species seems to me totally inadmissible, and diametrically opposed to everything that we learn from the study of zoology and physiology. This theory connects itself, as I have before observed, with the idea of a scale of beings, and that of the gradual advance towards perfection in the succession of geological periods. This indeed is the bond of union, and the completion and the explanation of such an idea, giving it the consistency of a system. The naturalists who have adopted some of these views are naturally led to accept the others, and the same reasons which I have already adduced, and which lead me to deny generally and absolutely the existence of a scale of beings and the gradual advance to perfection of successive geological faunas, also oblige me to reject the notion of the transmutation of species as accounting for the succession of organized beings on the surface of the globe.

"In conducting this argument, it is necessary to point out how little reason there is for assuming that the powers of nature were at an earlier period of the earth's history very different from what they are now. The same general laws which now govern the world have probably been in action ever since its first creation, and it is impossible to admit any essential difference in their nature. The most that we are at liberty to do is to conjecture that the limits of action of each may have been somewhat more extended, that the temperature, for instance, may have been higher and the aqueous deposits more abundant and rapid, but the influence of these agents on organization must have been analogous to that which under similar circumstances would be exercised at present.

"The study of the fossils of the more ancient rocks exhibits similar organization to that of existing species, and there is nothing from which we can safely conclude that the temperature was very different or that the constitution of the atmosphere varied. To admit therefore any modifications in organization produced by external agency, seems to me the needless introduction of a ground of uncertainty, and the phrases so often made use of with reference to the youthful vigour and the more energetic forces of nature at an earlier period should, I think, be avoided, as representing false, exaggerated, or indefinite views.

"If then, assuming a sounder basis, we endeavour to deduce the unknown from the known,—that is, to apply to the earlier period of the earth's history what we have learnt with regard to existing nature,—we shall arrive at the following conclusions.

"All observations and researches of any value agree in proclaiming the permanence of species at the present day. The thirty centuries which have passed away since the Egyptians embalmed the carcases of men and animals, have not in any way influenced the characteristic peculiarities of the races which inhabit Egypt. The crocodiles, the species of ibis and the ichneumons now living there, are identical in specific character with those which so many ages ago trod the banks of the Nile. Between the living animal and the mummy there are not only no differences in the essential organs, but there are none even in the most minute details, such as the number and shape of the scales, the dimensions of the bones, &c. And this permanency of species seems ensured to us by nature by the existence of those important regulations which prevent the mixture of distinct races, and the consequent formation of intermediate types. All physiologists are aware, that if two species are not very closely allied, they will not breed together at all; and that even if the species are very near, but not identical, they produce hybrids which are incapable of continuing their race and becoming the progenitors of a modified form or new species. Every aberration from the type in the way of crossing species is thus instantly stopped.

"True it is, indeed, that the changes and varieties introduced in domesticated species have been brought forward as an argument against this conclusion; but although such changes unquestionably take place in horses, oxen, sheep, pigs and goats, and yet more remarkably perhaps in dogs, where the form of the cranium becomes modified, yet these very facts appear to me to furnish a conclusion totally different from that which it has been attempted to draw. The individuals the most widely removed from the primitive type never present any real difference of form in the important organs. The skeleton always exhibits invariable characters, as well with regard to the number of the bones and their apophyses as to their relations with one another, while the organs of nutrition, the nervous system, and in short every distinctive peculiarity of organization is submitted to the same law. The only marked difference exists either in the absolute dimensions, a point known to be very variable, or in external peculiarities yet more fugitive; and with the exception of these modifications in the form of the cranium, which we may easily suppose to be connected with differences of instinct and to be the direct result of education, it cannot be said that any one of the domestic animals in its most extreme varieties loses the character of the species. If therefore we find that the most energetic among external agents,—modifications of climate, of habit, of instinct and of food,—have only been able during the lapse of ages to produce some trifling change, which has not altered the type of the species, are we not, from this examination of the domestic animals, justified in believing the permanence of species rather than their transmutation?

"And this view is the more probable, since the differences between one fauna and another are very considerable; and we have not to treat of trifling modifications of a type, but rather of complete transitions, often into very remote forms. Some naturalists indeed have not shrunk from such consequences, and have asserted that the reptiles of the secondary period owe their parentage to the palæozoic fishes, and were themselves the progenitors of the tertiary mammals. Where is the physiologist who will admit such conclusions? and yet quite as much must be granted if it is attempted to deduce all the geological faunas from an original one by the simple transformation of species, and by means of a passage from one to another, without the direct intervention of a creative power acting at the commencement of each epoch.

"And if for the production of such results it is assumed, contrary to what we have supposed, that there have been great alterations of temperature, and changes in the constitution of the atmosphere, or that nature in her early youth was more vigorous, the laws of physiology are not less violated. Such extreme changes in the external agents might well have *destroyed* the species, and they very probably would have done so, but they could hardly modify them in any essential point.

"It seems therefore to me impossible that we should admit as an explanation of the phænomenon of successive faunas the passage of species into one another. The limits of such transitions of species, even supposing that the lapse of a vast period of time may have given them a character of reality much greater than that which the study of existing nature leads us to suppose, are still infinitely within those differences which distinguish two successive faunas.

"And lastly, one can least of all account by this theory for the appearance of new types, to explain the introduction of which we must necessarily, in the present state of science, recur to the idea of distinct creations posterior to the first.

"The theory of *successive creations* is the only one that remains, and although it is, like the rest, opposed by very weighty objections, I am not aware of any good argument directly impugning it, and I believe that in the present condition of our knowledge it is the only theory admissible, although I am bound to add that it is by no means completely satisfactory, since it does not seem to me to account sufficiently for all the facts, and perhaps it is at best only provisionary. It explains well the differences which exist between successive faunas, but there are also resemblances between these faunas for which it offers no explanation.

"In order to illustrate the unsatisfactory nature of this theory, we have only to compare two successive creations of the same epoch, as for instance two faunas of the cretaceous period. In such a comparison, no one could fail to be struck by the intimate relation that exists among them, since most of the genera would be found the same, while a large number of the species are so nearly allied that they might easily be mistaken for one another. In other words, two successive faunas often have the same physiognomical aspect; and in the case just mentioned, if we compare the *turonian* with the *albian* fossils (those of the upper chalk with the species from the uppermost greensand), we shall readily find close resemblances. Is it probable that the earlier fauna had been completely annihilated, and then, by a new and independent act of creation, replaced by another fauna altogether new and yet so much resembling it? Surely there must be something which has still escaped observation; but I must repeat, that the somewhat vague objections thus suggested are in no way to be compared to those more definite ones which militate against the other theories.

"These facts also influence the manner in which we regard the existing creation. Do all animals appear exactly as they issued from the hands of the Creator, or have only a certain number of types been introduced, whence the others were derived? It seems to me difficult to admit that each one of those innumerable species, of the accurate determination of which we are so often in doubt, was in all its characters of detail a distinct and separate act of creation.

"To these questions, however, Palæontology is able to answer only in a very insufficient manner. The succession of organized beings, the origin of existing species and their geographical distribution, the formation of the different families of mankind,—all these are but different aspects of the same great problem, a solution of which on any one point would necessarily throw great light upon the others.

"I believe then that the theory of successive creations*, which is the least objectionable of all, is true in a general sense, but that other causes have perhaps combined with it to determine the actual state of existing creation and of earlier faunas. Possibly those modifications of species, which, as I have already shown, cannot explain the introduction of new types and the appearance of very distinct species, have still had some share in producing a number of allied species from a common type; or in other words, perhaps we must in this, as in other questions, not expect a too exclusive explanation, but admit the intervention of various causes.

"I do not, however, believe that our science is at present in a condition to give a satisfactory solution of these difficulties; and though we may with greater or less distinctness foresee such a solution, it cannot yet be demonstrated. A strict and intelligent study of nature is required, in order to bring together the various materials. We must know better than we do now each one of the successive creations, in order to form a complete idea of their mutual relations, and of their differences from those which have preceded and followed them. This is the most important problem of Palæontology, and its solution is only to be found in the observation of facts, for they alone are permanent, and they perhaps will outlive all the theories discussed at the present day."—Pages 85–94.

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* "I would observe here that this theory is the only one that connects itself logically with our first law, namely that species belonging to different formations are distinct; for such a law necessarily results if the present theory is admitted, and this in my opinion is a powerful argument in its favour. Still we must not be in too great a hurry to limit future discoveries in Palæontology by our preconceived notions, but rather seek for truth wherever it can be found. Possibly some intermediate theory might also agree with this law."

III. MISCELLANEA.

I. Annual Meeting *of the* French Geological Society *for* 1846.

It has been decided that the Annual General Meeting of the French Geological Society for the year 1846 shall be held at Avallon, an interesting locality situated on the limits of the chalk and the old rocks.

Avallon is a clean and well-built town situated on the right bank of the little river Cousin, a tributary of the Yonne, and is distant about 150 miles from Paris, on the high road to Chalons-sur-Saône. It is built on a sort of granite promontory, and is surrounded by extremely picturesque scenery, chiefly produced by the contrast of rich and luxuriant cultivation with the almost savage beauties of the gorge along which the Cousin runs. These natural objects of interest arising entirely from the peculiar geological constitution of the district, it cannot be doubted that the meeting will be one of considerable interest. The meeting is fixed for the 14th of September, and the President of the Society has already directed the attention of the members to the fact that there are some questions regarding moraines or supposed moraines which it will be desirable to clear up.

II. Foot-prints *in the* Connecticut Sandstone.

The remarkable locality on the banks of the Connecticut river (U.S.), which has furnished more numerous and more singular examples of the footsteps of various animals than any other spot on record, has lately yielded to Dr. Deane's investigations some markings which he considers must have been made by a progressive movement of the nature of leaping, the creature which formed them either leaping like a frog, or, more probably, like a kangaroo, without the fore-feet touching the ground. In these prints, each foot has five toes, the central one marked with four articulations, and each adjacent one on both sides of it diminishing by one in succession. The diameter of the foot is $2\frac{1}{2}$ inches, and the impressions, which are remarkably perfect, are associated with several species of bird-tracks, and with rain-drops in wonderful preservation.—*Silliman's Journal*, vol. xlix. p. 80.

III. *On the* Composition *of* Chlorite.

This mineral, described by M. Friedler, had been analysed first by M. Erdmann (Journ. f. prakt. Chem. t. vi. p. 89), and afterwards by M. Bonsdorff (Voyage of G. Rose in the Ural, vol. i. p. 252), but with results so different, that M. Rammelsberg suggested that these two chemists had probably analysed different minerals. M. Gerathewohl has lately undertaken the analysis of a specimen named by M. Friedler himself, and the results of this analysis confirm those obtained by M. Erdmann.

	Gerathewohl.	Erdmann.
Silica	24·40	24·93
Oxide of iron...	30·29	30·05
Alumina	45·17	45·02
	99·86	100·00

These results correspond with the formula $Si\,O^3$, $3\,Fe\,O + Si\,O^3$, $3\,Al^2\,O^3$, or rather, $Al^2\,O^3$, $3\,Fe\,O + 2\,(Si\,O^3, Al^2\,O^3)$.—*Journ. f. prakt. Chem.* 1845. No. 8.

IV. D'Orbigny's 'Paléontologie Universelle.'

M. Alcide d'Orbigny, For. Mem. Geol. Soc., &c., the author of the 'Paléontologie Française,' has undertaken to prepare a work under the above title, in which he proposes to give figures, with accompanying descriptions, of *every species* of fossil shells hitherto determined, from all geological formations in all parts of the world. It is calculated that the figures will occupy about 1500 plates, which it is intended shall appear in seventy-five numbers, the price of each number, including the letter-press, to be six francs.

The work will be published by Messrs. Gide and Co., No. 5 Rue des Petits-Augustins, Paris.

In a letter* recently received from M. d'Orbigny, he states, "In order to arrive at satisfactory results in an undertaking so vast, I shall need the assistance of all persons who are interested in the advance of geology, and I trust to your procuring for me in England many correspondents willing to exchange the fossil shells of various formations for such portions of my works on Palæontology as they may most require. I wish, for instance, to obtain, 1st, fossils of the Crag and London Clay, and 2nd, those of the Cretaceous formations of the Isle of Wight and Blackdown; but, above all, the fossils of your Carboniferous, Devonian and Silurian beds."

M. d'Orbigny's address is No. 6 Rue St. Hyacinthe St. Honoré, Paris.

* Addressed to Mr. Darwin.

IV. GEOLOGICAL BIBLIOGRAPHY

FOR THE YEAR

1844.

The following list of Books and Maps comprises, it is believed, a tolerably complete list of those published during the year 1844; but the difficulty of collecting information of this kind is so considerable, that many errors and omissions will no doubt be found in it. It is however proposed to publish in the last (the November) number of the present volume of the Journal, a similar list for the year 1845, in which may be included some at least of the omissions in the one now given. Information that can render more complete these lists—manifestly so useful to every geologist—will be very thankfully received by the Editor.

The list does not include separate memoirs from Transactions, except when they are published and sold in a distinct form.

1. WORKS ON DESCRIPTIVE GEOLOGY.

a. Igneous Rocks.

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b. Stratified Rocks.

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Garner, Rob. Natural History (including Geology) of the County of Stafford, with Illustrations. 1 vol. 8vo, plates. *London* (Van Voorst).

Nicol, James. Guide to the Geology of Scotland, with Geological Map and Plates of Sections. 1 vol. 12mo, pp. 272. *Edinburgh* (Oliver and Boyd).

FRANCE.

Beaudouin, Jules. Déscription Géologique de l'Arrondissement de Châtillon (Côte d'Or). 8vo, 1re partie, pp. 121. *Châtillon-sur-Seine.*

Gueymard, Emile. Statistique Minéralogique, Géologique et Métallurgique du Département de l'Isère. 8vo, pp. 998, 8 plates. *Grenoble.*

Guibal, —. Notice sur la Géologie du Département de la Meurthe. 8vo, pp. 22. *Nancy*, 1843.

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Reuss, Aug. E. Die Kreidegebilde des westlichen Böhmens &c. nebst Bemerk. über die Braunkohlenlager jenseits der Elbe u. eine Uebersicht der fossilen Fischenreste Böhmen. 8vo, pp. 312, and 3 plates. *Prague* (Medau).

Italy.

Catullo, T. A. Trattato &c. (Treatise on the Geologico-physical Constitution of the Alluvial or Post-diluvial Formations of the Venetian Provinces.) 8vo, pp. 467. *Padua.*

——— Sulle Caverne &c. (On the Caverns of the Venetian Provinces.) 4to, pp. 91, and 9 plates. *Venice.*

Scortegagna, F. O. (On the Fossil Bones of the Zoppega.) See *Palæontology.*

Villa, A. and F. B. Sulla Constituzione &c. (On the Geological Structure of the Brianza, and especially of the Cretaceous Formations.) 8vo, pp. 46, map and 2 plates. *Milan.*

Switzerland.

Agassiz, L. Geologische Alpenreisen (published by M. E. Desor under the superintendence of Prof. Agassiz, with topographical description by Dr. Voght.) 8vo, pp. 552, and 3 plates. *Frankfort.* (Literary Institut.) (also a French edition.)

Bergmann, Jos. Untersuchungen &c. (Researches on the Francs Valaisans in the Canton of the Grisons and the Voralberg.) 8vo, pp. 108, map. *Vienna.*

Scandinavia.

Keilhau, B. M. Gaea Norvegica. 2nd part, folio, pp. 149–340, 2 plates. *Christiania.*

America.

Jackson, Chas. T. Final Report on the Geology of the State of New Hampshire, U. S. 4to, pp. 376, 10 plates and maps. *Concord, N. H.*

2. WORKS ON PALÆONTOLOGY.

Agassiz, L. Monographie des Poissons Fossiles du vieux grès rouge. Fol., with plates. *Soleure* (Jent et Gassmann).

Burmeister, Hermann. Die Organisation der Trilobiten aus ihren lebenden Verwandten entwickelt; nebst einer systemat. Uebers. aller zeither beschriebenen Arten. Large 4to, pp. 160, and 6 plates. *Berlin* (Reimer).

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Germar, Ernst Fr. Die Versteinerungen des Steinkohlengebirges von Wettin u. Löbejün im Saalkreise. 1st Part. Fol., pp. 16, and 5 plates. *Halle* (Schwetschke).

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Mantell, Gid. A. The Medals of Creation, or First Lessons in Geology. 2 vols. 12mo, 6 plates. *London.*

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Johnston, Prof. Elements of Agricultural Chemistry and Geology. 3rd edit., 1 vol. *London.*

Kane, Dr. On the Industrial Resources of Ireland (including Geological Mines, &c.).

Lyell, C., and Prof. Faraday. Report on the Explosion at Haswell Colliery.

Paillette, Adr. Ensayos quimicos &c. (Chemical Essays on several Combustible Minerals of the Asturias.) 8vo, pp. 10, 2 plates. *Oviédo.*

——— Apuntes Historicos, &c. (Historical Notices of the Mines of the Asturias.) 8vo, pp. 4. *Ferrones.*

4. WORKS ON MINERALOGY.

Chapman, E. J. A brief Description of the Characters of Minerals. 1 vol. 12mo. *London.*

Dana, James D. A System of Mineralogy. 2nd edit., 8vo, pp. 673, and 4 plates. *New York and London* (Wiley and Putnam).

Kote, B. Das Mineralien-Kabinett der höhern Gewerb- u. Handlung-Schule. 2nd edit., 8vo, pp. 136. *Magdeburg* (Schmilinsky).

Kurr, J. G. Grundzüge der ökonomisch-technischen Mineralogie. 2nd edit., 8vo, pp. 656, with 6 plates and 1 coloured plate. *Leipzig* (Baumgärtner).

Partsch, Paul. Die Mineralien-Sammlung im k. k. Hof-Mineralien-Kabinette zu Wien. Ein tabellar. Schema der neuesten Aufstellung derselb. mit einem Index. 12mo, pp. 84. *Vienna* (Heubner).

5. MISCELLANEOUS WORKS ON GEOLOGY.

Ansted, D. T. Geology—Introductory, Descriptive and Practical. 2 vols. 8vo. *London* (Van Voorst).

Chambers, R. Rudiments of Geology. 1 vol. 12mo. *Edinburgh.*

Chevalier, E. Géologie et Minéralogie du Voyage autour du Monde, exécuté pendant les années 1836 et 1837 sur la corvette la Bonite. 1 vol. 8vo. *Paris.*

Fuchs, J. N. Uber die Theorien der Erde, den Amorphismus fester Körper u. den gegenseitig Einfluss der Chemie u. Mineralogie. 8vo, pp. 96. *Munich* (Fleischmann).

Hell, Xavier Hommaire de. Les Steppes de la Mer Caspienne, le Caucase et la Russie Méridionale. Voyage pittoresque, historique et scientifique. Text in 8vo, and plates in folio. *Paris.*

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Körber, C. v. Populaire Analyse u. Darstellung der physikalisch-geolog. Ursachen der Erdbeben. 8vo, pp. 56, and one 4to plate. *Vienna* (Kaulfuss and Co.).

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Wagner, Andreas. Geschichte der Urwelt mit besondere Berücksichtigung der Menschenrassen u. des mosaischen Schöpfungsberichtes. 8vo, pp. 670. *Leipzig* (Diehl).

6. GEOLOGICAL MAPS.

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Carte Géologique du Finisterre, par M. de Fourcy. En 6 feuilles, col. *Paris.* Avec Notice Explicatoire. 8vo, pp. 196. *Paris.*

Carte du Département de la Meurthe, coloriée géologiquement, par M. Guibal. 1 feuille colomb. *Nancy.*

Geographical and Geognostical Map of the Odenwald, the Bergstrasse and the banks of the Neckar, extending to the adjacent country. 1 sheet sm. fol. *Darmstadt.*

Mineralogico-petrographical Map of the Bavarian Alps, between the Isar and Wertach. 1 sheet folio. *Munich.*

Carnall, R. v. Geological Map of Upper Silesia. In 2 sheets large fol. *Berlin.*

Chain of the Tatra and the parallel elevations. 1 sheet imp. fol. *Berlin.*

Note.—In those cases in which the full title is not given, the Editor has not had access either to the work catalogued or to any more complete account of it.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

1. *Notice of the Fossils of the Palæozoic beds of the province of* ASTURIAS, *in the North of* SPAIN. By M. E. DE VERNEUIL and the COUNT D'ARCHIAC.

(From the 'Bulletin de la Soc. Géol. de France,' 2me Ser. tome ii. p. 448.)

[The subjoined extract forms the Appendix to a memoir read before the French Geological Society on the 19th of May, 1845, entitled "Researches concerning some of the rocks which constitute the province of the Asturias," by M. Adrien Paillette. M. Paillette describes successively, but briefly, the position and localities of the principal rocks, some of which he found to resemble very closely the beds of the same age in Brittany and Normandy. These rocks include Silurian, both lower and upper, Devonian, and Carboniferous strata, the latter containing important beds of workable coal. The carboniferous beds are greatly disturbed and dislocated, and the author proposes to continue their investigation in greater detail before publishing any general conclusions.—ED.]

OUR knowledge of the faunas of the various departments of the Palæozoic series of formations is not yet sufficiently complete, or deduced from observations of a sufficient degree of generality, to enable us to determine the age of any one of them by the presence of a single species of fossil; but this is not the case when we have before us a group of fossils from the same locality, obtained from beds whose mutual relations are well established. The following list, therefore, of the organized bodies obtained by M. Paillette from the deposits which he has so well studied and described, will enable us to draw certain conclusions, tolerably definite, as to the period of their deposit, by comparing them with what we already know with regard to other parts of Europe.

Fossils of the Palæozoic rocks of the Asturias.

*Orthoceratites Jovellani.**
Cardium (resembling C. alæforme, Sow., and identical with a species from the limestone of Nehou, La Manche).
*Terebratula subconcentrica.**
—— *Pelapayensis.**
—— *Campomanesii.**
*Terebratula Ferronesensis.**
—— *Ezquerra.**
—— *Hispanica.**
—— *Toreno.**
—— reticularis, Schlotth. (T. prisca, Dalm.)
—— *Olliviani.**
—— *Adrieni.**

Terebratula Daleidensis, Röm.
*Spirifer Pellico.**
—— *Cabedanus.**
—— heteroclitus, Defr. (sp.)*
—— *Cabanillas.**
—— Verneuili, var., Murch.
Orthis resupinata, Mart. (sp.)
—— orbicularis, Sow.*
—— crenistria, Phil. (sp.)
Leptæna Murchisoni, D'Arch. et De V.*
Leptæna Dutertii, Murch.
Serpula omphalotes, Goldf.
Pentremites Pailletti, De Vern.*
—— *Schulzii.**
Aulopora serpens, Goldf.
Criserpia Michelini, Miln. Edw.
Favosites polymorpha, Goldf.
—— fibrosa.
—— —— var. ramosa.
Lithodendron cæspitosum, Goldf.

NOTE.—The species in italics are new; and those to which an asterisk is attached are described and figured by the authors in the original memoir above referred to.

The relative preponderance of Brachiopoda is, it is well known, the distinctive character of the Palæozoic faunas, just as the preponderance of Cephalopoda, represented by Belemnites, Ammonites and other of the siphoniferous multilocular genera, marks the secondary period.

Among the Brachiopoda, of which two-thirds of the whole number of our series of Asturian fossils consist, those most remarkable by their peculiar mode of development are the Terebratulæ of the group called *Concentricæ*, characterized by concentric striæ more or less lamellar, by the uniform absence of *deltidium*, and by a round aperture at the beak of the ventral valve. The *T. concentrica*, V. Buch, the type of the group, and a species found in the Devonian beds of northern and western France, of England, Belgium, the Eifel and Russia, does not however appear among these specimens from Spain, although six species, one of which we have named *T. subconcentrica*, from its very close resemblance to this typical form, —a resemblance so near that it might almost be considered as a variety,—form a link connecting it by common characters, although gradually diverging from it more and more widely by successive modifications.

The presence of a medial furrow is the peculiar character which connects these very different forms. This furrow, hardly appreciable in *T. subconcentrica*, which is distinguished from the type of the group by its generally rounded, subelliptical and transverse form, its large dimensions and the disposition of its striæ, is seen to be combined in the next species (*T. Pelapayensis*) with a subpentagonal and more elongated form, smaller dimensions, and a less open angle at the apex. Still more decidedly indicated in *T. Campomanesii*, the medial furrow is there accompanied by folds and lateral furrows, and the front of the ventral valve is little different from that of the dorsal one. The large and lamellar striæ of this species, present at all stages of growth, clearly distinguish it also from *T. Ferronesensis*, where indeed the development of four plications on each valve, separated by broad and deep furrows, the striæ becoming still finer and closer together, would fully justify the separation.

Up to this point the forms had oscillated, if we may use the expression, between pentagons more or less rounded and ellipses more or less elongated; but at length departing from this character, we find the transverse direction predominate in *T. Ezquerra*, by the extreme elongation of the two lateral folds which we have traced from their first origin in *T. Campomanesii* through their further development in *T. Ferronesensis*. At the same time, the angle at the apex becomes more open, the ventral furrow is as deep as the dorsal one, the general contour of the shell becomes heptagonal, and its surface becomes divided into five parts, which are hollow and unequal, but disposed symmetrically on each side of the axis, and corresponding on the two valves. The *T. Hispanica* is simply the result of a still greater extension, and of an elevation of the lateral folds, which in it become confounded with the hinge, which is straight and very long, as in the winged Spirifers. The angle at the apex is nearly equal to two right angles, and the medial furrow is always as deep as the sinus. Lastly, the variety (A) of *T. Hispanica* presents the concluding term of this series of transformations, which, commencing with a suborbicular shell, has conducted us gradually to a form very nearly resembling that of a *Solen*.

We have paid every attention in determining these species; and the examination of a considerable number of individuals of each of them, in various stages of growth, induces us to think that the distinctions we have established are well founded, and that they will be confirmed by future investigations. Among the species, *T. Pelapayensis* occurs both in the Ural and Eifel Devonian beds, and *T. Ezquerra* in the limestones of Nehou (Manche).

If we inquire concerning the localities already known of the other fossils in the preceding list, we find that *T. Adrieni* occurs in the Eifel limestone, *T. reticularis* is common to the Silurian and Devonian rocks of the north and east of Europe, and *T. Daleidensis* appears in the grauwacke of the banks of the Rhine. Among the Spirifers, one variety of *S. heteroclitus* and a variety also of *S. Verneuili* are confined to Devonian beds; and the three other species, which are as yet peculiar to the Asturias, recall to mind by their transverse form and simple plications the characteristics of the genus, especially as developed during the Devonian period. All the three species of *Orthis* are known: *O. crenistria* is a Devonian form, *O. resupinata* both Devonian and Carboniferous, and *O. orbicularis* Silurian; but with regard to the latter, there is some doubt still as to its identity. Of two species of *Leptæna*, one, *L. Dutertrii*, is common in the Devonian beds of the Bas Boulonnais; and the other, a variety of *L. Murchisoni*, the type of which occurs in the grauwacke of Siegen, is somewhat widely spread in the ancient limestones of Brittany and Normandy.

Among the Polyparia of Ferrones, three are species common to Silurian and Devonian rocks, and two are exclusively Devonian. *Serpula omphalotes* is one of the most characteristic of the Devonian fossils both in Western Europe and in various parts of Russia; and, lastly, the presence of two species of *Pentremites*, a genus hitherto unknown in the Silurian system, furnishes a still further argument for referring these beds of Ferrones and Pelapaya to the Devonian period.

On the whole, therefore, we find that of thirty-one species obtained from these localities, three, namely *Terebratula Daleidensis*, *Orthis orbicularis*, and *Leptæna Murchisoni*, are true Silurian, four are Silurian and Devonian, one (*Orthis resupinata*) is Devonian and Carboniferous, eight are exclusively Devonian, and fifteen are new. Of these latter, however, three have been found in the Devonian rocks of other countries, so that as many as eleven, or about one-third of the whole number of species known, are exclusively Devonian.

Besides the fossils of Ferrones, Pelapaya and the neighbourhood, M. Paillette has also sent some specimens from Arnaos, where the beds of true coal, which he has described in his memoir, appear to be covered up by limestones similar to those of Ferrones. Among the species thus obtained, the specimens of which are generally less perfectly preserved than those previously described, we have *Terebratula reticularis* (*prisca*), *T. Ezquerra*, *T. primipilaris* (Von Buch), *Orthis resupinata*, *O. striatula*, *O. arachnoidea*, and the *Spirifer Pellico*, so characteristic of the Ferrones limestones. It is impossible to doubt that these beds of Arnaos are of the same age as the others*.

As to the fossils of Cabrales, for which we are also indebted to M. Paillette, they are quite distinct from the preceding, and certainly announce the presence of the true carboniferous series at this point. They consist of *Productus semireticulatus*, Mart. (*antiquatus*, Sow.), and *P. tenuistriatus*, De Vern., *Spirifer attenuatus* or *striatus*, and *S. Mosquensis*.

D. T. A.

* We think it right to call attention to this fact, since it is the first time that fossils unquestionably Devonian have been found regularly superposed on beds of workable coal. All the great coal and anthracite deposits of England, America and Russia are well known to be superior in geological position to the Devonian system.

MISCELLANEA.

I. *On* Icebergs *in the* Southern Hemisphere, *and the Boulders and Erratic Blocks conveyed by them.*

[In the *Narrative of the United States Exploring Expedition during the years* 1838 *to* 1842, by Charles Wilkes, U.S.N., Commander of the Expedition*, there appear some remarks of great interest to geologists with respect to the icebergs in the southern hemisphere. To the volumes themselves the Editor is not at present able to refer, and he is indebted for the following particulars to an extract given in 'Silliman's Journal' for July last, where the reference to pages is not given.—Ed.]

The ice-islands form rapidly in successive horizontal layers from accumulations of snow assisted by the fogs. These layers are from six inches to four feet in thickness; and the icebergs were seen in all stages of formation, varying from 180 to 210 feet in height, attached to the land, and forming a straight and perpendicular wall in advance of the land, for a distance of fifty miles and more together.

Detached from the land, but found along the coast, the icebergs were from a quarter of a mile to five miles in length. At a distance of about fifty or sixty miles from land they exhibited marks of decay, and the stratification was often inclined at a considerable angle to the horizon.

In the southern seas, these ice-islands float down as far as latitude 60°, without being much changed by melting, since the temperature of the sea shows but little alteration from this point towards the pole. Further towards the equator their texture is altered, and they rarely exhibit signs of stratification. They drift rapidly westwards and north-westwards at an average rate of from half to three-quarters of a mile an hour, and they are frequently found between latitudes 40° and 50° S.

Vast multitudes of boulders are imbedded in these icebergs. All those observed apparently formed part of the nucleus, and were surrounded by extremely compact ice, so that they appear to be connected with that portion of the ice which would be the last to dissolve, and they would therefore in all probability be carried to the furthest extent of their range before they were let loose or deposited.

Captain Wilkes concludes, from the abundance and drift of icebergs, as well as from other causes, that the land near the South Pole is very extensive.

* Five volumes, with atlas. Philadelphia 1845.

II. Upheaval *of a* Chain of Hills *in Modern Times.*

[The following interesting notice is translated from the second volume of M. Tschudi's work on Peru, now in course of publication. It presents an instance of elevation of a kind of which examples appear to be very rare, but an almost parallel case is quoted by Mr. Darwin (Journal, 2nd ed. p. 359), to whom the Editor is indebted for pointing out the passage here translated.]

Two leagues from Lima the road which up to that point has run in a north or north-westerly direction suddenly turns towards the north-east, and follows the course of the river Chillon as far as Cavallero. From this point there is a steep and continued ascent in the same direction (north-east) as far as Llanya, but at a considerable distance from the river, which takes a wide turn to the north. From Cavallero the road proceeds for a distance of about eight miles through a district entirely barren, and along the dried-up bed of a river (thence called Rio seco, dry river). All this time there is a steady ascent, the last half league being tolerably steep, until we reach the crest of a chain of hills which extends directly across the valley. The ground is covered with boulders and blocks of porphyritic rock, just as in the river-bed of the Rimac. As soon as we reach the crest of the hilly chain, there is seen, on the other side, a valley resembling the dried bed of a lake, along whose middle may be traced a furrow—the prolongation of the bed of the stream broken through by the elevation of the hills. After going up this valley and following for nearly three leagues the bed of the 'dry river' as far as the village Alcocoto, we again find ourselves on the banks of the river Chillon.—*Peru, v. J. J. v. Tschudi*, 2 Bd. s. 8.

III. *On* Marine Infusoria *in* Volcanic Tuff.

It has been a matter of considerable interest to those who are pursuing microscopic investigations, that in the various examples of volcanic rock, such as pumice, ash, tufa and other materials, in which infusorial animalcules have been determined, the species thus met with have hitherto all been referable to freshwater groups.

In the case of some examples of volcanic ash procured by Mr. Darwin, and recently examined by Prof. Ehrenberg, several species of marine types have however been met with. The specimens examined were from Patagonia.—*Berlin Academy*, '*Bericht*,' 1845, p. 143.

RISTIANIA.

E.

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c.

moir on the Geology of Scandinavia, very imper- The original section, as given in the great work justify the conclusions insisted on in the memoir succession there traceable from Lower through small scale, towards the right-hand side of the the effects they have produced, though it is not

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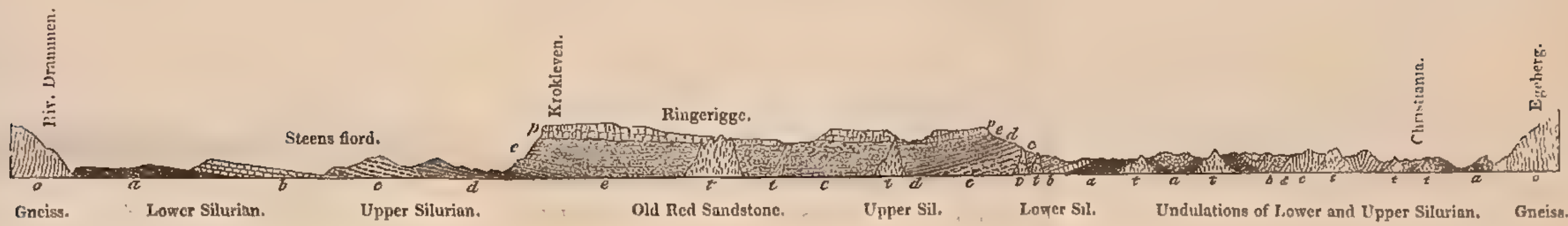
IV. SECTION ACROSS THE TERRITORY OF CHRISTIANIA.



References to the above diagram :—

Old Red Sandstone—*e.* Red sandstone and conglomerate.

Upper Silurian { *d.* Calcareous flagstones, &c.
c. Coralline limestone and shale.

Lower Silurian { *b.* Pentamerus limestone.
a. Schists, flags, and lower sandstone.

o. Azoic or gneissose rocks, with old granite, greenstone, &c.

{ *p.* Rhombic porphyry in the Old Red Sandstone.
t. Eruptive and trappæan rocks of various characters.

The diagram in page 469 of the first volume of the Journal, accompanying Mr. Murchison's memoir on the Geology of Scandinavia, very imperfectly represents the interesting and remarkable phænomena exhibited in the Basin of Christiania. The original section, as given in the great work on Russia (p. 13), by Messrs. Murchison, de Verneuil, and de Keyserling, is now reprinted to justify the conclusions insisted on in the memoir alluded to, and to give an idea of the perfect evidence existing in that part of Norway of the succession there traceable from Lower through Upper Silurian to the Old Red Sandstone inclusive. The section as now given represents on a small scale, towards the right-hand side of the wood-cut, the intrusive rocks (granite, syenite, porphyries, greenstones, amygdaloids, &c.), and the effects they have produced, though it is not pretended that even a twentieth portion of the flexures and contortions are here shown.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

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1. *On the Remains of* Infusorial Animalcules *in* Volcanic Rocks. By C. G. Ehrenberg.

[The present article has been prepared from two communications made by Prof. Ehrenberg to the Royal Academy of Sciences at Berlin, and published in the '*Berichte*' (Proceedings) of that Academy for September 1844 and April 1845. It has not been thought necessary to reprint the lists of species and the diagnostic description of the new species, since these may be referred to in the pages of the '*Berichte*.'—Ed.]

The influence of animalcules (or organic bodies so minute as to be invisible to the naked eye) on the formation of the actual solid masses which make up the earth's crust has only lately been recognised, even with regard to the newest stratified rocks and those of the most recent geological period; but amongst these the so-called mountain meal, peat, sea and river-mud, bog-iron, the earth in which the mineral *Vivianite* occurs, and others, are now known to be either partly or entirely composed of the organic products secreted by these little animals.

A similar origin must however now be assigned to those tertiary rocks which are known by the names tripoli, polishing slate and semi-opal, to some of the porcelain earths, to the so-called *dysodil*, and to the paper-coal of the brown coal formation; and even among the upper secondary rocks we find that the greater part of the white chalk, the nummulite and catacomb limestone of Egypt, the firestone of the same period, and several of the chalk marls, are, beyond question, the direct products of similar minute organic beings.

Amongst the middle secondary rocks, again, we find that the hornstone of the coral rag of Cracow and some widely-spread oolitic rocks in various parts of Europe exhibit distinct traces of a similar origin; while even in the newer palæozoic rocks we learn from Count Keyserling and Prof. Blasius that there is a compact limestone of the carboniferous period near Lake Onega in which these little organic bodies are present in vast abundance, associated with a species of Bellerophon.

The hornstone of Tula also, considered and described by Helmersen as mountain limestone, and in which *Choristites mosquensis* is present in great beauty, has certainly been formed for the most part by these microscopic animalcules; and it is not long since Prof. Bailey of New York forwarded to Europe specimens of a hornstone from near Madison, Wisconsin, U.S., considered by the American geologists as belonging either to the carboniferous or oolitic group; and this M. Ehrenberg on examination has found to be also entirely composed of similar remains, and to resemble very closely the formation of carboniferous limestone from Lake Onega.

Amongst the stratified fossiliferous rocks therefore, it remained only to exhibit similar relations with regard to the lower palæozoic rocks, where however the difficulty arising from the great amount of chemical change such rocks have undergone, destroying the vestiges of these minute creatures, besides the opake and troublesome character of the rock itself, renders the negative result at present obtained little to be depended on. It is very possible that in the lowest of the series of deposited rocks such minute bodies have suffered change, but it is also highly probable that they have occasionally been preserved, owing to some favourable circumstances, and may therefore still be discovered.

Beyond these limits it has been hitherto considered that all our investigations must necessarily cease, the field of observation seeming to be completely shut out in those cases where volcanic forces have come into play. The calcareous rocks when exposed to heat soon lose all indications of their having been formed by organized beings, and the siliceous earth, when burnt in association with clay, limestone and particles of iron, passes into a kind of glass, which, whether compact or cellular, has the character of an entirely inorganic mineral. It also appeared that the great depth at which it was supposed volcanic products must be elaborated, rendered it impossible that any of the results of organization should be affected by or should affect them.

It is indeed several years since M. Ehrenberg stated to the Academy that the polishing slate and *Kieselguhr* (siliceous sinter), as well as the so-called volcanic ashes or porcelain earth of volcanic districts, might be considered as actually made up of the remains of these little animalcules; but in the various places whence the specimens had been obtained (near Cassel, the Caucasus, the Isle of France, &c.), it seemed probable that they had been developed in great abundance during the intervals between volcanic eruptions, the crater under such circumstances becoming a small lake in which these animals lived and increased rapidly, and deposited their flinty skeletons, another eruption after a time drying up the bed of such a temporary lake, and covering it up with erupted ashes, which also in their turn afterwards became the receptacle of a similar deposit. This it was thought might go on until a more powerful and energetic upheaval of the bottom of the crater either gave to these strata a steep inclination or fairly lifted the concave bed into a convex dome, thus precluding any further repetition of the process. It appeared, indeed, from an examination of its internal structure, that the hornstone-like and glassy semi-opal was not formed immediately by volcanic agency.

Two other cases in which microscopic animalcules were associated with volcanic rocks had also been noticed by the author, but in these the conditions were less distinctly marked than in the former. One of them had reference to the red firestone of the north of Ireland, which has apparently undergone fusion, and in which some of the chalk infusoria are distinctly present; and the other was the edible earth of the Tungusians, from the Marekan mountains near Okhotsk, of which M. Ermann, jun., had brought specimens. So long ago as in March 1843 *, the author had stated that in this edible earth, which appears under the microscope to consist almost entirely of pounded pumice, there were three distinct species of known siliceous Infusoria † and one of Phytolitharia ‡. M. Ermann considered, from the circumstances under which it occurs, that the edible earth consists of a very fine, dry and meagre dust of pounded rock, in which this strange association of infusorial animalcules has unaccountably become mingled; and the author admitted such an explanation, describing the species as offering a remarkable instance of geographical extension, whatever be the relation in which they stand to the rock or formation. The recent investigations with regard to pumice give a new interest to this remarkable fact, and take away from its apparently anomalous character by showing that there is no necessary relation of the organic remains in question to the rock or deposit called *Marecanite.* With regard to the other instance mentioned, that of the fused firestone, it appeared to possess little general interest, since the rock containing the remains might easily have become associated with the lava in which it was found, fragments of the adjacent rock existing in it in considerable number.

The only example of any distinct relation of microscopic organic bodies with recent volcanic phænomena was one recorded by M. von Humboldt, and occurring near Quito, where an extensive volcanic mud-eruption distinctly presents the phænomenon of minute organic bodies, especially those of vegetable origin, proceeding from the interior of a volcano, apparently from a great depth and in direct association with those volcanic effects which have upheaved mountain masses.

It has however lately become an important object of investigation to learn where we are to seek for the first traces of organic life, and although for some time calcareous rocks have alone been considered as affording distinct evidence of its existence, on account of the change effected in the siliceous parts of infusorial animalcules in fused rocks, the anticipations of the author that these remains were more permanent than had been supposed, are fully borne out by the facts about to be recorded, since he is now able to announce that pumice both in its normal state and in powder, volcanic tuff, volcanic conglomerate, trass, decomposed porphyry and porcelain earth

* Monatsbericht, p. 104.

† *Fragilaria amphicephala*, *Gaillonella distans*, and *Tabellaria vulgaris.*

‡ *Pilus plantæ.*

or volcanic ashes, as well as clink-stone, and apparently the crumbling marecanite-tuff, besides the various volcanic fused and erupted rocks, have one after another and in rapid succession been found to exhibit a direct and necessary relation with the most minute forms of organic existence, and that such is the case from whatever part of the earth these rocks are obtained.

The progress of the investigation is as follows:—

A specimen of very white siliceous earth of loose texture and small specific gravity, obtained from the foot of the volcano 'Hochsimmer' near the lake of Laach on the Rhine, was in July 1844 forwarded to the author by Prof. Nöggerath of Bonn for microscopic investigation, the specimen being suspected to contain infusorial remains. It appeared on examination that the whole mass, with the exception of a few grains of quartzose sand, consisted of siliceous infusorial cases, while the peculiar association of species and their diminutiveness, and especially the remarkable preponderance of *Pinnularia viridula*, induced the author to conclude that there existed some peculiarly interesting relations of the beds; and he expressed a wish that a strict local investigation might be carried on with respect to some at least of the peculiar species obtained. M. Nöggerath at once undertook to do this, and in the month of August the author received specimens obtained from M. Spenler of Mayen, but the original pits were at that time filled up, so that this first investigation was not satisfactory as regarded the locality, and it became necessary to have the pits re-opened. The specimens however which were forwarded were such as to induce the author to wish for a yet further investigation concerning the local relations, since in some of them the infusorial earth appeared to be most intimately and strikingly mingled with volcanic tuff.

In the months of August and September his investigations on these rocks were for a time suspended during a journey made by the author into Bohemia, where he had the opportunity of observing similar phænomena in the field and on a grander scale.

On this occasion he examined the vicinity of Bilin in company with Dr. Reuss, and found that volcanic action had there produced great disturbances and disruptions of the stratified rocks, which rendered it very difficult to determine, at least during a hurried survey, the original relations of the superficial phænomena and the date of the metamorphism. The Bilin infusorial polishing slate is however clearly a stratified rock, having relation to the other formations, for it is seen at the top of the Kutschliner mountain, whose principal mass is gneiss, and which is surmounted first by a thickness of about twenty-five fathoms of a cretaceous marl belonging apparently to the Pläner-kalk, and then by about ten feet of clay containing ironstone balls. The infusorial mass, which on the whole is about fifty feet thick, surmounts this clay, and presents the appearance of a mammillated slate, a polishing slate, or a semi-opal, according to its degree of hardness. Dr. Reuss's sections have rendered all this perfectly clear. The author endeavoured to find some springs of water which might have produced these phænomena in modern times, but there was no trace of a spring on the bare barren summit, nor could any channel be discovered on the declivity down which such spring might have poured. But the amphitheatre which the form of this isolated hill presented was extremely striking. Many delicate well-preserved organic remains of animals and plants*, some of them known, but some belonging to species now extinct, distinctly prove that this polishing slate belongs to an ancient division of the tertiary period, immediately subsequent to the chalk, and at the same time that it was a quiet deposit in fresh water, exhibiting by its organic remains a gradual passage from the animal to the vegetable kingdom. The thin superficial coating of gravel seems to show that the whole has been since subjected to the action of currents of water.

The environs and the springs of Töplitz and Carlsbad were also objects of investigation during the author's brief stay, and he looks forward to a time when he may be able to follow out these investigations in greater detail; but he was particularly struck with the large crater-shaped valley of Franzensbad, whose diameter is about four miles, and within which is the little volcanic cone of the Kammerbühl. In this spot were exhibited many highly interesting conditions and relations of the most minute forms of organic existence.

It was evident from the first glance that the infusorial siliceous earth played a very important part in the valley of Franzensbad. That it was indeed by no means a mere local phænomenon exhibited in the little hillocks or heaps on the surface, as had been originally supposed, but existed as a regular and extensive deposit beneath the coating of vegetable soil, had been noticed before by Dr. Palliardi, but the author observed its extension in so many places besides those noticed by Dr. Palliardi, wherever the denuded surface was visible, and it appeared to be so completely an integral part of the turf or bog earth, that the whole valley seemed completely covered with it, and in fact the whole of the turf, whether its thickness is one or twenty feet, belongs more or less exclusively to this formation.

Near Franzensbad the development of *Pinnularia viridis* in great masses of siliceous earth is extremely striking, and at the east end of the valley the presence of *Campylodiscus clypeus* is equally abundant in the same manner. Similar formations were observed by the author to be still in progress, but the great mass of the deposit consists of the mere empty infusorial cases. Scarcely less extensive than these are the deposits of massive carbonate of iron in the neighbourhood of the acidulous springs, which commonly, but not always, contain fragments of *Gaillonella ferruginea*. In the midst of the true siliceous infusorial earth there also occurs phosphate of iron in the form of blue vivianite, above which the fen-mud appears, and is often quite filled with and hardened by the black iron pyrites.

Here however it will be seen that neither the mineralogical nor the physiological conditions are wanting for the combination of the materials, and the black pyrites is manifestly a local and subsequent

* There is an extremely rich and beautiful collection of these in the museum in the Lobkowitzian palace, but the specimens have not yet been described.

formation. Whether indeed the sulphates of soda and lime in the water have received the excess of carbonate of iron after the formation of the pyrites, or whether the *Gaillonella ferruginea* has absorbed sulphuric acid given off after death by the bodies of the siliceous-shelled animalcules, the author leaves it to other naturalists to determine, but he expresses his belief that the vast multitude of microscopic animalcules at Franzensbad have had a direct and important influence on the local peculiarities observed in that neighbourhood.

By such investigations the volcano in the neighbourhood came to be viewed in a new light. It rises from the plain with a gentle inclination on the eastern side, but to the west there is a nucleus of cellular basalt or basaltic lava-slag rising to the summit; the formation in the neighbourhood is mica-slate. The whole of the eastern dome-shaped slope forms a stratified heap of light volcanic erupted ashes, often containing lumps of some size and also very small fragments of mica-slate, quartz, or white pumice. The impression made by viewing these phænomena was, that the eruptions of cellular lava and slag, and consequently the whole slope of the hill, consisted of nothing more than a valley or the bed of a lake of volcanic origin, which existed before the outburst of lava, but that the valley was not destroyed by the eruption, and received no elevation. Several experiments were made with a view of confirming this impression, and with regard to the stratification of the ashes it appeared not necessary to assume any subaqueous action and subsequent elevation, or any subsequent covering by water, since they most resembled the great rubbish heaps near Cahira in Egypt and elsewhere, which exhibit the same appearance of regular stratification, and have been formed without water.

The idea therefore of a relation between volcanic action and the conditions of existence of the most minute organic beings ceased to be a mere vague speculation, and some proof of its correctness was presented by gradual successive steps in investigation.

On his return from his summer excursion, the author found an admirable and systematic collection from his correspondent at Bonn. The first glance of these under the microscope showed their nature, and the investigations at Hochsimmer have gradually led to the following results.

The infusorial polishing slate occurs on the eastern slope of the Hochsimmer (about four miles from the Laacher-See), between the roads which branch off from Ettringen to St. Johann and Waldesch. It is interstratified between beds of pumiceous conglomerate.

Immediately under the vegetable soil we find—

	feet.	in.
1. Ferruginous pumiceous conglomerate	8–10	0
2. Volcanic tuff	1	0
3. Infusorial stratum (polishing slate)	0	2–3
4. Finely-grained pumice conglomerate......	0	2–3
5. Coarse pumiceous conglomerate which has been penetrated to a depth of..........	3	6
Total thickness..	12 ft.	4 to 15 ft.

The lower pumiceous conglomerate evidently reposes on the grauwacke, which with clay-slate forms the underlying deposit in the neighbourhood. The beds of volcanic conglomerate which enclose the infusorial polishing slate have a considerable dip, amounting to 20° north-west, and their thickness appears in some places to amount to as much as twenty-four feet, but the bed of polishing slate nowhere exceeds three inches. The upper covering seems to form part of a grey basaltic lava-stream proceeding from Seelsberg. The author was indebted to M. von Dechen for this information.

A careful microscopic examination gave the following singular results with regard to this locality :—

First:—Not only is the stratum of polishing slate entirely made up of the siliceous cases of infusorial animalcules, but the beds associated with it, consisting, as we have seen, of volcanic tuff and pumiceous conglomerate, are composed in great part of the same substance.

And secondly, the tuff and pumice conglomerate exhibit the infusorial cases in a distinctly fused condition, resembling that noticed by the author in some investigations made several years ago on infusorial earth that had been burnt for tiles or porcelain.

Thirty-eight species of microscopic infusoria were determined by the author from the Hochsimmer beds, and it seemed probable that many more might be added to the list; of these species, however, only two are new, and of the remaining thirty-six, one has hitherto been known in Europe only as a tertiary fossil, but all the rest are living European species.

Before extending his investigations further in the determination of additional species from this locality, the author thought it advisable to advance in another direction, and since the very fragments of volcanic rock themselves had exhibited these organic remains, he availed himself of M. Krantz's collection at Berlin, and selected several different kinds of pumice for examination. He thus obtained a number of specimens of volcanic ash or trass from Brohl on the Rhine, and he afterwards also obtained specimens of similar tuff from Civita Vecchia, and from Posilippo near Naples. All these he carefully examined.

The result was very striking, since the nature of the pumice was apparent everywhere, and exhibited not merely that peculiar cellular structure which reminds the observer of fused specimens of *Gaillonella*, but every minute fragment, even from the very middle of the mass, exhibited more or less distinctly the contained forms, and a number of species was soon added to the list of those contained in pumice.

The next step in the investigation involved the examination of specimens of pumice and similar volcanic rocks from the Royal Mineralogical Collection at Berlin, which is exceedingly rich in various departments of scientific mineralogy, and here the author first turned his attention to the Manilla specimens, partly on account of the wide extension of the volcanic tuff there said to exist, and partly because from this locality an infusorial polishing slate had already been brought by Prof. Meyen. The result of this examination was unexpected, but at the same time instructive, since it taught that the object sought for was neither everywhere present in the same form nor everywhere manifest without some trouble, even when it existed in that form. Under such circumstances it appeared that a special examination might be necessary; the Manilla tuff, however, did not exhibit any infusoria.

Although however this was the case, M. Meyen's collection furnished a pumice from Santiago in Chili, marked 'Tollo,' and fully described in his 'Travels' (vol. i. p. 338). This pumice forms a steep and almost isolated hill 300 feet high, near the volcano Maipu, at whose foot lies Tollo, 3600 feet above the sea. In this pumice the author found three species of siliceous-shelled infusoria.

Further investigation showed that a rock at Arequipa in Peru, near the volcano, and described by M. Meyen as being probably a decomposed porphyry, was in fact a true infusorial polishing slate. Several decomposed porphyries are also mentioned as occurring in this neighbourhood, one of which is a hard specimen about five inches in length, from Cangallo near Arequipa*, from which as many as eighteen species of siliceous-shelled infusorial animalcules and twelve species of Phytolitharia have been obtained. Of these, two of the latter group are identical with those found at Santiago, but the third is not among the thirty Arequipa species.

The author considers it right to add that he has examined several specimens of pumice without finding in them infusorial remains, but he states that the trouble and difficulty of recognising them was at first exceedingly great. Amongst the instances however in which his labours were rewarded with success was that of a specimen in the Royal Mineralogical Museum, obtained from Mexico, marked 'Tisar, clay-slate and siliceous earth.' It consisted of a white substance from the vicinity of a volcano, and proved to be an almost pure infusorial polishing slate, in which thirty-three species of polygastric infusoria and five Phytolitharia have already been made out.

These two beds of fossil infusoria from South America and Mexico were the first observed from that locality, and are interesting not only by their direct relation with recent volcanic action, but also because they show the conditions under which we may expect to find the material in which further investigations of this kind may be expected to be successful.

The following are the general results of his investigations, as stated by the author at the close of his first communication :—

1. We have presented for microscopic investigation infusorial masses that have been fused by exposure to volcanic fires.

2. Beneath the fused masses of infusorial remains other masses are found resembling polishing slate, but containing none of those remains elsewhere common, which are capable of being dissipated by exposure to moderate heat.

3. It appears that from the depths of a volcano masses of organic bodies have been thrown up, which either, as at Moya in Quito,

* This spot is 7753 feet above the sea, and is a volcano which, according to Meyen, has never erupted lava, but always pumice.

contain imperfectly carbonized vegetable remains, or, in the case of more complete fusion, exhibit similar forms imbedded in pumice or tuff. With regard to the peculiar change produced by fusion, it does not seem possible that the effect can have resulted in any other way, or by foreign organic bodies penetrating the rock while moist, and soon after its formation, since the appearance is peculiar, and can be brought about by artificial means.

4. Organic remains have not been met with in all kinds of pumice; and only those appear to have been formed out of the infusorial cases where there has been no powerful flux present to reduce the mixture to the condition of glass. It will require further investigation to determine the relation of Obsidian to these pumiceous formations.

5. In the vicinity of many volcanoes which either have erupted or do erupt chiefly pumice, there are great deposits of infusorial animalcules, which under the names of porcelain earth, volcanic ashes, siliceous sinter, polishing slate, mammillated slate, semi-opal and decomposed porphyry, have been considered, and generally without sufficient reason, as having a direct relation to the volcano. Such is the case in the Isle of France and the Isle of Bourbon with the porcelain earth and volcanic ash; and also near Cassel, near Cayssal in the Puy-de-Dôme and in the Caucasus, and is recognised again in the case of the polishing slate near Bilin, where the polishing and mammillated slate and semi-opal are found, and at Arequipa in Peru with the rock described (but falsely) as decomposed porphyry. Other similar deposits however, as for instance that at Luzon near Manilla, that near Mexico, and those near Eger and Franzensbad, appear to have no reference to volcanic action; and to this class also belongs the recently discovered polishing slate of the Laacher-See.

Of the infusorial deposits however, which are distinctly the result of volcanic activity, and have sometimes been brought up and erupted from great depths, we have several examples:—1st, that of Hochsimmer near the Laacher-See (perhaps not erupted, and only exposed to the action of heat); 2ndly, the trass of the Brohl Valley (supposed by those on the spot to be the site of an ancient volcanic eruption), and the similar beds from Lummerfeld; 3rdly, the tuff of Civita Vecchia near Rome; 4thly, the pumice of Tollo, near Santiago in Chili, belonging to the Maipu volcano; 5thly, the pumice from Kammerbühl near Eger; 6thly, the marecanite tuff near Okhotsk; and also, 7thly, the same rock at Moya near Quito.

6. At Hochsimmer there is also a formation resembling phonolite, the component parts of which have the closest relation with siliceous-shelled animalcules.

7. It is extremely remarkable, that in all the various instances, whether in Europe, Africa, Asia or America, in which microscopic organic bodies are seen to exist in direct or approximate relation to extinct or active volcanic action, all of these belong exclusively to freshwater formations*.

* In the subsequent part of this article it will be seen that an exception to this has been found.

8. It appears to result from this review of the phænomena, either that in the great depths beneath the surface there are ancient deposits, perhaps of coal, formed under conditions remarkably similar to those now existing; or else, which is more probable, that these immeasurably great masses of tuff, pumice, trass and mud, erupted from volcanoes, have been sucked in by the volcano from time to time, in the form of existing turf and bog, or fen-mud, greatly assisted perhaps by the vicinity of freshwater lakes and pools of water; and then having been partially fused are thrown out again during the next eruption.

9. The invisible portion of the animal kingdom is thus found to possess a new, important and unexpected influence upon the solid, and in this case volcanic portion of the earth,—an influence which invites a closer investigation, and recommends itself to universal attention.

On the 24th of April 1845, Professor Ehrenberg made another communication to the Academy, stating the result of further investigations into the subject, partly with reference to some additional specimens from Hochsimmer, and partly on various volcanic tuffs, &c. from distant localities.

I. *On the Volcanic Infusorial Tuff* (Pyrobiolite) *of the Rhine.*

Owing to the active researches of the local authorities, and especially of M. von Dechen, the author has obtained much new information with regard to the Laacher-See and Hochsimmer; and he states that, including a firestone forwarded by M. Nöggerath, not less than thirty-nine different kinds of rock had been forwarded to him for investigation. The geological relations of these rocks he considers it highly essential to record; and they are the more important, since other objects had been forwarded to him for examination from distant localities, and a comparison of the results with what we know of the volcanic relations of the inland Rhine district would tend to a completion or rapid extension of our general knowledge of the subject.

The sections at Hochsimmer are obtained from six points; and the following account is quoted by the author from a communication he had received from M. von Dechen:—

"The first result is, that the peculiar infusorial mass is not confined to the one stratum first made known, although the others recently laid bare do not equal that in purity and regularity.

"From the relations of the originally exposed infusorial stratum, the immediate deposit of the whole series of volcanic tuffs and conglomerates containing that bed, and resting upon the grauwacke, is distinctly seen.

"The thickness of the conglomerate and tuff, as far as it has been hitherto proved, amounts to about $27\frac{1}{2}$ fathoms or 165 feet; and it is not likely that the whole thickness is much greater than this, since the grauwacke comes out to the day at no great distance towards the north-east.

"Notwithstanding that the whole thickness of the deposit has not been penetrated at this point, there is no doubt that the series of deposits upon the grauwacke consists exclusively of various conglomerates and tuffs of volcanic origin, having very different thickness, and containing, interstratified with them, several infusorial masses; and the whole sequence is essentially identical with the very similar series in the neighbourhood of the Laacher-See."

The microscopic investigation of the thirty-nine specimens forwarded has led to the following results:—

1. The whole stratified deposit of volcanic tuff and conglomerate reposing on the grauwacke at Hochsimmer, just as in the case of the Brohl Valley, and the similar masses on the east bank of the Rhine (*e. g.* the pumiceous conglomerate or sandstone of Engers), all exhibit relations with minute organic life, and are often, to all intents and purposes, actually formed of microscopic animalcules.

The relation with organic beings is of this kind: not only are there complete layers of distinctly recognisable organic bodies, which were once the siliceous cases of infusorial animalcules, but, with few exceptions, every fragment of tuff not larger than a pin's head will be found to contain several portions, sufficiently preserved to enable us to identify specific forms, and often exhibit complete shells of these minute beings; sometimes also the whole mass is almost entirely made up of them.

In the rock at Brohl and the firestone of Bell, it is the included pumice which exhibits remains of this kind either complete or in a fragmentary state; and in the pumiceous conglomerate, or, as it is called, the sandstone of Engers, it is not the grey interstratified mass, but the white pumice-like nucleus of the conglomerate, which also here and there contains similar organic bodies though in a fragmentary condition. Many of these in the regular volcanic tuff formations appear to have become quite unrecognisable; but amongst the mass some may often be found which enable us to determine both the genus and species of the little animalcule of which they are the remains.

In most of these volcanic tuffs one may often perceive, by using transmitted light, green, brown or white crystals, of which the green are for the most part columnar, oblique-rhomboidal, acutely-pointed prisms, appearing black with reflected light, being in all probability crystals of augite, while the obtuse brown crystals are more likely to be hornblende. Many of the tuffs contain great quantities of exceedingly small white transparent crystals in which sometimes there may be distinctly traced the rhombic-dodecahedral form, and these no doubt are sodalite, or perhaps occasionally leucite.

2. The masses thus characterized appear to be, as they have always been considered, of volcanic origin. The numerous small crystals of augite which make up so large a part—often at least one-half of the whole mass—and those white kernels and particles of sodalite and leucite visible to the naked eye, have hitherto been considered as the result of the action of heat, since we are not aware of the possibility of such forms of the mineral being producible by aqueous

action. The application of the microscope to this subject, showing that the condition of the siliceous infusorial cases is such as would be the effect of exposure to very high temperature, has fully confirmed this view.

3. The stratified mass at Hochsimmer can no longer be considered as an aqueous formation, fused into a mass by volcanic action immediately after its deposit; since the condition of the different strata is not such as would be produced by such means. Several experiments seem to prove that the most perfect fusion has been effected in portions which are by no means the lowest in position.

4. The tuff of Hochsimmer could not, it would seem, have been formed under water, because the materials of the strata are not arranged according to the law of gravitation. The author states that he has made out, by direct experiment, that the white, siliceous, infusorial powder by no means retains its white colour, nor does it arrange itself in the same way after being mixed under water with the fine tufaceous ash with which it is interstratified. The hollow cells also of these infusorial cases rise to the surface when mixed with coarse particles, so that some other cause than mere deposit from water must have produced the alternation of fine layers of these with beds of coarse tuff.

If it should be said that these coarser particles of tuff, amongst the fine layers of infusorial animalcules, consist of concretions which have formed in water from the more minute particles since the mass was deposited, or that they have been formed at all by aqueous action, the association with volcanic crystals, sometimes of considerable size, renders such an explanation impossible. In the same way it seems impossible to account for the appearance by supposing that the masses containing infusoria were deposited regularly in alternation with deposits of tuff, because the internal structure and composition of the tuff itself, and the fact that it is often partly and sometimes almost entirely made up of similar organic bodies, is directly opposed to such a view.

But again, it may be imagined that the infusorial animalcules were introduced after the volcanic deposits had been effected, and partly by aqueous action. To this idea, however, is opposed the fact of their being almost always in fragmentary condition, and in great part metamorphosed,—an appearance which the author has never seen in the rapidly forming beds of these animal remains, either in Berlin or in the Luneburg forest, or near Eger, however thick the deposits may be. The regular stratification and distinctly arranged appearance are also opposed to this view; and indeed it becomes altogether impossible, when we consider the mingling that there is of Phytolitharia—the siliceous particles of certain minute vegetable bodies—which could as little form and increase in these places, or even penetrate to them, as the bones of quadrupeds.

5. The Löss in the Rhine neighbourhood appears quite distinct from the tuff, although it contains parts made up of organic bodies. It bears no appearance of having undergone the action of heat.

6. There are at this time ninety-four different species of micro-

scopic bodies recognised as forming an integral part of the Rhenish volcanic tuff; and of these seventy-two are *Polygastrica* and twenty-two *Phytolitharia*, and all without exception consist of land or freshwater forms. Only four or five of the whole number are unknown and peculiar.

7. With regard to the particular species, the author remarks that the toothed *Eunotiæ*, viz. *Eunotia triodon* (having three teeth) and *E. diadema* (with six teeth), have not hitherto been met with by him in a living state in Germany, and are generally considered as northern fossil forms in Sweden, Finland and North America. The first of them was however found living near Salzburg by the late Dr. Werneck, and has recently been recognised in atmospheric dust from the Cape de Verd Islands. There are also three species of *Biblaria* not now known to exist in Europe.

8. Among those whose remains form great masses in the Rhine district may be enumerated *Discoplea comta* and *Pinnularia viridula*. The first is only at present known as an existing species on the high lands of Koordistan, but the other is common in a living state everywhere in the vicinity. The *Discoplea* occurs also in the phonolitic incrustation of Hochsimmer and at Wistershan in Bohemia, and is also present in the ashes which have buried the ancient city of Pompeii; and a very similar species is found in the tertiary tripoli of Virginia: it is closely allied to *Gaillonella crenulata*.

The author mentions that he has seen and carefully avoided errors of observation arising from the resemblance of some forms of infusorial cases to fragments of crystalline bodies, such as sodalite and leucite, which are often present, and might readily be the cause of mistaken descriptions.

9. If, after a further extension of our knowledge as to the circumstances of the case at Hochsimmer, it should appear possible that this deposit might have been formed by a shower of ashes, or by projectiles consisting of a fine dust fused together into a mass without the presence of moisture, such showers occurring at intervals and after the lapse of short periods of time; or if the local conditions should require that such ashes have been driven by a steady wind into a dry crater-shaped hollow, where they have been received and accumulated in layers, such a mode of accounting for the phænomena would best agree with the result of the author's investigations, and his knowledge of the materials of which the deposit is made up.

10. With regard to the very puzzling question, whence these infusoria and Phytolitharia came, he suggests, partly on account of their including forms not now met with in a living state, that they may possibly have formed layers of turf, or perhaps brown-coal, which by some accident have come within the range of volcanic activity; and owing to their incombustible and almost infusible condition have been erupted as showers of ashes. Such layers of infusoria he has already shown to exist, forming and accompanying the fissile coal near Siegburg and Geistingen on the Rhine, although on the Upper Rhine none have yet been determined. The tuff and firestone appear to have had a similar volcanic origin, but to be the result of eruptions of mud in which the infusorial strata have not been repeat-

ed, owing to their toughness. The sandstone from Engers appears to have been erupted in the condition of fused lumps, which have afterwards been united into a mass by a cement of a very different kind*.

II. *On a remarkable Tuff of Volcanic Ashes containing Infusoria, from the Island of Ascension.*

The author was indebted to Mr. Darwin for several highly interesting specimens for microscopic investigation, obtained during his journey; and amongst them was a singular white and soft volcanic tuff obtained from an extinct volcano in the island of Ascension. Before stating the result of his examination of this rock, the author quotes from Mr. Darwin's work the following account of the circumstances of its occurrence :—

"*Concretions in pumiceous tuff.*—The hill marked in the map 'Crater of an old volcano,' has no claims to this appellation which I could discover, except in being surmounted by a circular, very shallow, saucer-like summit, nearly half a mile in diameter. This hollow has been nearly filled up with many successive sheets of ashes and scoriæ of different colours, and slightly consolidated. Each successive saucer-shaped layer crops out all round the margin, forming so many rings of various colours, and giving to the hill a fantastic appearance. The outer ring is broad and of a white colour, hence it resembles a course round which horses have been exercised, and has received the name of the Devil's Riding-School, by which it is most generally known. These successive layers of ashes must have fallen over the whole surrounding country; but they have all been blown away except in this one hollow, in which probably moisture accumulated, either during an extraordinary year when rain fell, or during the storms often accompanying volcanic eruptions. One of the layers of a pinkish colour, and chiefly derived from small decomposed fragments of pumice, is remarkable from containing numerous concretions," &c. (Volcanic Islands, p. 47.)

This singular example of volcanic ashes met with in a true volcanic island, isolated and situated off the coast of Africa, exhibits however, on a careful microscopic investigation, none of the characters of an ordinary inorganic volcanic ash; but, on the contrary, the whole mass is of organic origin, scarcely changed in its separate parts, but entirely deprived of every form of carbon, which has probably been dissipated on the mass being exposed to a red heat. This completely rainless and treeless island, covered only with a scanty vegetation, on which no land birds are able to exist, as we are informed by Mr. Darwin in his 'Journal,' can hardly have had such a periodical supply of water in this so-called 'old volcano' as to have allowed many plants to grow, since our traveller does not mention the existence of their remains in that place.

When it is considered that thirty species of organic bodies, chiefly remains of plants (Phytolitharia), but including also siliceous-shelled infusoria, have been obtained from this most characteristic form of a tufaceous deposit in a circular band surrounding a supposed volcano, the phænomenon appears beyond a doubt very enigmatical, and requires to be considered in a somewhat new point of view in order that it may be solved.

* The author here appends a table, in which the occurrence of each species in each one of the thirty-nine different rocks of the Hochsimmer section is recorded. It will be found facing page 139 of the Proceedings of the Berlin Academy (*Berichte*) for 1845.

The specimens of this tuff that were examined do not merely exhibit the organic forms distributed more or less abundantly through the mass, but they seem actually made up of them, since even the dust-like powder or detritus mingled with them may be considered as merely fragments reduced to a very fine state of subdivision.

An examination of the specific forms determines the singular and very important fact, that the greater number of these are widely spread, reaching even to Europe, and that they are of land or freshwater origin. Eleven of the number, besides these known species, must also be placed amongst the freshwater forms, and most of them are little siliceous particles from grasses, while there is not one single marine species to be met with amongst the whole number of organic bodies thus composing a rock in the middle of the ocean. It yet remains to be determined what the thickness of the bed is, and in what relation it stands to the other pumice in the neighbourhood; but these infusoria can hardly be considered as having relation to the present scanty vegetation of the island.

III. *On a White Volcanic Rock or Tuff from Patagonia containing Marine Infusoria.*

The author states, that amongst many other objects for examination received by him from Mr. Darwin, one of them was a white tufaceous rock, described by Mr. Darwin in his 'Journal *' as characteristic of the tertiary formations of Patagonia, and covering a great deposit, including many tertiary shells, all apparently extinct. This bed (the tufaceous rock) has been incorrectly described as chalk, but it much more nearly resembles a deposited felspathic mass.

The specimen examined presented under the microscope the character of a crumbling pumice or tuff containing fragments of infusoria. When this result was communicated to Mr. Darwin, he requested the author to experiment upon the mass in a more special manner, and forwarded specimens from Port St. Julian, Port Desire and New Bay, accompanied by the following remarks received in a letter from him:—

"I have to thank you for your remarks on the white Patagonian rock, and to state that for many reasons I had arrived at the same conclusion as yourself, that it is originally a volcanic product. Unfortunately you do not mention which of the specimens of white stone contain infusoria, and I think I forwarded several, with their localities marked †. The formation is on a grand scale; it contains much gypsum, it has the consistence of our chalk, but is perhaps somewhat softer, and it has an enormous extension. At Port St. Julian it cannot be less than 800 feet thick. Its average breadth is at least 200 miles, and probably more, while it extends from north to south at least 550 miles."

The author on this renewed his investigations with every possible attention, and communicates the result, enumerating the species and

* 1st ed., p. 201; 2nd ed., p. 170.

† The author had found these remains in all the specimens.

their localities. The number of species described amounts to thirty; but he states that every fresh investigation has increased this number, and has also tended to confirm the volcanic character of the rock*.

These thirty organic bodies, associated with very minute fragments of cellular glassy pumice greatly resembling them, so completely make up the whole mass of this Patagonian rock, especially at New Bay, that either the shells or fragments of them can be detected in every little morsel not larger than a pin's head. It is also perfectly clear that they have been subjected to a high temperature, which has burst them asunder, bent, polished and altered them. It is even probable that the glassy crushed fragments are also derived immediately from these organic products; but there are here and there, besides these, green crystals resembling augite.

This mass chiefly consists of species which inhabit salt water, and of these many have been long known and are widely extended through the ocean; but several of them are new and peculiar, and resemble in shape small stars. Nearly half of them are the siliceous particles of marine sponges whose forms are known, and of which we are in some cases acquainted with the origin.

The Patagonian rock thus described is therefore manifestly a sea-bottom which has been subject to volcanic action.

In this case, as before, the spiculæ of sponges, which are always detached and fragmentary, can neither have penetrated the volcanic tuff, nor can they have been there developed in a fragmentary state, while such a notion is still less tenable with respect to the infusorial animalcules. A merely elevated sea-bottom which had not been exposed to intense heat must necessarily have exhibited various organic bodies, as in Oran, Sicily and Virginia, containing entire sponges, corals, foraminifera and shells, and would not merely consist of fragments of pumice and of siliceous-shelled infusoria. Foraminifera and all other calcareous remains are here entirely absent, and they, as well as the argillaceous particles on the sea-bottom, have probably served partly as a flux for reducing the fused siliceous particles, and have partly been decomposed to form the gypsum.

[The author then proceeds to describe several infusorial remains occurring in the loamy earth of Patagonia and the banks of the Plata, whence were obtained the gigantic mammalian remains of Edentates and other animals brought home by Mr. Darwin and described by Professor Owen. These are almost entirely of fresh-water origin, and differ therefore from those found in the rock already alluded to. He next mentions two kinds of Phonolite, the trass of the Siebengebirge, and the ashes under which Pompeii is buried, as all containing infusorial remains, although the number of species is not considerable; and he concludes by alluding to a singular instance of a body apparently organic but not infusorial, found in the trachyte of Zimapan in Mexico. These matters not bearing directly upon the principal point in question in this memoir are here omitted.—Ed.]

* The species of Polygastrica (infusorial animalcules) amount to seventeen, and the Phytolitharia are thirteen. They are thus distributed:—

	Polygastrica.	Phytolitharia.	Total.
Port St. Julian	10	8	18
Port Desire	13	7	20
New Bay	2	1	3

Sketch of the general results of these investigations.

1. The recent varied and careful researches have confirmed the notion that there exists on the Rhine, in districts marked by volcanic action, a very intimate and general relation between organic life in its most minute form and the results of volcanic activity. Crystals of volcanic origin, either pyroxene (augite), sodalite or leucite, are mixed up directly and intimately with the fused fragments of freshwater infusorial remains in rocks the thickness of which amounts to nearly 200 feet.

2. On the volcanic island of Ascension in the middle of the Atlantic, which is singularly barren of life, being entirely without trees and almost without water, there exists a considerable deposit of volcanic ashes, which according to microscopic analysis is clearly shown to be made up exclusively of organic bodies, most of them the siliceous parts of plants, but some of them the remains of infusorial animalcules; and these are not species inhabiting the sea, but are, without exception, confined to fresh water.

3. According to the result of numerous observations made with reference to various localities in Europe, Asia, Africa and America, it appeared that the relation of microscopic organic bodies to volcanic rocks was strictly confined to those forms known only as existing in fresh water, and it seems also, as stated above, that this is the case in the island of Ascension, under very striking circumstances. This might have been supposed to arise from the similar marine forms not having been yet observed, or from the mixture of other material at the sea-bottom having rendered the whole more readily fusible, and so not presenting the phænomenon for investigation. There has now, however, been found a volcanic formation of infusorial tuff forming mountain masses in Patagonia, and exhibiting distinctly its marine origin, so that this remarkable appearance of an exclusively freshwater origin is taken away, and the marine forms are fully represented.

4. In Patagonia this *Pyrobiolite* rock is developed into a terrace-shaped formation upwards of 800 feet high, greatly resembling the European chalk, although without any trace of carbonate of lime, and containing here and there a considerable quantity of gypsum. It forms apparently one of the largest uniform masses of rock that we know of on the earth, amongst those manifestly due to the same agency throughout and perfectly continuous, and it exhibits everywhere, and is perhaps chiefly derived from, the influence of the most minute forms of organic existence.

5. The Patagonian white tuff, formed perhaps during the submarine eruptions of the great Chilian and Patagonian Cordilleras of the south-western part of South America, and possibly the result of the great and uniform activity of the eruptive forces which elevated that chain of mountains, must be of tertiary or yet newer date, since the pyrobiolite rock reposes on fossiliferous tertiary strata. It would not be unimportant to subject to careful microscopic in-

vestigation the fine dust which often falls during showers of volcanic ashes.

6. The ashes which buried Pompeii were of freshwater origin, and neither sea-water or a sea-bottom seem to have had anything to do with the volcanic eruption to which they were due. The formation, in all essential points, resembles that of Hochsimmer.

7. From an examination of its microscopic contents it has been made clear that the ossiferous beds on the Plata and at Monte Hermoso, as well as those near Bahia Blanca (both of which are in Patagonia), are unchanged deposits made in slightly brackish water —probably the result of some great irruption of the sea upon the low lands of the mainland.

8. It also appears that the original trachyte of Mexico, the matrix of the fire-opal, affords distinct indications rendering probable its relation to organic forms, and suggesting closer examination. It appears within the limits of possibility that all masses derived from trachyte may be in a similar condition.

9. The idea that the most minute and invisible living beings exercise a mighty influence on the solid igneous framework of the earth,—an idea which was at first only suggested, but is now confirmed by every fresh investigation,—renders it possible that a far greater extension may yet be looked for, and we may therefore be prepared to expect corresponding results on the grandest scale.

10. The recognition of organic influence in the case of so many of those rocks of which the earth's crust is made up, renders it very desirable that the limits of the extent of this influence should, as far as possible, be marked out. The names siliceous sinter (Kieselguhr), mountain meal (Bergmehl), tripoli, polishing slate, paper-coal or dysodil (Blätterkohle), limestone, semi-opal, hornstone, ironstone, &c., now require, not indeed mineralogically but geologically, that we should be able to distinguish them by some general name, so that there should be no danger of describing under the same appellation matter of very different kinds. This might no doubt be effected by speaking of 'organic or infusorial siliceous sinter,' 'infusorial tripoli,' and 'altered volcanic or unaltered volcanic freshwater or infusorial tripoli;' or we might speak of 'polythalamial limestone,' 'organic or infusorial iron,' &c.; but all these long additions to ordinary expressions are manifestly inconvenient, and the same difficulty occurs with regard to the names 'tuff,' 'volcanic conglomerate,' 'pumice,' 'phonolite,' &c.

The author then suggests as a convenient nomenclature, that we should denominate those minerals which do not exhibit either among their actual component parts or from the conditions of their aggregation any marks of organic existence, 'elementary tripoli,' 'elementary limestone,' 'elementary pumice,' &c., or together, *Stœchiolite* (elementary rock), in contradistinction to the other group, which we may designate *Biolite* (organic rock).

True *Biolites*, however, are not those rocks and formations which simply contain fossils, but those which are deduced from and consist of agglomerations of organic bodies either absolutely or essentially, and which merely contain inorganic particles here and there distributed amongst them. By this name however we may correctly designate infusorial polishing slate, tripoli, the whole mass of polythalamial chalk, coal, &c. Fossil shells, corals and bones are sometimes indeed so far components of rocks as to form entire masses, but they are generally extraneous, although often characteristic contents.

On the other hand, the true well-defined elementary rocks (*Stœchiolites*) are those which have no essential and original relation with organic existence, and only occasionally and accidentally contain fossil organic bodies.

For those rocks of organic origin which have not been subsequently modified by volcanic agency it would be both convenient and definite to employ the more special name *Hydrobiolite*, while those, on the other hand, which have been so altered, we might call *Pyrobiolite*, or *pyrobiolitic rock*, *earth*, or *formation*. And if it should seem that a still further subdivision would be useful, we might describe such rocks as the paper-coal (dysodil), the Bilin polishing slate, mammillated slate, and other freshwater substances of this kind, *Hydrozoolite*, while coal, &c. might be called *Hydrophytolite*. So on the other hand we might designate white chalk and the Sicilian marly chalk, as well as the Virginian infusorial marl, *Halizoolite* (from its relation to marine organic life).

It is to be hoped that after this manner the relations of rocks to their organic and inorganic elements may find a more ready and general expression, and that investigations which are not to the purpose, and collision with existing theories so far as they relate merely to forms of expression, may be avoided, and the principles involved be soon distinctly recognised.

D. T. A.

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2. *On a capillary condition of* Obsidian *from the Island of* Owhyhee (Hawaii). *By* Professor Nöggerath.

[From Leonhard and Bronn's 'Jahrbuch,' volume for 1846, p. 23.]

At the meeting of the German naturalists and physicians held at Nuremberg in 1845, I received from Dr. Focke of Bremen a small box marked 'Thread-like Obsidian,' with a request that I would bring the subject before the Mineralogical Section during the meeting. The substance in question had been brought in considerable quantity from Owhyhee by Captain Wilken, and had been forwarded by M. Kind from Hamburg.

The box contained a multitude of detached delicate needles of obsidian, confusedly interspersed amongst minute nuclei of the same substance. The needles or capillary fragments were of olive-green colour and transparent; they were for the most part about $\frac{1}{24}$ inch long and of uniform thickness, resembling human hair or swine's bristles. There were however with these, others not so regular in form, these latter being generally terminated with a pear-shaped knob, like what one sees at the extremity of a thread of glass that has been melted. In this state the knob is of darker colour towards the extremity, and quite black when of larger size than usual, being then like the fragments of obsidian found detached in the general mass. Detached threads terminated in a point, and many of them exhibited distinctly under the microscope a number of striæ along the length of the thread. One might suppose this to indicate crystalline structure, if it were not that drawn threads of glass exhibit similar striations; but at the same time I am not inclined absolutely to deny the crystalline origin of the specimens in question, though it seems to me more probable that they have resulted from certain conditions of cooling after the mass has undergone fusion.

This singular condition of obsidian is not however without parallel. Von Born, in the 'Catalogue des Fossiles de la Collection de Madm[lle] E. de Raab' (Vienna, 1790, i. 454), speaks of "a volcanic glass in detached filaments, capillary, vitreous and of green colour, from the Isle of Bourbon." These vitreous and flexible filaments were thrown out during the eruption of 14th of May 1766. Hausmann also (Jahrb. 1837, p. 500) describes a similar product from the same island, using an ingenious analogy in illustration. He says, "An appearance consisting of a very loosely compacted confused mass of extremely delicate glass threads is sometimes seen in glassy slag, and has a similar origin to the so-called *spun glass*. It is sometimes formed in the hearth of a blast-furnace, where the opposing currents of wind form and retain for a long time a number of balls of slag in the hearth. Sometimes a somewhat similar result is produced during a volcanic eruption, as happened in the island of Bourbon in the year 1821, when there fell a shower of exceedingly fine volcanic ashes consisting of delicate glass threads."

I am informed by Professor Wiebel of Hamburg, that Captain Wilken had also brought from Owhyhee numerous specimens of obsidian, the broad crevices of which were filled up with a similar confused heap of particles; a fact which is by no means inconsistent with the explanation offered by Hausmann, since gases may here have performed the part of the artificial blast.

I have thought this short notice worthy of being communicated, since volcanic products of this kind must always be rare; and the analogous phænomena from Bourbon are not known to me by personal observation.

D. T. A.

MISCELLANEA.

I. *Palæozoic Rocks of Armenia.*

M. Abich, Professor at the University of Dorpat, has been employed by the Government of Russia to make geological investigations in the Transcaucasian districts. He has lately written to Colonel Helmersen that he has found on the northern flanks of the greater Ararat, near the monastery of Corveral and in the valley of the Aras, ancient limestones with such fossils as *Spirifer speciosus*, *S. ostiolatus*, *S. aperturatus*, *Orthis*, *Lingula*, *Catenipora escharoides*, *Cyathophyllum flexuosum*, *Favosites*, &c.; and it appears that these beds extend for a considerable distance to the east and north-east of Ararat.

This discovery is the more interesting, since the very existence of the palæozoic series in these regions was before quite unknown, and the whole tract was supposed to be completely covered up by deposits of far more modern date. While waiting for the expression of M. Abich's opinion on the relations of this great spread of palæozoic rocks, may we not suspect that they are connected with those Silurian deposits exhibited on the flanks of the eastern extremity of the Balkan range, and constituting a portion of the Thracian Bosphorus?—*Bull. de la Soc. Géol. de France*, 2nd Ser., vol. iii. p. 138.

II. *Palæozoic Rocks of Siberia.*

In a letter from M. L. Zeitzner, read before the French Geological Society, and dated the 30th of June 1844, we find the following announcement:—

I have the honour of forwarding a short notice on the fossils of the chain of Stanowa Hrebeta, near Baikal in Siberia, brought by M. Mitkiewcz. The rock containing the fossils is quartzose, and of a greenish colour; it has a marked resemblance to the grauwackes of the Rhine, and the fossils are distinctly palæozoic species. I have determined the following:—

1. *Gorgonia retiformis*, De Kon., An. Foss. de Belg. pl. A. fig. 2. The minute branches are marked by longitudinal and transverse striæ.

2. *Terebratula prisca*, Schloth. There are bifurcating ribs along the whole length of the valves.

3. *Calymene macrophthalma*, Brongn. The specimens are all curved, and the head is covered with little tubercles.

One cannot determine the exact division of the palæozoic series indicated by these fossils, because, with the exception of the Gorgonia (a Silurian species according to MM. de Verneuil and d'Archiac), they are met with in deposits of different dates.

There was also a specimen of sandstone, from the same country, exhibited markings of a *Neuropteris*, having a close resemblance to specimens of ferns from coal-measures.—*Bulletin de la Soc. Géol. de France*, 2nd Ser., vol. iii. p. 62.

III. *On the Chemical Composition of Calcareous Corals.*

The recent analysis of the solid parts of several species of recent Corals has exhibited the very interesting result, that the Zoophytes which form these stony skeletons secrete a very important proportion of silica, and that of the salts the fluates greatly exceed in amount the carbonates. The following examples are among the most remarkable in this respect, and may serve to suggest some interesting investigations with regard to the conditions of deposit, and the nature of fossil corals and the siliceous minerals (and chiefly common flint) found so frequently associated with organic secretions from sea-water.

	Porites favosa. — Sandwich Isles.	Madrepora palmata. — Antilles.	M. prolifera. — Bermudas.	Astræa Orion. — Ceylon.
Silica	22·	12·5	10·32	30·01
Lime	13·03	7·5	15·57	17·45
Magnesia	7·66	4·2	38·49	24·57
Fluate of lime	7·83	26·34	7·5	0·85
Fluate of magnesia	12·48	26·62	2·62	4·31
Phosphate of magnesia	2·70	8·	0·25	0·32
Alumina and iron	16·	14·84	25·25	22·49
Oxide of iron	18·30			
	100·00	100·00	100·00	100·00

Silliman's Journal for May 1846.

IV. *Discovery of spirally-dotted or scalariform Ducts and other Vegetable Tissues in the* Anthracite *of Pennsylvania, U.S.*

An interesting notice on this subject (illustrated by figures) will be found in the May number of Silliman's Journal for this year (1846). The author, Professor J. W. Bailey, of the U. S. Military Academy, examining the burnt ashes of the coal from a common fire, found many of the masses separable into laminæ, on almost all of which vegetable structure could be detected. The specimens thus obtained exhibit, both as opake, and (when properly prepared so that the carbonaceous matter is removed) as transparent objects, indications of perfectly preserved dotted vessels. The author deduces as a conclusion, that the coal must have been composed of thin layers of vegetable matter scattered in a confused manner, and that no trunks of trees, or any considerable portion of their branches, had anything to do with its formation.—*Silliman's Journ.*, 2nd Ser., vol. i. p. 407.

V. *Remarks on* TEREBRATULA DIPHYA. By M. D'HOMBRE FIRMAS.

THIS singular form of Terebratula occurs in the neighbourhood of Moscow (?) and Warsaw, in the Carpathians, in Switzerland, near Verona and Belluno, in the Departments of Les Basses-Alpes, Drôme, Vaucluse and Ardèche, and near Gigondas, Baumes, and Berias in the Neocomian series. The author describes six specimens, offering every variety of form, from those which have a simple continuous outline to others in which there is a perfect aperture through the middle of the shell, and all of these varieties are either derived from differences of age, or are such modifications as can only be ranked amongst varieties of structure. From a comparison of these and a multitude of other specimens in different cabinets, he comes to the conclusion that the so-named *Concha diphya*, Colonna, *Terebratula cor*, Brug., *T. deltoidea*, Lamarck, *T. triquetra*, Park., *T. antinomia*, Catull., and *T. diphya*, Von Buch, form but one species, and cannot be divided into three (*T. antinomia*, *T. diphya* and *T. deltoidea*) as recently proposed by Catullo (Osserv. Geogn. Zool., Padova, 1840), for if any subdivision is made, we must establish at least ten species. M. Firmas also considers that *Terebratula pileus*, Brug., and *T. triangulus*, Lamarck (var. *T. mutica*, Catul.), described as species from the same formation as the former, are really only rare varieties of the same. They appear to exist only in the Veronese and Belluno beds.—*Leonhard and Bronn's Jahrbuch for* 1846, p. 117.

VI. *On the Structure of the* ORTHOCERATITE.

AT a meeting of the French Geological Society on the 15th of December 1845, M. Defrance read the following communication with regard to the Orthoceratite:—

In a visit which I recently made at the Château of Aux, near Nantes, I observed on a marble table the shell of an Orthoceratite of unusual size and in remarkable preservation. Although cut slantwise, it was still more than a yard long, and nearly an inch (·945 inch) across in its middle part. In the portion of the shell preserved there were seventy-four simple concave chambers, the last of which was something more than a foot long; the rest were traversed by a marginal siphuncle of rather large size.

On the same table there was a portion of the extremity of another

Orthoceratite, showing that the shell terminated in a point; and if we calculate the rate of diminution from the part preserved, we may suppose that the whole shell could not have been less than four feet long,—dimensions equal to those of the specimen seen by M. von Buch at Komberg.

The shell itself being exceedingly thin, and yet of so great a length, it must have been internal, since it is not possible to imagine how it could in any other way have been preserved uninjured: surrounding the shell, and in the direction of its length, indications of the enveloping substances may be traced.

This shell, not having been cut along the middle, must have been somewhat larger than the size recorded, and the last chamber was probably at least an inch in diameter.

These shells seem to have many points in common with *Baculites*, from which they differ in the complex intersection of the septa with the shell in the latter, while in the Orthoceratite this intersection is simple.

It is thought by MM. de Verneuil and Murchison, who have seen this specimen, that the whole length of the shell would exceed six feet. It is probable that the fossil in question is from Oeland.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

1. *General View of the* PALÆOZOIC FAUNA *of* RUSSIA.

[The following general view of the Palæozoic fauna of Russia forms the Introduction to the second volume (in French) of the work on Russia lately published by Sir R. Murchison, M. E. de Verneuil, and M. von Keyserling.

IN addition to that geological view of a group of fossils by which we are enabled to acquire a general idea of the inhabitants of the globe during various epochs, it is important also that we should consider the different groups zoologically, and determine as far as possible their extension in time and space. It is the object of the following essay to perform this task so far as Russia is concerned, and by passing in review the various species of organic remains obtained in this one district, and comparing them with the fossils of other countries, we shall endeavour to deduce certain facts concerning the distribution of organic life at a particular period, and obtain general results with regard to the introduction and extinction of the various species. We propose to run through the whole scale of animated nature, from the lowest to the highest—to distinguish those peculiar to Russia, to mention those which on the other hand are not so limited but are common also to other countries, and lastly, to allude to those which predominate in a particular part of the series in various parts of the world. Taking also each species at its first introduction into Russia, we shall carefully note whether it had previously existed in other countries under such conditions that it might have been transported by marine currents from one place to the other, or whether, on the contrary, it appeared for the first time almost contemporaneously over the whole of Europe and became extinct in a similar manner.

Genera incertæ sedis.—It need not excite surprise, that among the fossils of the most ancient date there should exist some which are so different from organic forms now living that we can hardly determine to what class they must be referred. Amongst such fossils are the *Graptolites* and the *Tentaculites.* The former, which seem most nearly allied to *Virgularia* or *Sertularia**, have been known ever since the time of Linnæus, and the number of species has been increased to thirteen, although, as it seems to us, without due consideration in some cases.

These species are distributed throughout the rocks of the Silurian system, though chiefly in the lower members. Whatever may be the ultimate decision with regard to the actual zoological relations of these animals, their geological place at least is well-determined, since they rarely pass out of the Silurian series of rocks, and in Russia as in Sweden they characterize its lower beds. In Esthonia the schists which contain them are superposed directly on the *Obolus* clay, and may be regarded as the equivalents of the aluminous schists of Sweden.

Graptolites are presented under two well-marked forms, those serrated on only one side, and those on which the two sides are thus marked. Both of these appear to exist in Russia, since although we have only met with *G. sagittarius*, which we consider the representative of *G. ludensis*, M. Eichwald has described a species under the name of *G. distichus* which belongs to the latter group. These bodies, tolerably plentiful in Bohemia, in the island of Sardinia, in the Pyrenees†, in Brittany and Normandy, and in England, extend also to the opposite coast of the Atlantic, where Messrs. J. Hall and Emmons have described two species.

Having as wide an extension as the Graptolites among Silurian rocks, the *Tentaculites* are however not limited to that group, one or two of the ten (?) species which have been mentioned by various authors extending into the Devonian rocks of the Eifel. We have also a Russian species in the Silurian limestones of Podolia, and another in the Devonian beds of Voroneje; but these fossils do not descend into the lowest beds of the Silurian system. They are widely spread over the earth's surface, and are met with in the Silurian rocks of the United States.

Corals.—Of these animal remains‡ two species are particularly abundant, the *Chætetes Petropolitanus* in the lower part of the Silurian system, and *C. radians* in the carboniferous rocks. Of these the first occurs in Sweden and in England, in the same position, and the second is found in England, in the carboniferous limestone near Bristol, but is there much less common than in Russia, where it

* Recently discovered near S. Béal by M. Boubée (Bul. de la Soc. Géol. de France, 2nd Ser., vol. ii.).

† Judging from some specimens of Graptolites which appear to possess roots, and into the composition of which carbon enters, Mr. Vanuxem considers these bodies as belonging to the vegetable kingdom. We have also ourselves been frequently struck by the carbonaceous appearance presented by certain individuals.

‡ The Russian Corals have been described by Mr. Lonsdale, who had only before him the imperfect specimens obtained by the authors, and who unfortunately had not been able to avail himself of the fine collections at St. Petersburg. The present notice is confined to some general facts which struck the authors during the course of their travels.

forms considerable banks. The *Syringopora* (*Harmodites* of Fischer), chiefly represented by the two species *S. parallela* and *S. distans*, is in that form characteristic of the mountain limestone, and widely spread. *Catenipora* on the other hand, in Russia as elsewhere, is confined to the Silurian rocks, and is there unknown in the lowest beds, but appears towards the termination of the lower series, and is especially abundant in the upper part of the system. The genus *Fenestella* is common in the carboniferous and Permian systems, and in the Ural furnishes a useful means of distinguishing the carboniferous from the lower limestones, which are often entirely made up of *Stromatopora concentrica* and *Favosites alveolaris* and *F. polymorpha*. It is worthy of remark, that in the Ural Mountains the Devonian system, there developed in massive limestones, contains a number of corals, but in the plains these fossils are rare; and it is only in the middle of the country and on the banks of the Don near Voroneje that a few species, as *Aulopora serpens*, *Favosites spongites*, &c., are found. The genus *Lithostrotion* is represented by four species, viz. *L. emarciatum*, *L. mammillare*, *L. astroides* and *L. floriforme*, and is met with throughout in the carboniferous limestone.

Infusoria and Foraminifera.—Although, if we may judge by their simplicity of organization, it is most probable that these animals existed from the very first introduction of organic life, the altered condition of the ancient rocks in most parts of the world has hitherto prevented remains of this kind from being discovered. No such obstacle however is met with in Russia, where the carboniferous limestones are still in their original condition, and thus they have already furnished several species to naturalists who have examined them under the microscope. In the silex disseminated through the limestones, and in the limestones themselves, M. Ehrenberg has discovered most of these minute animals, and he has already enumerated seven or eight species, one of which, *Borelis sphæroidea*, appears to differ but little from a recent Italian species. Such minute fossils however, so difficult to perceive and determine, are far less useful in practice than the *Fusulina cylindrica*, a Foraminiferous shell common in the upper carboniferous limestone, and especially characteristic of this part of the formation on the Dwina, the Volga, the Kliasma and the Donetz, and in the Ural.

Radiata.—Various plates and spines found in the carboniferous limestone have till lately been referred to the genus *Cidaris*; and it is rather singular that Mr. M'Coy and M. Agassiz should have been the first to observe that these plates being hexagonal could not have belonged to Cidaris, since in that genus the ambulacral and inter-ambulacral spaces are only composed of two ranges of pentagonal pieces. From the form of the plates, it is evident that the animal of these carboniferous fossils was provided with several rows of inter-ambulacral pieces, and differed from Cidaris in the same manner as the palæozoic Echinoderms, called by Dr. Scouler *Palæchinus*, differ from the Echinus of a newer period or of the existing seas. Although in Russia we have not found plates in which the form has been well-preserved, we do not doubt that *Cidaris* *rossicus*, so widely spread in the carboniferous system of that country, really belongs to the genus *Archæo-cidaris*, M^cCoy (*Echinocrinus*, Ag.), which indeed appears to be limited to this part of the palæozoic series in Europe.

The Crinoidea, generally so rich in varieties of form in the palæozoic rocks, are limited in Russia, so far as regards the three upper portions of the series, to detached fragments of the stem or arms, of which the species is rarely determinable. The only perfect head that we have met with is a specimen of *Cupressocrinites nuciformis*, Fisch., from the carboniferous limestone of Miatchkova.

In the Lower Silurian rocks of St. Petersburg, and on the shores of the Baltic, we observe a curious relation among the specimens, the instances of the perfect heads being more frequent than the occurrence of the fragments called Entrochi; but this is readily explained by the fact, that most of the Crinoids of this epoch belong to genera deprived of arms, and having only a short and rudimentary stem. It is to these genera that M. von Buch has given the name *Cystidea**, grouping them into a family of which the principal distinguishing characters are the absence of true arms† and the presence of an ovarial orifice on the side of the cup. 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 portion of the Silurian system, and disappear entirely where that terminates. In Russia the family is represented by the genera *Echino-sphærites* (*Sphæronites*), *Echino-encrinites*, *Hemicosmites* and *Cryptocrinites*. In Sweden it is limited to the first two, in England to the first only ‡, while in the rest of Europe, and even in America, it is doubtful whether there is a single representative. *Echinosphærites aurantium* is one of the most common of the Lower Silurian fossils both in Russia and in Scandinavia. *E. pomum* is, however, much more rare, and *E. balticus* seems peculiar to Russia. The species *E. tessellatus*, of which the true nature is very imperfectly known, is found higher in the series, and both in the Ural and in Devonshire occurs in Devonian rocks.

In glancing over the general list of palæozoic fossil Crinoids, we find the genera *Actinocrinites*, *Asterocrinus*, *Cyathocrinites*, *Euge-*

* See Quart. Geol. Journ. vol. ii. Part 2. p. 20.

† The very delicate tentacula which M. Volborth has recently discovered in the genus *Echino-encrinites* (Bull. de la Cl. Phys. Math. St. Petersb., vol. iii. No. 6) are placed on the very edge of the orifice of the mouth, and do not penetrate the plates as the arms of ordinary Crinoidea do. It also appears that these were not provided with a receptacle intended to contain eggs, since the genus *Echino-encrinites* (*Sycocystites*, v. Buch) has, according to M. von Buch, a large ovarial orifice. [The authors figure a specimen of *Cryptocrinites*, and state that on this specimen five small depressions may be distinguished round the mouth which appear to have been points of attachment of similar tentacula.—Ed.]

‡ *Echino-sphærites aurantium* has lately been discovered by the officers of the Geological Survey in Pembrokeshire, in those rocks which have been described by one of the authors as Lower Silurian.

niacrinites, *Platycrinites* and *Rhodocrinites*, quoted by M. Eichwald as occurring either in Esthonia or the Valdai Hills. The identifications of this author having unfortunately been made after an examination of fragments only of the stem, cannot be received with confidence, especially when it appears that, contrary to what happens in other classes, there are so many species common to two or more systems. We may however except from this remark the beautiful head figured by the Duke of Leuchtenberg under the name of *Apiocrinites dipentas*.

Brachiopoda.—Of all the classes of animals which peopled the palæozoic seas, there is none more worthy of attention than the Brachiopoda, and none is more generally distributed. In whatever locality, at whatever part of the group of deposits, or whatever be the nature of the rock which we examine, we very commonly find that there is little beyond the remains of these animals to guide us in our geological investigations. In a collection like that acquired by ourselves during a rapid journey and under circumstances in which the proportionate abundance of the various species of animal remains is not disturbed by the undue preponderance of rare and exceptional species almost always met with in local collections, the Brachiopods form almost half the whole number,—a decided proof of the important place which these animals occupied among the population of the ancient seas.

The causes which contribute to this great development of individuals in point of number having been also favourable to the establishment of new forms derived from the primitive type, a rich variety of each form has resulted, constituting a number of genera peculiar to this period. Observations are offered on these in the body of the work, so that we confine our present remarks within moderate limits.

The total number of species of *Terebratulæ* in Russia amounts to forty-four, according to our own actual observations, but must be extended to fifty-two if we include species cited by other authors. Considered only so far as regards the Russian empire, these species are characteristic of the various formations in which we meet with them, except *T. reticularis*, which is both Silurian and Devonian, *T. elongata* carboniferous and Permian, and *T. concentrica**, which passes at once from the Devonian rocks, where it is constant, into the rocks of the Permian age, without appearing at all in the carboniferous deposits between them. If however we take into account the palæozoic rocks of other parts of Europe, we find, besides the instances above-quoted, two species common to the Silurian and

* The true *T. concentrica* has been met with in four localities in Russia, but one from the Ural (figured by the authors, pl. 8. fig. 10) is distinguished by the small furrow which separates the ligament of the ventral valve. In the Devonian limestones of the Asturias in Spain there exist five or six species characterized by this same furrow, and one of them, absolutely identical with the Uralian species, has been named by the authors *T. Pelapayanensis* (Bul. de la Soc. Géol. de Fr., 2nd Ser. vol. ii. p. 448. See also Quart. Geol. Journ. vol. ii. Part 2. p. 65, where this memoir is translated).

Devonian systems (*T. aspera* and *T. Wilsoni*), four which are Devonian and carboniferous (*T. acuminata*, *T. pugnus*, *T. rhomboidea* and *T. saceulus* *), two which are both carboniferous and Permian (*T. Roissii* and *T. Schlotheimi*), and two others, (*T. canalis* and *T. elongata*,) which appear to be common to the three uppermost divisions of the palæozoic period.

The true Terebratulæ are however rare in the Lower Silurian rocks, and most of the species that have been quoted from such deposits must be referred either to *Orthis* or *Spirifer*. The species peculiar to the Silurian system are represented in the Ural by *T. reticularis*, *T. nuda*, *T. camelina* and *T. subcamelina*, and in Lithuania and Esthonia by *T. Duboisi*, *T. aprinis* and *T. Wilsoni*. In the Devonian system the Terebratulæ become more common, and one group, nowhere hitherto met with in any true Silurian deposit, requires especial mention. It includes those Terebratulæ covered with concentric lamellar striæ which never present a *deltidium*, and of which the rounded apicial aperture is placed directly on the crochet of the ventral valve. In Russia this group includes *T. concentrica*, *T. Helmersenii*, *T. lamellosa*, *T. Roissii* and *T. pectinifera*, two of the species belonging to the Devonian system, one to the carboniferous, and two to the Permian; but it is worthy of note, that *T. Roissii*, confined in Russia to the Permian rocks, is found in Belgium to range also into the oldest carboniferous beds. Amongst other Devonian species, we may mention *T. Meyendorfii*, widely spread throughout Russia, *T. Livonica*, and perhaps also *T. Daleidensis*, which M. Römer describes as occurring in the grauwacke on the banks of the Rhine; and we have also from the Ural *T. arimaspus*, *T. Strajeskiana* and *T. sublepida*, of which the latter has many relations with *T. lepida* of the Eifel.

Although our own researches have proved the existence of about twelve species of Terebratula in the rocks of the Russian carboniferous system, yet these species are generally rare and limited to so few spots, that the genus on the whole is by no means so abundantly represented by individuals as in the districts further to the west. The species *T. Schlotheimi* of Sterlitamak is the most remarkable of the whole number, as well by its internal structure, in which it resembles *Pentamerus*, as from the fact of its occurrence as a carboniferous fossil in Russia, although in Germany and England it is confined to the zechstein and magnesian limestone. If we consider the whole group of Terebratulæ, we shall find that the most common in Russia are *T. reticularis*, *T. concentrica*, *T. elongata*, *T. Meyendorfii* and *T. pleurodon*, and all these, with one exception, are widely distributed in distant countries, and extend also through many successive deposits.

In Russia we only know of one species of *Strigocephalus* (*S. Burtini*), which occurs in limestones supposed to be of Devonian age on the banks of the Serebrianka (Ural). Such is not the case with

* We somewhat doubt whether these four species are really met with in the Devonian rocks, although they are so described by Mr. Phillips (Pal. Fos. of Cornwall, &c., pp. 87, 88, 91).

Pentamerus, which occupied an important place among the palæozoic fossils of Russia, but the species, with the exception of a small variety of *P. galeatus*, are all Silurian. Most of the species belong to the Ural, but one, *P. borealis* (the representative of *P. oblongus* of Sweden, Germany and America), is found in the provinces bordering on the Baltic, and, like its analogue, indicates the limit between the lower and upper stages of the great Silurian deposit. The Ural species are almost all peculiar to that locality; three of them (of which two resemble more or less closely *P. Knightii*) are, together with this latter species, characteristic of the Upper Silurian rocks, and are widely spread, some of them in the northern and the rest in the southern part of the chain; and there is a fourth species, *P. galeatus*, which is less common, but which appears both in the Silurian and Devonian series as in Western Europe.

With regard to *Spirifer*, there are no less than thirty-six species, nearly a fourth part of the whole number known. If to these we add twelve others cited by other authors, and four which are doubtful, the number rises to fifty-one.

The species *S. glaber* and *S. lineatus* are the only ones which we have found in Russia passing from one system to another, and if others should be hereafter met with, we may be pretty confident beforehand that their number will be small. It is only toward the close of the Devonian system that this genus begins to be greatly developed, and the lower rocks are only represented in Russia by some species more or less anomalous, such as *S. insularis*, which is common to Norway and Russia, and also by the group of *Equirostrata* and the *Biforata*. *S. lynx*, which belongs to the latter group, is one of the most remarkable. It is characteristic of the lower stage of the Silurian system on this side of the Atlantic as well as on the other, where it is widely spread through the states of Ohio, Kentucky, Tennessee, and on the banks of the St. Lawrence. The Devonian species are characterized, as in the rest of Europe, by their fine and non-dichotomous plications (*e. g. S. Murchisonianus*, *S. Anossofi*, *S. disjunctus*, *S. Verneuili*, *S. Glinkanus*, *S. Archiaci* and *S. tentaculum*), and some of them extend as far as the Altai Mountains, where M. Tchihatcheff has found *S. Verneuili*, and others more or less analogous. The smooth species are more rare. The carboniferous system affords twelve more species, but of most of them the development is local, only three species, *S. Mosquensis*, *S. incrassatus* and *S. glaber*, being found in several places and abundantly; and of these three the first-named is one of the most common and most characteristic shells of Russia, and occurs also in Belgium and at Cabrales in the Asturias. Following the law of progressive decrease, the Spirifers are thinly scattered through the Permian rocks, where they are only represented by four species confined to a small number of localities.

The species of *Orthis* also observe a law of progressive decrease in their vertical distribution, but, unlike the Spirifer, this commences from the lower members of the Silurian system, where they have already obtained their maximum of development. The neighbourhood of St. Petersburg and the cliffs of Esthonia are celebrated for the abundance of their species, the whole number of which in Russia amounts to twenty-three, of which fourteen are Silurian, three Devonian, one Devonian and carboniferous, four carboniferous, and one Permian. This number is not more than one-third of the whole number of species quoted by various authors, but many of those described will no doubt require to be suppressed; it forms about two-thirds of the species distinctly made out. The small species with simple folds are as usual characteristic of the more ancient beds; those found in the carboniferous and Permian rocks are larger, and belong to our division *Recto-striatæ*, having a single area, and they may readily be distinguished from the other species of Orthis usually provided with a double area. The most common Russian species are *O. arachnoidea*, which is nearly allied to *O. pecten*, but is much higher in stratigraphical position; *O. caligramma* and *O. parva*, which either have representatives or are actually repeated by identical species in Sweden and America; and *O. resupinata*, which, as well as the variety *striatula*, is widely extended vertically as well as horizontally, passing from the Devonian into the carboniferous system, and found in the Altai Mountains and in the Ural, in the plains of Russia and Poland, in Belgium, in England, in the Asturias, and lastly, on the other side of the Atlantic in North America, where it has been mentioned by Mr. J. Hall as occurring in the state of New York. The *O. crenistria* is in Russia as in America a Devonian species, while in England it ranks as carboniferous.

Leptæna, considered, not as synonymous with *Productus*, but as a distinct genus resembling *Orthis*, from which it is distinguished by the concave ventral valve, is represented in Russia by fourteen species out of the twenty-four or twenty-five at present known. One only of these, *L. Ouralensis*, belongs to two systems, and not one occurs so high as the carboniferous series, all of them being confined to the two lower divisions of the palæozoic group. The decrease in the case of these two is so marked (falling at once from eleven to four species), that we might have expected, *à priori*, their early extinction. Among the most interesting species we may mention *L. sericea*, which occurs not only in Russia, Sweden and England, but also on the Asiatic shores of the Thracian Bosphorus and in North America; *L. imbrex*, which Captain Bayfield has found in Canada; and lastly, *L. Dutretii*, which M. Paillette has just discovered in the schists and Devonian limestones of the Asturias. The species *L. depressa*, which in Russia is exclusively Silurian, in other countries passes into the Devonian system, and following the law that those species which extend through different systems are also widely distributed in space, this one is met with in a vast number of localities, and has become one of the most common fossils of the double period.

The little genus *Chonetes* *, only comprising two species in Rus-

* The species of *Chonetes* recently discovered in America by Mr. J. Hall prove, by the persistence of the characters which we have assigned to this genus, how well-founded it is in nature.

sia, would hardly deserve mention, were it not that one of them, *C. sarcinulata*, is as common in the carboniferous limestone of Russia as it is elsewhere in the Silurian rocks.

The *Productus*, with which one species of Chonetes (*C. sarcinulata*) has been long confounded, offers in Russia a variety of forms corresponding to the vast extension in that country of the carboniferous limestone, in which this genus is chiefly developed. Both before and after the carboniferous period, indeed, it seems to have existed only in an imperfect and languid manner, presenting but three species in each of the two neighbouring systems, Devonian and Permian. The species in the older deposit are not striated, but are covered with spines, and greatly resemble one another, being in fact conformable to the single type of the genus occurring at this period elsewhere in Europe and in America. The carboniferous system in Russia contains twenty-two species, of which two only are new. The most common of the number are the following: *P. striatus*, *P. giganteus*, *P. lobatus*, *P. punctatus*, *P. scabriculus* and *P. semireticulatus* (*antiquatus*). The latter of these species abounds everywhere and deserves special remark, for distributed, as it is, as widely in Russia as elsewhere, and extending from Archangel and Spitzbergen as far as Cabrales in Spain, it serves better than any other to prove how different the physical and climatal conditions of the earth's surface must have been at the time it flourished from those which now obtain.

Those Brachiopoda which have no true hinges appear to have been represented formerly as at present by a much smaller number of species than the group just alluded to. The genus *Obolus* (*Ungulites*), whose remains are so widely spread in the neighbourhood of St. Petersburg and on the coasts of Esthonia, seems to have been replaced both in England and in America by small species of *Lingula*, to which, from its subcoriaceous shell, it has considerable resemblance. The only animals hitherto found associated with these early inhabitants of our planet are two small Orbiculas, which by the form of their ventral valve are quite distinct from existing species, and resemble closely an American species, *O. Lodensis*. The Lingulas appear in Russia a little later, and in the chloritic limestones which rest on the sandstone; but there are two or three species, one of which, discovered by M. Eichwald in the isle of Dago and near Hapsal, is remarkable for its large size. These shells are still unknown in the carboniferous system of Russia, and we have only found one small species in the Devonian sandstones of Dörpat, and one other still smaller in the Permian limestones of Cleveline between Sergiesk and Bougoulma. With regard to *Crania*, the genus is generally very rare in the palæozoic rocks, and for this reason the species found near St. Petersburg deserves mention. Lastly, to conclude the review of this group of Brachiopoda, we may mention the genus *Siphonotreta*, remarkable for the position of the apicial opening, and by the tube which proceeds from it. It has only hitherto been found in the environs of St. Petersburg.

Acephala.—If in the Brachiopoda the large number of the species sometimes induces uncertainty in the determination of them, a still greater difficulty, and one of a different kind, is presented, when we consider the remains of Acephala in the palæozoic rocks; for most of the specimens having their valves either closed or buried in the rock, it is often impossible to recognize those characters on which genera are usually based, such as, for instance, the arrangement of the various parts of the hinge, the number of the teeth, the form of the muscular and palleal impression, and the position of the ligament. It will readily be seen how much this uncertainty diminishes the value of these fossils, and the limited use we are able to make of them in their application to geology.

The *Tubicolaria*, *Pholadaria* and *Petricolaria* are certainly absent in Russia, as elsewhere, in the palæozoic rocks. The *Solenacea* are only represented by the genus *Solemya*, of which there are two species, one of them Permian and the other carboniferous; and the new genus *Allorisma*, of the same family as Pholadomya, also presents two species, one of them, *A. regularis*, resembling *A. sulcata* (*Sanguinolaria*, Phillips), very common in the carboniferous system both in Russia and England. We may mention here also a small shell, which we have described as an *Osteodesma*, though not without special notice of the singularity of a genus whose development is recent commencing so low in the series of beds. The two genera *Amphidesma* and *Edmondia* are the only representatives of the family *Mactracea*, which was afterwards to take so much more important a position among marine animals at the sea-bottom. *Edmondia unioniformis*, which lived during the carboniferous epoch, is common to England and Russia. The *Cardiaceæ*, now met with in the sea in all latitudes, commenced their existence at the earliest period, but the number of species in the older rocks is far less considerable in Russia than in the rest of Europe; and the genus *Cardium*, which alone includes fifty palæozoic species, is there represented by only five or six, of which three belong to the division *Pleurorhynchus*. These species all belong to the carboniferous system, with the exception of *C. striatum*, which M. Pander states he has found in the island of Œsel, and *C. palmatum*, which we have observed among Nova Zembla fossils. We also refer to this latter species a small shell found in the bituminous schists (Domanik-schists) on the banks of the river Uchta, associated with Goniatites resembling those which in Westphalia accompany the very same species. The genus *Cardiola*, which is tolerably abundant in England and Normandy, and extends as far as the Fichtelgebirge and the environs of Prague, does not penetrate into Russia; but this is not the case with the *Cypricardia*, of which there are two species, one of which, *C. rhombea*, presents no modification of form, whether exhibited in the Silurian rocks of the Ural, in Belgium or in England.

Among the species of *Nucula* and *Arca* which are described, and of which there are three of the former and four of the latter, we may mention *N. Kazanensis* as peculiar to the Permian beds, and *A. Oreliana* to the Devonian series. In the latter the serial teeth are almost entirely effaced. The Nuculas and Arcs formed with the Cardiaceæ the groups of dimyarian Acephala which most abound in the palæozoic rocks, taken as a whole; and reckoning up all the species described by various authors, we find the number of the first (Nucula) to be thirty-seven, and that of the second genus (Arca) seventeen, from which small number it appears that the physical conditions in Russia could not have been very favourable for their development; when however we remember that the species of these genera generally have a local and very circumscribed development, it will not seem impossible that future discoveries may raise this number, and render it proportionably as great as that which characterises other countries.

The genus *Megalodon*, which is exclusively Devonian, is represented by only one or two species in Russia. Of *Mytilus* (including *Modiola*) there are, on the other hand, six species recognized by ourselves, besides two that have been named by M. Eichwald, and of these *M. Pallasi* is the most widely spread, and it is also one of the most characteristic fossils of the Permian system. The *Pinna* hardly seems to have shown itself during the palæozoic period, but was represented by two species smaller than those of our own time, one of them occurring in the coal-shales of Lissitchia-Balka (Donetz), while the other is met with in the English mountain limestone.

Among the *Acephala monomyaria* only two genera, *Avicula* and *Pecten*, seem to have been greatly developed. Of the first-named there are however nine or ten species, of which six are peculiar to Russia.

Considered in regard to their development in time, the Russian species are thus distributed :—two are Devonian, two carboniferous, four Permian, and two occur in the Muschelkalk of Mount Bogdo. Among the latter is the *A. Alberti* of the German trias, and of the whole number only one, *A. antiqua*, offers the rare example of a species surviving through several systems. The *A. subpapyracea* of the coal-shales of Lissitchia-Balka greatly reminds one of *A. papyracea* from the similar deposits in England and Belgium, and *A. Kazanensis* of the Permian system affords a striking analogy in the great inequality of its valves with the *A. gryphoides*, which lived at the same time in the English seas. Although however the Aviculas are very rare in the Silurian system in Russia, such is not the case in North America, where we meet with upwards of fifteen of the twenty-two species found in the deposits of this age.

Pecten was introduced somewhat later, and is totally unknown in the Silurian rocks of Russia as elsewhere. It is however represented by one Devonian species, but only appears abundantly in the carboniferous system, where we can already enumerate five species. This increase is analogous to that which has been found to take place in other countries; for, in Ireland, Mr. Griffith and Mr. M^{c}Coy have discovered no less than fifty-six new species in the carboniferous limestone, bringing up the whole number of palæozoic species of Pecten to seventy *.

* The collections from Van Diemen's Land, brought by M. Leguillou and de-

The family of *Ostraceæ*, which has formed so important a part of the submarine fauna ever since the commencement of the secondary period, was only previously represented in Russia by a very small species discovered in the Permian limestones of Itschalki near Arzamas.

Gasteropoda.—From the first introduction of organic life upon the earth down to the present time, the Gasteropods have followed a law of constant progression, and the small proportionate number of animals of this class in the ancient seas compared with the important place they occupy in the existing creation, is one of the characteristic features of the palæozoic fauna. *Capulus* or *Pileopsis*, and the genus which has been separated from this group under the name *Acroculia*, represented in the palæozoic formations of Europe and America by twenty-five species, offers but two species in Russia, one of which only is known to the authors. Such is not the case with *Euomphalus*, a genus which, owing to its abundance throughout the palæozoic seas, may be considered as one of the most important types among the Gasteropoda of that period. We have found seven species in Russia, and including those mentioned by other authors, the whole number appears to amount to sixteen, nearly one-third of the species at present known. Of our seven species, one occurs in each of the two lower systems, and the remaining five are carboniferous. *E. gualteriatus*, the Silurian species, is known to be characteristic of the lower beds, and is found not only in Sweden and Norway but also in the island of Newfoundland and the United States of North America. The Devonian species, *E. Voronejensis*, is the only one peculiar to Russia; and of the carboniferous species, *E. pentangulatus*, *E. catillus* and *E. æqualis* were distributed at that time throughout the greater part of the European ocean.

In singular contrast with this group, we find *Pleurotomaria* affording in Russia a mixture of known forms with new species, and developed to a smaller extent there than elsewhere in comparison with the Gasteropoda in general. Thus, whilst the general palæozoic fauna contains sixty species, there are in Russia only nine, of which number we have either described or seen seven. Most of the species are carboniferous, and we may mention amongst them *P. Yvanii*, a Belgian species, which we found on the eastern flanks of the Ural. On the eastern flank of that mountain-chain, but further towards the north and in the older beds, we find in tolerable abundance a pretty species of *Murchisonia*, which M. von Buch has identified with *M. cingulata*. Russian species of *Trochus* and *Turbo* have been mentioned by M. Eichwald as occurring in the Silurian rocks of Esthonia, but they are rare. This however is not the case with *Melania rugifera* (*Loxonema*, Phil., *Chemnitzia*, De Kon.), which we have

posited in the Paris Museum, show how widely extended is this generalization with regard to the development of Pecten during the carboniferous epoch. In fact, we find the species of Productus and Spirifer, as well as the plants collected by this naturalist near Hobart Town, all indicating deposits of the carboniferous period, and amongst these fossils are associated some beautiful species of Pecten.

several times observed in the carboniferous limestone; and, according to M. Eichwald, this shell is common to the Devonian and carboniferous systems in Russia as it is in England. According to the same authority, species of *Natica* are also not uncommon in Russia, chiefly in the Silurian beds of Esthonia, but we have only met with two species (both carboniferous); one of them, *N. Mariæ*, new, and the other, *N. Omaliaria*, a Belgian shell. It is very doubtful whether any true *Buccinum* is met with in beds of the palæozoic age, and the shells which have been so named, but which have a mouth very differently formed, have been properly separated by Mr. Phillips under the name *Macrocheilus*. Amongst these are *B. acutum* and *B. imbricatum*, which we have observed in the carboniferous limestone of the Ural. Those mentioned by M. Fischer consist of indeterminable casts.

The *Bellerophons*, so widely distributed throughout the long series of deposits formed during the three older divisions of the palæozoic period, do not extend into the uppermost group, nor are they met with in any newer beds, and their type, now entirely lost, is so far removed from any existing organic form, that even the best zoologists are at a loss to what place amongst animals they should be referred. The whole number of species known, including both Europe and America, is upwards of fifty, and increases from below upwards, commencing with the Silurian rocks and terminating with the carboniferous—a fact which renders the total extinction of the group after the coal-measures the more striking. The old rocks of Russia, following the general law of the distribution of these beings during the palæozoic period, present a tolerably large number of Bellerophons, of which about eight or ten species have come under our own observation; and twelve others are quoted by various authors, several of them however only established on the evidence of casts somewhat widely spread in the carboniferous limestone. The species carefully determined are *B. megalostoma* and *B. ingricus* of the Silurian system, *B. hiulcus* and *B. decussatus* of the carboniferous limestone of the Ural, and *B. Ouralicus* of the Silurian rocks of the same mountain-chain. We have also recognised *in situ* fragments of *B. bilobatus*, *B. globatus* and *B. striatus*. None of the Russian species pass from one system into another, and we are inclined to suspect that in other parts of Europe where this law does not appear to hold, and where some species, such as *B. urii*, belong to several systems, that the number of these apparently common species will diminish as the subject is more carefully studied.

Pteropoda.—The *Conularia*, a genus which two of the authors (MM. de Verneuil and d'Archiac) have referred to the Pteropoda, is rarely represented in Russia. We know at present only of the small species, *C. Buchii* of St. Petersburg and *C. Sowerbii* of Kamenetz-Podolsk, which we have also met with in the neighbourhood of Christiania.

Cephalopoda.—In commencing the study of these shells, and observing their development during the period we are considering, we cannot but take notice of the fact, that from the earliest introduction of organic beings, those of highest organization and most perfect structure in the class of Mollusca have been present, and that throughout the long duration of geological periods there have been many modifications of specific form, but no advance on the whole. The testaceous Cephalopods were even much more abundant and more varied in ancient times than they are now, and most of the typical forms of that period are now lost.

The *Orthoceratite*, which preceded the Nautilus and Goniatite, may be looked upon as one of the earliest forms assumed for the shell of these animals, since we find indications of this genus associated even with the first traces of life, and if the species appear less varied in form in the lower beds of the Silurian system than in the upper deposits, this difference is compensated by the greater profusion of individuals. Thus in Russia and Scandinavia the species *O. duplex* and *O. vaginatus* fill entire beds by their remains, while it is curious enough to observe that the genus becomes rare in the Devonian rocks of Russia, differing therefore in that respect from the rest of Europe. In fact, except *O. vermicularis*, remarkable for the bead-like form of the siphuncle, the Devonian rocks only present one species, of which we found some fragments at Voroneje and to the north of Bielef. The whole number of Russian species, according to our determination, is only eleven, and if we add those quoted by other authors, it amounts to twenty; the distribution of the eleven being, five Silurian, one Devonian and five carboniferous; but considering that on the whole more than 130 species of this genus have been already described, it is probable that many still remain to be discovered in Russia: and, in fact, besides the five Silurian species described in our list, we have also fragments (from the neighbourhood of Reval) less distinctly marked, and belonging to two other species with transverse rings, one of which resembles *O. tubicinella*, Sow. None of the Russian species are common to two formations in that country, but two of the Silurian species described by us appear identical with Devonian species from the Fichtelgebirge, although this apparent identity must be received with some hesitation, because Orthoceratites afford so few good specific characters, that distinct species may very possibly not be determinable from the exterior. Of our five carboniferous species, two, *O. ovalis* and *O. calamus*, are from the Ural, two, *O. annulatus* and *O. ornatus*, from the Valdai, and the other, *O. Frearsii*, from near Moscow. They are all rare and limited in their distribution. The genera *Melia* and *Sannionites* of Fischer are only crushed or deformed Orthoceratites, and the *Hyolites* of Eichwald is nothing more than the interior of the siphuncle of *O. vaginatus*. Like the Bellerophons, the Orthoceratites do not extend into rocks of the Permian age.

The genus *Gomphoceras*, proposed for those short Orthoceratites of which the last chamber is swelled and the aperture narrow and contracted, affords two species in Russia and one in Poland. Of the two former, one is Silurian and the other Devonian, while the Polish species appears to be identical with *G. subpyriforme* of the Devonian limestones of the banks of the Rhine. The *Cyrtoceratites* are also represented by three species, all of them new; one of the most interesting is *C. Archiaci*, which seems to have a bead-like siphuncle like certain Orthoceratites of the group of *Cochleati*.

Contemporaneous with the Orthoceratites in their first introduction, the genus *Lituites* was still more limited in point of distribution in time, and its existence does not seem to extend beyond the Silurian rocks. The four species that we have seen in Russia belong to the lower members of the series, three of them occur in beds of the same age in Scandinavia and England, and one of the three, *L. cornu-arietis*, even extends as far as America.

The genus *Nautilus* is less ancient than *Lituites*, and with the exception of two species in the isle of Odinsholm mentioned by M. Eichwald, no species appears in Russia in rocks older than the carboniferous period, a fact however which is little in accordance with the observations made in other countries. The species thus found are also for the most part of small dimensions, and affect that discoid flattened form with a large umbilicus and open whorls which remarkably distinguishes the Palæozoic from the Secondary species of this genus. They are also carinated, or provided with one or more ridges on the back of the shell,—another mark peculiar to the Nautili of this period. The local conditions seem to have been little favourable for their development in Russia, for not only is the number of species so limited that there have hitherto been only six described—less than a fourth part of those discovered in other countries—but their distribution is inconsiderable and altogether local. *N. tuberculatus* is the only one that we have found in several localities, four others are limited to the Ural, and the sixth is peculiar to the Donetz. Of our six species, three are new, and three known in other countries.

The genus *Clymenia*, generally characteristic of Devonian limestones, is altogether absent in Russia, but according to M. Eichwald, two species have been found in the Silurian beds of the isle of Dago, and one in that of Odinsholm. We have however some doubt with regard to this, for the specimens so described and shown to us by M. Eichwald do not exhibit the angular septa of Clymenia, and some of them must probably be re-united to Lituite or Nautilus. According to M. Pusch, one of the most common of the Fichtelgebirge species occurs at Kielce in Poland.

Considered with reference to the period of their introduction and extinction, the Russian *Goniatites* follow the usual law as observed in other parts of Europe, being extremely rare in the Silurian rocks, where they have only been observed by M. Eichwald, being developed in the Devonian and carboniferous series, and then disappearing. They combine with a rather remarkable local development a very limited distribution, the eighteen species which have been determined being derived from only three localities. The species from Artinsk are the most interesting, their lobes being often subdivided in a manner, the form of which reminds us of that of the lobes of Ceratites and Ammonites, without however indicating a true passage*. Three of the Goniatites from Cossatchi Datchi, besides *G. Jossæ* from Artinsk, are proved by the number of their lobes to belong to the group of which *G. Listeri* may be considered as the type, and which are distinguished from *G. striatus*, *G. sphæricus* and *G. crenistria* by the rounded form of the dorsal and lateral saddles. The *G. cyclolobus*, already known in England, presents a character altogether exceptional in the deep channeling of the medio-dorsal saddle.

The Goniatites of the Russian carboniferous rocks, like most species of the same period, have the dorsal lobe divided by an accessory saddle more or less elevated†. When this saddle is equally prominent with the dorsal saddle, it is called by the same name, and there might thus be established a true passage between Goniatites in which the dorsal lobe is divided and those in which it is simple. Several of the Devonian species which we obtained from the river Uchta in the chain of the Timan Mountains are of this kind, but others, on the contrary, have the accessory or medio-dorsal saddle buried as it were between more prominent saddles on the right and left; and these, instead of being true dorsals, as in the carboniferous species, are thrown upon the sides, as, for instance, is seen in *G. intumescens* and *G. carinatus* of Beyrich, where they may be considered as lateral saddles. Of eighteen species of Goniatites which we have obtained from Russia, eight belong to the bituminous schists (Domanik-schists) of the river Uchta; and of these eight, four are new, and four identical with species from the Fichtelgebirge, the Hartz, Brilon in Westphalia, and Oberscheld in Nassau. The carboniferous system affords nine species, two of which, *G. diadema* and *G. cyclolobus*, occur in England and Belgium, while the others are new. M. Pusch has mentioned three species from Kielce in Poland.

Annelides.—The remains of animals referred to this class would hardly deserve mention, were it not for the abundance with which one species (*Serpula omphalotes*) is distributed almost throughout Russia in the Devonian rocks, and the fact that this species, exclusively confined to the beds of the Devonian period, is important in distinguishing those beds from the lower ones. This species is not only found in Livonia and in the governments of Novogorod and St. Petersburg, but also in those of Orel and Voroneje, and it extends as far as to the eastern districts of the government of Vologda and towards the mountains of the Timan range, where the Devonian deposits have undergone no change. It accompanies in many cases the remains of fishes, and disappears, as they do, in the Ural, where the Devonian system puts on a peculiar character.

Crustaceans.—In the older palæozoic deposits the *Trilobites* are

* However striking the subdivision of the lobes may seem in the case of these Artinsk Goniatites, these species are not less distinct from Ceratites by their medio-dorsal saddle channeled at the summit than they are from the Ammonites by their lateral saddles always simple and not channeled.

† Amongst all the carboniferous species found in Europe, we are only aware of *G. Henslowi*, *G. evolutus*, *G. serpentinus* and *G. Belvalianus* which have the dorsal lobe simple.

almost the only representative of the class of Crustacea, and we can scarcely even recognise a trace of other families. In Russia the only exceptions are *Limulus oculatus* from the copper grits of Perm, *Eurypterus tetragonophthalmus* from Podolia, and specimens of *Cytherina*, of which we have noticed several species in the Silurian, Devonian and Permian systems. The whole interest with regard to the group is therefore concentrated in the Trilobites, animals belonging, as is well known, to the most ancient fauna of the globe, and presenting, like the genus *Orthis*, this remarkable fact in the history of fossils, namely, that we are not able to discover any indication of their advance towards the state of perfect and full development. From the very earliest period they seem to have been in full vigour, both in point of numbers and organization: they preserved for a time a great relative importance, they then became less abundant, and ultimately they died out towards the termination of that part of the palæozoic period during which the coal-measures were deposited. Owing no doubt to peculiar local conditions, this diminution is more rapid in Russia than in countries further to the west, and, in fact, after having attained in the lower part of the Silurian system a development resembling that which they seem to have enjoyed during the same period in Scandinavia and the British Islands, the Trilobites diminish rapidly in the Russian Upper Silurian rocks, almost entirely disappear in the Devonian system, and only show themselves in rocks of the Carboniferous epoch under the peculiar forms which have been included in the genus *Phillipsia*.

Amongst the genera of Trilobites most widely spread in the neighbourhood of St. Petersburg and on the shores of the Baltic, *Asaphus* and *Illæna* are the most prominent, and of these, *A. expansus* and *I. crassicauda* are the species most frequently met with, and these are especially characteristic of the lower members of the Silurian series. The vast thickness of the deposits in which they occur explains in some measure the wide extension of these species over the globe, the latter species (*I. crassicauda*), to which we unite *I. perovalis*, being found not only in Russia and Scandinavia, but in England and Ireland, in Brittany, and even as far as Canada and the United States of North America; while the other species (*A. expansus*), if it does not itself extend so far, still appears to be represented in Ireland and on the other side of the Atlantic by a nearly allied form, *A. platycephalus*. Other species also, as *A. Buchii* and *A. tyrannus*, are mentioned as occurring in the environs of St. Petersburg, but these are less common, and are associated with three new species discovered by the Duke of Leuchtenberg.

The genus *Calymene* has only afforded to our researches three species, *C. Fischeri*, *C. bellatula* and *C. Odini*, all of them also characteristic of the contemporaneous beds of Scandinavia, and of these, *C. Fischeri* is the most abundant at St. Petersburg. Besides these, however, M. Eichwald and M. Pander have also mentioned five others. The genus *Brontes*, of which the species oscillate between the base of the Devonian and the uppermost beds of the Silurian system, is only represented by one species, *B. flabellifer*, found near

Bogoslofsk in the Ural. Of the genus *Phacops*, we have from Russia only the *P. Downingiæ* (*Calymene* auct.), to which we ought perhaps to restore the name of *macrophthalma* given by M. Brongniart*. This species, which has been long known as occurring in the Dudley limestone, is common to both divisions of the Silurian series. In addition to this, *P. macrophthalma* of authors (*Calymene latifrons* of Bronn) has also been mentioned as amongst the fossils from near St. Petersburg; but we greatly question whether this species, common to the Devonian and Silurian series, descends into the lower members of the latter, although, from an indifferent specimen brought by M. Tchihatcheff, it appears to exist in the Altai. Lastly, amongst the St. Petersburg Trilobites we may mention *Ampyx nasutus* and three species of the genus *Metopias*, established by M. Eichwald. Two of these are well known in Sweden and Ireland under the names *Trilobites sphæricus* and *Nuttainia hibernica*.

While most of the Trilobites which generally characterise the Devonian system are absent in Russia, we find in tolerable abundance in the carboniferous beds, two species of the genus *Phillipsia*, one of the last forms under which the family of Trilobites presented itself before its final extinction.

It will appear from what has been said above, that most of the Russian Trilobites are concentrated in the lower members of the Silurian series, where we have observed ten species, viz. *Calymene Fischeri*, *C. Odini*, *C. bellatula*, *Asaphus expansus*, *Illænus crassicauda*, *Phacops Downingiæ*, *Metopias aries*, *M. Hübneri*, *M. coniceps* and *Ampyx nasutus*. We may also add, *first*, that all these species are characteristic of the lower members of the Silurian series, except *Phacops Downingiæ*, which occurs also in the Dudley limestone and even in the limestone of Ferques; and *secondly*, that all, with the exception of *M. coniceps*, occur both in Scandinavia and in the British Islands at precisely the same geological horizon.

We have nothing more to add on the subject of the Trilobites observed in the course of our rapid traverses through the country. The number of species mentioned in our list as observed by other authors, no doubt proves that our collections are very incomplete; but it is also possible that the same species found in detached fragments may have received different names, and that the whole number may thus have been increased without sufficient ground from actual investigation†.

Fishes.—It is well known that the most diligent research has failed in discovering any traces of these animals amongst the earliest strata

* Hist. Nat. des Crust. Fos., p. 15. In his plates M. Brongniart has confounded two distinct species under the name *Calymene macrophthalma*, but it is easy to satisfy oneself that his description applies to the species now commonly called *C. Downingiæ*.

† To obtain an idea of the actual state of our knowledge on the subject of Trilobites, M. Burmeister's beautiful work, 'Die Organisation der Trilobiten,' must be referred to. More than fifty genera and upwards of 200 species are there described. [An English edition of this work, with impressions from the original plates, and enriched with much additional matter by the author, has recently appeared among the publications of the Ray Society.—Ed.]

of the globe, and it is only towards the uppermost beds of the Silurian series that we first find *Ichthyodorulites* belonging to the genus *Onchus* and to other genera of which the family is not yet determined.

These remains, although found in England, are generally very rare, and analogous fossils have not yet been obtained in Russia. According to the present state of knowledge in palæontology, it seems to have been in the Devonian period that fishes became for the first time considerably developed, and this important point in the history of these animals is fully confirmed by the study of the Russian formations, for no country is richer in the fossil fishes of that period, and none, considering the recent date of investigations of this kind, has furnished greater material for this department of ichthyology. In fact, from the specimens which have been forwarded to him, M. Agassiz has already been able to determine as many as forty-six Russian species (nearly half the whole number of Devonian fishes actually known), and of these species, eighteen are common to Russia and Scotland and twenty-eight are peculiar to Russia. In the Carboniferous system however, we only know of the Ichthyodorulite found by M. Helmersen near Troitzkoje, about thirty wersts to the west of Serpoukhof*, and one tooth which we discovered at the mouth of the Pinega, and which M. Vogt considers as having belonged to a new genus of the Cestraciont family, establishing a passage to Hybodus†. The Permian system has afforded several species found at Kargala near Bielebi and in the grits of the neighbourhood of Perm, but most of them are not yet made out.

General conclusion.—From our own investigations, it appears that the palæozoic fauna of Russia, including the Saurians, Fishes, and all the Invertebrata except the corals, embraces 392 species‡; and if we add to these the species quoted by other authors, the total will amount to 560. This number, not one-fifth part of the general palæozoic fauna§, cannot but suggest how much yet remains to be done in this vast empire; but however incomplete the list may be that we now offer, it is already capable of furnishing useful material towards making out the history of the various epochs of our globe. When it appears that in the case of so important a portion of the earth's surface as is presented by the whole of Europe, we can trace at its two extremities the succession of changes which its inhabitants

* Erm. Arch. 1841, pl. 3. fig. 3.

† According to M. Vogt, this tooth is characterized by its single obtuse cone and the large folds of its enamel. It resembles the hinder teeth of *Hybodus*, but differs in the absence of an elliptic base and a longitudinal axis.

‡ Adding to this number the thirty-eight species of corals determined by Mr. Lonsdale, and several others of which we were not able to bring specimens, we may consider the whole number of species admitted by us and the result of our own personal investigation to amount to very nearly 440.

§ In the memoir published by M. de Verneuil and M. d'Archiac on the fossils of the Rhenish provinces, the whole number of palæozoic species was stated to be 2700. Since then the number has been increased by the labours of MM. Conrad, Emmons, J. Hall, Mather and Vanuxem on the state of New York, by those of MM. A. and C. Römer on the banks of the Rhine and the Harz, those of MM. Portlock and M'Coy on Ireland, &c.

have undergone, one is struck by the simultaneity of the principal phænomena to which they have been subject, namely the appearance and extinction of species. In spite of the differences presented by the almost horizontal plains of Russia, when compared with the countries further to the west, the succession of species has taken place throughout in the same order. The lower members of the Silurian system, for example, are there characterized, as in all other countries hitherto investigated, by the abundance of *Orthis*, *Leptæna*, *Orthoceratites* and *Trilobites*, while the upper beds afford a multitude of corals, as *Catenipora* and *Favosites*. The Devonian rocks there, as in Scotland, exhibit a remarkable development of the class of fishes, and, as in Devonshire, the *Productus* first appears and the *Spirifer* first becomes abundant in rocks of this age. Most of the species which formed the submarine population during these two earlier periods becoming one after another extinct in Russia as elsewhere, they are there also replaced by others, amongst which the *Productus* everywhere characteristic of the carboniferous rocks is the most striking. And lastly, the Permian deposits, although deposited beneath the waters of a far more widely extended ocean than the contemporaneous beds of Western Europe, still present a remarkable agreement in the appearance of Saurians, and the complete extinction of Trilobites, Goniatites, Orthoceratites and Bellerophons, of which we nowhere find traces. If, struck by this strange sequence, we turn our attention to North America, and there discover a series of analogous phænomena, it will appear certain that all these modifications of species, their extinction and the introduction of new ones, cannot be owing to mere change in marine currents or other causes more or less local and temporary, but depend on general laws which govern the whole animal kingdom.

On comparing together the four divisions of the palæozoic series as developed in Russia, we find that the number of species gradually increases from the Silurian to the Carboniferous in a constant ratio analogous to that observed in the general fauna of the epoch. With regard to the Permian division, the gradual advance seems there to have received a decided check, and, as is the case elsewhere, the number of species is much less considerable than during the earlier period.

If in the next place we compare the species of each system or division of the whole period, it is hardly possible not to be struck with the fact, that in a district where the deposits appear to have been uninterrupted and continuous, there are so few species passing from one system into another. Eight species only are common to the beds of two of these great divisions, two seem to have endured the vicissitudes of a greater number, while *Chonetes sarcinulata* is the only one that appears to have survived throughout the palæozoic period. When however in this kind of comparative view we include a greater area, and extend our observation for example to the whole of Europe, the number of species common to several systems sensibly increases, and we then discover relations between the thickness of the deposits through which the species extend and the geographical area which they occupy, or, in other words, between their distri bution in space and in time,—relations on which was founded the proposition enunciated by M. d'Archiac and one of ourselves, namely, "that species which are found in a great number of localities and in very distant countries, are almost always those which have lived during the formation of several successive systems*."

Of the 392 species which we have observed in Russia, 205, or more than half, are peculiar to that country. Some of these, it is true, differ so little from species found in the deposits of the same age in the west of Europe, that we may look upon them as their representatives; but still there are such marked differences between the faunas of the two extremities of Europe, that we are bound to admit the important fact, that even at this early period species were not uniformly distributed throughout distant seas, but, on the contrary, were already grouped into localities, marking in their distribution those geographical divisions or groupings into limited areas which were more and more distinctly marked in after-times†.

Confining our view of the Russian palæozoic fauna to the species thence obtained by ourselves, we may observe, *first*, that they are all marine, with the exception of some shells associated with land plants in the Carboniferous and Permian system; and *secondly*, that there are very few species passing from one system into another, notwithstanding that the rocks very frequently indicate such passage.

If, however, instead of limiting the comparison in this way to the Russian species, we include the general European palæozoic fauna, we may observe, *first*, that the number of species common to both faunas (the Russian and general European) is sufficient to satisfy us that the sea then covering Russia was in communication with that covering Western Europe. *Secondly*, that there is at the same time a sufficient number of species confined to each locality to prove that the distribution then was not very different from what is ob-

* Trans. Geol. Soc. of London, 2nd ser. vol. vi. p. 335. The observations of geologists in America, as well as our own in Russia, tend to strengthen this position. It may be worth while to mention, as examples, some of the most widely-spread species, as for instance, *Favosites gothlandica*, *F. polymorpha*, *Stromatopora concentrica*, *Terebratula reticularis*, *T. aspera*, *T. concentrica*, *T. elongata*, *T. sacculus*, *T. pugnus*, *T. cuboides*, *T. Wilsoni*, *Pentamerus galeatus*, *Spirifer glaber*, *Orthis crenistria*, *O. lunata*, *O. resupinata*, *O. striatula*, *Leptæna depressa*, *Chonetes sarcinulata*, *Melania rugifera*, *Bellerophon Urii*, *Phacops macrophthalma*, *P. Downingiæ*, *Calymene Blumenbachii*, *Brontes flabellifer*, &c. This rule is not only applicable to the distribution of species vertically through thick deposits, but also to their distribution in existing seas; for Professor E. Forbes has observed in the Ægean Sea, that the species which can exist at very different depths beneath the surface are generally those most widely observed in horizontal extension. (Report of the Thirteenth Meeting of the British Association.)

† Whilst in Russia the number of species peculiar to the country amounts to one-half, in North America it is still more considerable in consequence of the greater distance. Of 184 species from the state of New York, described by Mr. J. Hall, about three-fourths are peculiar to the new world; and in the fine collection of American fossils which Mr. Lyell has obligingly placed at our disposal, at least five-sixths of the species have appeared to us distinct from those of Europe.

served with regard to subsequent periods. *Thirdly*, that if the palæozoic species differed more according to place and climate than has been generally supposed, there is still a greater uniformity in the types to which they must be referred than is the case at present, whence we may conclude that the animal creation was indeed then distributed as it is now into geographical groups, but that these groups were then less distinct from one another, owing to a greater uniformity in the climate in different parts of the earth. *Fourthly*, that the great laws which governed the introduction and extinction of species were the same in Russia as in the rest of Europe. And *fifthly*, that the species which traverse several systems of deposits are generally those which appear most widely distributed in distant countries.

Lastly, if we bring the palæozoic fauna generally into contrast with the existing fauna, we find differences which involve not only a change in species, but an entirely distinct grouping of the animal kingdom. We learn that many classes, and amongst them the highest in the series, had not yet appeared upon the earth; that most of the genera were different from those now represented; that those which have been continued to our time exhibit in the relative number of their species a totally different and often inverse proportion; and lastly, that the actual population of the globe is by no means the remnant of a population formerly more extensive. At the same time we are forced to abandon the idea, that the first created beings exhibited merely the first rough and unfinished outline of the plan of nature; and if there has been any progressive movement in creation, such as the successive introduction of the different classes of the vertebrate animals, it is important to observe that the products of creative power, whatever rank may be assigned them, have at all times exhibited that admirable perfection which belongs to everything proceeding from the hands of the Creator.

D. T. A.

II. NOTICES OF NEW BOOKS.

Beiträge zur FLORA *der* VORWELT. Von AUGUST JOSEPH CORDA. Prag.*, 1845.

THIS work is a valuable addition to our knowledge of the internal structure of fossil plants. The author's researches appear to have been conducted with great care and labour, and he has been successful in discovering well-preserved vegetable structure in many instances where it had not before been looked for, especially in the plants of the coal-formation. Indeed, he affirms that the seemingly unpromising fragments imbedded in the sandstone and clay ironstone of that formation are sometimes in a more satisfactory state for microscopical examination than the more showy specimens mineralized in agates or opal.

The work is illustrated by sixty plates, containing very highly-magnified figures of the anatomical structure of the plants described. These magnified representations are indeed on so large a scale, that one might be tempted to suspect some exaggeration, did not the author strongly protest in his Introduction against such a suspicion.

The tribes of plants of which illustrations are given in the present work are the following:—

1. *Sagenariaceæ*. 2. *Sigillarieæ*. 3. *Diploxyleæ*. 4. *Cycadeæ*. 5. *Palmæ*. 6. *Flabellariaceæ*. 7. *Orchideæ*. 8. *Zygophylleæ*. 9. *Protopterides*. 10. *Phthoropterides*. 11. *Rhachiopterides*. 12. *Gleicheniaceæ*. 13. *Schizæaceæ*. 14. *Marattiaceæ*. 15. *Diplotegiaceæ*. The ninth, tenth and eleventh of these are merely artificial subdivisions of the great family of Ferns, founded on portions of stems and leaf-stalks which have not been found in connexion with the leaves.

1. The *Sagenariaceæ* correspond with the *Lepidodendreæ* of Unger's Synopsis, and include the genus *Lepidodendron* of Sternberg and Brongniart, together with a few others. The species here described and figured are four, three of which belong to new genera, namely *Lomatofloyos*, *Leptoxylum* and *Heterangium*. The structure of *Lomatofloyos crassicaule*, of which most elaborate details are given, agrees pretty closely with that of *Lepidodendron Harcourtii*, as explained by Adolphe Brongniart: the woody axis of the stem consists entirely of scalariform vessels, without medullary rays, and without any tendency to a radiated arrangement; it encloses a cen-

* Contributions to a Flora of the Ancient World, by A. J. Corda. Prague, 1845.

tral pith, and is itself surrounded by a very broad zone of loose cellular tissue, which is traversed by bundles of scalariform vessels passing from the woody axis to the leaves. But M. Corda differs very widely from M. Brongniart in his view of the affinities of this tribe of plants; he considers them as true Exogens, nearly allied to the *Crassulaceæ*, and especially to the shrubby Semperviva of the present world. It appears that this view has been more fully explained in a previous publication, to which he refers; but he does not, in the present work, bring forward any material evidence in support of it, nor does he attempt to answer the arguments (apparently very weighty) which Adolphe Brongniart has urged against it in his admirable paper on *Sigillaria elegans*.

2. *Sigillarieæ.*—The genera are *Sigillaria*, *Stigmaria*, *Rhytidophloyos* and *Myelopitys*,—the two latter new. The figures of *Sigillaria elegans* are avowedly borrowed from Adolphe Brongniart's paper above-mentioned, but here again our author is widely at variance with the illustrious French botanist, respecting the affinities of the plants in question. He believes the Sigillariæ to have been succulent Dicotyledons closely allied to the recent Euphorbiæ; and he supports this opinion by a very careful and minute comparison of the whole structure of *Sigillaria elegans* with that of *Euphorbia mammillaris* and *E. Hystrix*. The similarity in many respects is certainly very striking, but there is one important difference: in the Euphorbiæ the outer part of the ligneous body or axis consists of true woody fibre of the ordinary structure, whereas in the Sigillaria this kind of tissue is entirely wanting, the whole of the ligneous axis being composed of scalariform and porous vessels. It is on account of this uniformity of tissue in the Sigillaria that Adolphe Brongniart has referred it to the class of Gymnospermous Dicotyledons.

The leaves of the Sigillariæ have been hitherto unknown, except in the single instance of *S. lepidodendrifolia*, where they are described and figured by Brongniart. M. Corda has discovered the leaves of *S. rhytidolepis* (a new species from the coal-mines of Bohemia), and describes them as linear, very long and narrow, from one to two feet long and scarcely $1\frac{1}{2}$ line broad, with a prominent rib along the middle. They have much resemblance therefore to the leaves of *S. lepidodendrifolia*, and to those of some species of Lepidodendron, such as *L. acerosum* and *L. longifolium*. In fact, it is very likely that some of the so-called *Lepidophylla*, which occur very frequently in a detached state in the coal-formation, may be the leaves of Sigillariæ.

In treating of Stigmaria, it is remarkable that our author does not even allude to the theory, so much discussed of late in England, of that singular production being merely the root of Sigillaria. He gives the specific name of *anabathra* to our common Stigmaria, of which the anatomy has been fully illustrated by Lindley, Brongniart and others, and which is commonly known as *S. ficoides*; while the latter name is reserved for the plant originally described by Sternberg. The two species differ, as it appears, materially, in the nature of the vessels composing their solid axis; these, in the *Stig-*

maria anabathra, are uniformly and regularly scalariform, whereas in the other they are porous or dotted vessels. Moreover, this latter has two distinct sets or orders of medullary rays—several smaller or secondary rays occurring between every two of the principal ones. *S. anabathra* has only the large or principal rays. It is very possible that the *S. ficoides* of Corda may exist in this country as well as the other kind, but as yet it is known only as a production of the coal-mines of Bohemia.

3. The tribe *Diploxyleæ* contains only a single species, the *Diploxylon cycadeoideum*, first discovered by M. Corda, and described by him in the year 1840. Nothing is known of it except the structure of the stem, which is peculiar, being composed of two distinct ligneous bodies or zones, the outer of which consists of vessels arranged in radiating lines, the inner of vessels crowded together without any order. All the vessels in both zones are of the scalariform structure; and it is remarkable, indeed, how extensively this peculiar kind of tissue is found to prevail in the fossil plants of the older formations.

4, 5. The author's observations on the *Cycadeæ* contain nothing very new or important; and under the head of Palms, the most material novelty is the discovery of wood belonging to this tribe, or at any rate to the Endogenous class, in the coal-mines of Bohemia. It occurs, he says, only in small fragments imbedded in nodules of the mineral called Sphærosiderite (a carbonate of iron). This discovery is the more important, as Adolphe Brongniart has lately denied altogether the existence of Endogens in the coal-formation.

6. Concerning the *Flabellaria borassifolia* of Sternberg, much new and valuable information is here communicated. It is shown, that what its original describer took for the segments of a fan-shaped leaf, are in fact (as Brongniart had already suspected) simple leaves, crowded together into a fan-like tuft at the top of the stem. The straight and parallel veins of these leaves give to the plant the appearance of an Endogen, but the internal structure of the stem, here for the first time described, is totally at variance with that of the Endogenous class. The wood forms a hollow cylinder, entirely composed of scalariform vessels, which are regularly arranged in radiating lines, but without medullary rays; this cylinder encloses a large central pith, and is itself surrounded by a zone of cellular tissue, through which bundles of scalariform vessels run out to the leaves. In the form and position of this vascular cylinder, as well as in the nature of the tissue composing it, Flabellaria agrees on the one hand with the Sagenariaceæ or Lepidodendreæ, on the other with the Sigillariæ; but from the former it differs in the distinctly radiated arrangement of its vascular tissue, from the latter in the absence of medullary rays.

The other fossil plants included under the genus Flabellaria in Unger's Synopsis are widely different from this, and are referred by Corda to the Palm tribe, under the generic name of *Borassites*.

7. Under the head of *Orchideæ* is described a remarkable fossil, of which the locality is unknown. It is a mass of matted roots, si-

milar to those of an Orchideous Epiphyte, adhering to a fragment of coniferous wood,—the whole converted into silex.

8. The *Lillia viticulosa* of Unger, a fossil stem of peculiar structure, from the tertiary formation of Ranka in Hungary, is carefully described, and shown to bear more analogy to the stem of *Zygophyllum coccineum* than to any other that has been examined.

9. In proceeding to treat of Ferns, our author begins with a most elaborate examination of the internal structure of the stem in the recent kinds, showing, by a series of minute comparative analyses, how uniform in all essential points is the organization of the stem throughout the tribe of Polypodiaceæ, from the humble herbaceous Ferns of Europe to the loftiest arborescent kinds. He then proceeds to a similar comparative examination of those fossil Fern-stems which he includes under the name of *Protopterides*, and demonstrates their close agreement, both in external and internal structure, with the recent tree-ferns belonging to the groups of Cyatheæ and Dicksoniæ. This agreement is particularly striking in the case of an arborescent Fern* from Van Diemen's Land, which M. Corda conjectures to be *Balantium antarcticum* (*Dicksonia antarctica*, Hooker), and which exhibits several differences in the arrangement of its internal ligneous and vascular system from all those noticed by Brongniart, approximating still more closely to the fossil *Protopterides*. In particular, it agrees with these latter in the circumstance, that the layer of hard, dark-coloured, compact, fibrous tissue, which encloses the pith and constitutes the real wood, is *continuous*, presenting in the transverse section the appearance of a sinuous but uninterrupted zone, whereas in all the Fern-stems figured by Adolphe Brongniart† it is divided into distinct plates. The peculiar character which distinguishes *Protopteris* from all arborescent Ferns hitherto known in a recent state, is the shape of the vascular scar left by the breaking of the vessels that passed into the leaf-stalk: this scar, in Protopteris, forms a continuous line, in the shape of a horse-shoe or a trefoil, whereas in the recent kinds it is always interrupted or broken into several portions, and generally there are several concentric groups of such vascular marks on the surface of each leaf-scar.

The Protopterideæ are divided by Corda into eight genera, as follows:—

I. *Protopteris*. Four species:—1. *P. Sternbergii* (*Lepidodendron punctatum*, St., *Sigillaria punctata*, Brongn.), from Kaunitz, Bohemia; 2. *P. Singeri* (*Caulopteris*, Goepp.), from Kaunitz, and from Giersdorf in Silesia; 3. *P. Cottai* (*Caulopteris punctata*, Goepp.), found in alluvial soil at Grossenhaim, Saxony; 4. *P. microrhiza*, of which the locality is unknown.

All the species of Protopteris appear to be of very rare and strictly local occurrence in a fossil state; two of the four indeed are known only by unique specimens. The first three are extremely similar in their external characters. The internal structure of *P. Sternbergii*

* Corda, tab. 51. figs. 1–9.

† Hist. des Vég. Foss. t. 44.

and *P. Singeri* is unknown; that of *P. Cottai* is figured and described in great detail by M. Corda, and agrees most remarkably with that of the recent tree-fern from Van Diemen's Land, already mentioned.

II. *Sphalmopteris.* One species:—*S. Mougeotii*, figured by Brongniart (Hist. Vég. Foss. t. 80) as the stem of *Anomopteris Mougeotii.* From the red sandstone of the Vosges.

III. *Chelepteris.* Three species:—1. *C. Voltzii*; 2. *C. micropeltis*; 3. *C. Lesangeana.* All of them are figured as species of *Caulopteris* by Schimper and Mougeot in their monograph of the fossil plants of the Vosges.

IV. *Stemmatopteris.* Two species:—1. *S. peltigera*; 2. *S. Cistii.* Both described and figured by Brongniart as species of *Sigillaria.*

V. *Ptychopteris.* Two species:—1. *P. macrodiscus* (*Sigillaria*, Brongn.); 2. *P. striata*, a new species from Waldenburg, Silesia.

VI. *Caulopteris.* Two species:—1. *C. primæva*, Lindl. and Hutt. Foss. Fl.; 2. *C. Phillipsii*, L. and H.

VII. *Cottæa.* One species:—*C. danæoides*, Goepp.

VIII. *Zippea.* One species:—*Z. disticha*, from the coal-formation at Wranowitz and Chomle, Bohemia. This is a fossil of a very peculiar appearance, much more remote from any of the recent forms than the rest of those included among the Protopterideæ. The leaf-scars are arranged in two vertical rows, on the two opposite sides of the stem, and their vascular markings are extremely confused and irregular. In the transverse section the stem exhibits four ligneous bundles, of a curved form, placed opposite to one another in pairs.

10. *Phthoropterides.*—Under this name M. Corda brings together several fossils (partly described in Cotta's 'Dendrolithen' as species of *Tubicaulis*) which appear to have been portions of the stems of herbaceous Ferns, enveloped by a dense matted mass of roots and leaf-stalks, as we see in *Osmunda regalis* and other British Ferns. Most of the specimens which have been found, indeed, show only this mass of roots, the stem itself having been broken away. Corda divides his Phthoropterides into four genera, characterized principally by the form in which the vessels of the leaf-stalks are arranged:—

I. *Asterochlæna.* One species:—*A. Cottai* (*Tubicaulis ramosus*, Cotta Dendrol.).

II. *Zygopteris.* One species:—*Z. primæva* (*Tubicaulis primarius*, Cotta.).

III. *Selenochlæna.* Two species:—1. *S. microrhiza* (*Tubicaulis dubius*, Cotta); 2. *S. Reichii* (*Tubicaulis solenites*, Cotta).

IV. *Tempskya.* Four species, all of them new:—1. *Tempskya pulchra*, found among the rolled stones of the Elbe; 2. *T. macrocaula*; 3. *T. microrhiza*; 4. *T. Schimperi.* The localities of the last three species are not certainly known, but it is conjectured that they were found in Bohemia. Scarcely more than a single specimen of each of the species appears to be known. They consist in every instance of a dense mass of interwoven roots, among which the leaflets are imbedded in a scattered manner,—the whole mineralized by chalcedony. The distinctions of the supposed species depend mainly upon the comparative size of the leaf-stalks, and the form which they exhibit in a transverse section.

11. *Rhachiopterides.*—This is avowedly an artificial group founded merely on fragments of the leaf-stalks of Ferns, which have been found so preserved as to allow of the examination of their internal structure, but with no leaves attached to them. M. Corda thinks it expedient to distribute these remains among six different genera, which he groups according to the number and form of the vascular bundles in each leaf-stalk, thus:—

A. With one vascular bundle, which is curved upwards or inwards.

I. *Selenopteris.* Two species:—*S. Radnitzensis* and *S. involuta.* The vessels of the first species are of the porous structure (an unusual circumstance in Ferns), in the second they are scalariform.

II. *Gyropteris.* One species:—*G. crassa.*

B. With one vascular bundle, which is revolute.

III. *Anachoropteris.* Two species:—*A. pulchra* and *A. rotundata.* The genus is remarkable in two respects—that its vascular tissue consists of porous vessels, and that the bundle formed of these vessels is rolled back, or presents its concavity towards the back of the leaf-stalk, which Corda observes is not the case in any recent Fern that he has been able to examine.

C. With two or more vascular bundles.

IV. *Ptilorhachis.* One species:—*P. dubia.*

V. *Diplophacelus.* One species:—*D. arboreus.*

VI. *Calopteris.* One species:—*C. dubia.* This, like all the other remains included by Corda under the present tribe, occurs in the coal-formation at Radnitz in Bohemia.

12. *Gleicheniaceæ.*—Five different genera of fossil Ferns had been enumerated by Presl as belonging to this tribe, namely:—*Laccopteris*, *Asterotheca* *, *Phialopteris*, *Gutbieria* and *Partschia.* To these Corda adds two others, *Hawlea* and *Chorionopteris.*

I. *Hawlea.* One species:—*H. pulcherrima.* Founded on a specimen in fructification obtained from the coal-formation of Bohemia. It agrees very closely, in the form and arrangement of its fruit, with the recent genus *Mertensia* (included in *Gleichenia* by Sir W. Hooker), nor does there appear, so far as the evidence goes, to be any sufficient reason for separating them.

II. *Chorionopteris.* One species:—*C. gleichenioides*, found in Sphærosiderite in the coal-formation of Radnitz. This is a plant much more peculiar in its structure than the preceding, and materially different from any of the recent Gleicheniaceæ; in fact, the author considers it as intermediate between that tribe and the Cya-

* *Asterocarpus* of Goeppert.

theæ. It seems to have been a very small and delicate Fern, with its capsules grouped in fours, enclosed in a spherical indusium which opened by four valves.

13. *Schizæaceæ.*—Under this head is described a very beautiful fossil Fern, discovered in the coal-mines of Nachod in Bohemia, with its fructification in an extraordinary state of preservation. It closely resembles the existing genus *Mohria*, but is well distinguished by the structure of the ring of its capsules, which here consists of four or five rows of cells, in Mohria of a single row.

14. *Marattiaceæ.*—Our author refers to this tribe the remarkable fossils known under the name of 'Psarolites,' forming the genus *Psaronius* of Cotta; and he enters into a minute and elaborate examination of their structure, comparing it in detail with that of the recent Marattiaceæ, especially of *Angiopteris*, and showing the close affinity that exists between them. The most important points of internal structure in which the Marattiaceæ differ from ordinary Ferns, are, that the fibro-vascular bundles of the stem are irregular in form, not arranged in a circle, but scattered without any apparent order through the cellular tissue; that the vessels of each bundle are not enclosed in a woody sheath composed of hard and dark-coloured fibrous tissue, nor is the stem itself coated with a rind of such hardened tissue; and that the vessels of the roots are so arranged as to present in a transverse section the appearance of a star. In all these peculiarities *Angiopteris* and *Marattia* agree with the fossil Psaronii. But no recent Marattiaceæ, as far as is hitherto known, have their stems so densely clothed with a compact mass of matted roots, as is the case in most of the Psarolites.

In the present work, not less than twenty-six supposed species of Psaronius are described and figured, all of them from Bohemia and Saxony, where they occur either in the "Rothe-todte-liegende" or the coal-formation, and sometimes (in a rolled state) in alluvial deposits. The first two species, *Psaronius carbonifer* and *P. musæformis*, are extremely different in appearance from most of the others, so that no one would have supposed them to belong to the same genus; the external mass of roots is wanting, and the vascular bundles of the stem are arranged with a regularity which is not observable in any other Psarolites; in fact, the peculiar arrangement of these bundles has caused the second species to be taken for a plant of the Banana tribe. As the structure of the tissues is not visible in either species, the place assigned by Corda to these fossils can scarcely be regarded as definitive. The third species, *P. arenaceus* (which as well as the two preceding and the two following was discovered in the coal-sandstone of Radnitz in Bohemia), is likewise destitute of air-roots, and has two vertical rows of leaf-scars on each side of its compressed stem; but the appearance of its vascular bundles is somewhat more like that seen in ordinary Psarolites. *P. pulcher* exhibits a structure in some degree intermediate between the preceding and the better-known forms; and the fifth species, *P. Radnicensis*, likewise found in the sandstone of the coal-formation at Radnitz, has all the characteristic peculiarities of the genus.

The remaining twenty-one species (beginning with *Psaronius Helmintholithus*) all occur in a silicified state in the 'Rothe-todte-liegende' or in alluvial soil, principally about New Paka and Mulhausen in Bohemia, and Chemnitz in Saxony. They have a very great similarity to one another, and it may be doubted whether all of the species distinguished by the present author will be admitted by other botanists. There is however one remarkable, and apparently important, anatomical peculiarity pointed out by him as characterizing certain species, namely *Psaronius speciosus*, *P. alsophiloides*, *P. dubius*, *P. giganteus*, *P. asterolithus*, *P. parkeriæformis* and *P. macrorhizus*. This is the presence of regular cavities or lacunæ in the cellular tissue, such as occur constantly in the tissue of water-plants, whence M. Corda conjectures that the above-mentioned species were aquatic Ferns, like the recent Parkeria, which is provided with similar lacunæ.

The largest of the Psaronii described in this work are *P. Helmintholithus*, *P. intertextus* and *P. giganteus*, of which pieces as much as twenty feet long have been found; yet even these are said to be much inferior in size to the American kinds.

15. *Diplotegiaceæ.*—This family is established for the reception of a single fossil stem, found, though but rarely, in the coal-sandstone at Radnitz in Bohemia. Its outward appearance is somewhat like that of a Lepidodendron; the internal structure is very peculiar and anomalous, but is thought by the author to come nearest to that of the Marattiaceæ.

The work concludes with four tables:—the first showing the number of fossil plants in each formation of the earth, and the number of fossil Ferns in proportion to that of other plants; the second, an enumeration of living Ferns, distributed by tribes and according to the zones of temperature in which they occur, each zone including a range of ten degrees centigrade of average temperature; also a list of fossil Ferns by tribes, showing the proportion of the fossil to the recent species known of each tribe. The third table enumerates the arborescent Ferns known in a recent and in a fossil state, and also the Marattiaceæ known in each of these states, comparing them with the total number of Ferns, recent and fossil. The fourth is a list of the recent Marattiaceæ, distributed according to zones of 10° of temperature.

M. Corda adopts Adolphe Brongniart's opinion that the temperature prevailing during the period of the coal-formation (including the Rothe-todte-liegende) was very high, and this opinion he supports especially by the consideration of the great number of Marattiaceæ (Psaronii) found in that formation, since the recent plants of this tribe are almost confined to the tropical regions.

Charles J. F. Bunbury.

III. MISCELLANEA.

I. *Origin of* Saliferous Deposits. Salt-Lakes *of* Patagonia *and* La Plata.

Salinas or natural salt-lakes occur in various formations on the eastern side of the continent of South America, in the argillaceo-calcareous deposits of the Pampas, in the sandstone of the Rio Negro, where they are very numerous, in the pumiceous and other beds of the Patagonian tertiary formation, and in small primary districts in the midst of this latter formation. Port St. Julian is the most southerly point (lat. 49° to 50°) at which salinas are known to occur*. The depressions in which these salt-lakes lie are from a few feet to sixty metres (as asserted by M. d'Orbigny, Voy. Géol., p. 63) below the surface of the surrounding plains; and according to this same author, near the Rio Negro they all trend either in N.E. and S.W. or in E. and W. lines coincident with the general slope of the plain. These depressions in the plain generally have one side lower than the others, but there are no outlets for drainage. Under a less dry climate an outlet would soon have been formed, and the salt washed away. The salinas occur at different elevations above the sea; they are often several leagues in diameter; they are generally very shallow, but there is a deep one in a quartz rock formation near Cape Blanco. In the wet season the whole or a part of the salt is dissolved, being re-deposited during the succeeding dry season. In a large salina northward of the Rio Negro, the salt at the bottom during the whole year is between two and three feet in thickness.

This salt rests almost always on a thick bed of black muddy sand, which is fetid, probably from the decay of the burrowing worms inhabiting it. [This mud in some places rests on gravel, and in one case the salina is in an alluvial plain within the valley of the Rio Negro.] When I visited the salina about fifteen miles above the town of El Carmen on the Rio Negro and three or four miles from the banks of that river, the salt was beginning to crystallize; and on the muddy bottom there were lying many crystals of sulphate of soda, generally placed crossways, and, imbedded in the mud, were nume-

* According to Azara (Travels, vol. i. p. 56) there are salt-lakes as far north as Chaco (lat. 25°) on the banks of the Vermejo. The salt-lakes of Siberia appear to occur in depressions very similar to those of Patagonia.—*Pallas's Travels*, Engl. Tr., vol. i. p. 284.

rous crystals of sulphate of lime from one to three inches in length. M. d'Orbigny states that some of these crystals are acicular, and more than even nine inches in length, others are macled and of great purity; those I found all contained some sand in the centre. As the black and fetid sand overlies the gravel, and that overlies the regular tertiary strata, I think there can be no doubt that these remarkable crystals of sulphate of lime have been deposited from the waters of the lake. The inhabitants call the crystals of selenite *padre del sal*, and those of the sulphate of soda *madre del sal*; they assured me that both are found under the same circumstances in several of the neighbouring salinas, and that the sulphate of soda is annually dissolved and is always crystallized before the common salt on the muddy bottom. The association of gypsum and salt in this case appears to me interesting, considering how generally these substances are associated in the older stratified formations.

Mr. Reeks has analysed for me some of the salt from the salina near the Rio Negro: he finds it composed entirely of chloride of sodium, with the exception of 0·26 of sulphate of lime and 0·22 of earthy matter; there are no traces of iodic salts. Some salt from the salina Chiquitos in the Pampean formation is equally pure.

With respect to the origin of salt in the salinas, the foregoing analysis seems opposed to the view entertained by M. d'Orbigny and others, and which seems so probable, considering the recent elevation of this line of coast, namely, that it is due to the evaporation of sea-water and to the drainage from the surrounding strata impregnated with sea-salt. I was informed (I know not whether accurately) that on the northern side of the salina, on the Rio Negro, there is a small brine-spring which flows at all times of the year; if this be so, the salt in this case at least is probably of subterranean origin. It appears at first very singular that fresh water can often be procured in wells, and is sometimes found in small lakes, quite close to these salinas. I am not aware that this fact bears particularly on the origin of the salt, but perhaps it is rather opposed to the view of the salt having been washed out of the surrounding superficial strata, but not to its having been the residue of sea-water left in depressions as the land was slowly elevated.—*Darwin's South America*, 1846, pp. 73–75.

II. *On the* Chemical Composition *of* Calcareous Corals.

To the Editor of the Quarterly Journal of the Geological Society.

Yale College Laboratory, September 26, 1846.

Sir,—In No. 7 of the Geological Journal (Part ii. p. 94) there is a short anonymous paragraph quoted "from Silliman's Journal," "On the Chemical Constitution of Calcareous Corals," in which certain analyses by the writer are cited, as supporting the remarkable statement "that the Zoophytes which form these stony skeletons secrete a very important proportion of silica, and that of the salts, the fluates" (should read *fluorides*) "greatly exceed in amount the carbonates."

The reader is left to understand, that the analyses quoted are intended to represent the entire chemical constitution of the four species of corals named, and if so, to infer that carbonate of lime is not recognized by the analyst as an ingredient of corals, and that *lime* is present only as a minor constituent. The absurdity of such an inference is so plain, that no danger perhaps exists of its being made; and as the name of no analyst is given, on whose authority so singular a statement is based, there is no probability of its being an injury to the chemical reputation of the writer. It is however for this reason none the less proper that so important an error should be corrected.

The original memoir on the composition of calcareous corals was published in the 'Report on Zoophytes' by J. D. Dana*, and has since been re-published in several scientific journals†. Thirty-five species of corals were examined in these researches, and the general result was that they were composed as follows:—

Average Constitution of Thirty-five species of Corals.

Carbonate of lime	91·00 to 96·00
Phosphates and fluorides of lime and magnesia, with silica, lime, alumina and oxide of iron	0·50 to 2·50
Organic matter	2·70 to 8·30

Two sets of analyses were made; one to determine the general constitution as above, another to determine, by an entirely independent examination, the composition of that complex portion denominated in the memoir as phosphates and fluorides. It is here that the error in question arises. You have cited four of these ultimate analyses of about 1 per centum of the entire mass of the coral zoophyte, in such a manner as to leave it to be understood that they represented the constitution of the entire mass.

You justly remark that these analyses suggest some interesting investigations on the probable origin of certain minerals from the coral secretions. Allow me to call your attention to a short paper by Mr. Dana in the July number of the 'American Journal,' p. 88 (also in the London, Ed. and D. Phil. Mag. for Sept. 1846, p. 245), "On the Occurrence of Fluor Spar, Apatite and Chondrodite in Limestone." This paper contains some of the deductions which naturally proceed from the coral analyses in question.

Your obedient servant,

B. Silliman, Jun.

* United States' Exploring Expedition in the years 1838—1842. Report on Zoophytes, by J. D. Dana. 4to, pp. 740:—p. 712.

† American Journal of Science, March 1846, p. 189; Jameson's Edinburgh Journal, April 1846, p. 243; Archives des Sciences Physiques et Naturelles, Supp. à la Bibliothèque Universelle, April 1846, p. 319.

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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.

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