THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

VOLUME THE THIRD.

1847.

PART THE FIRST.

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:

LONGMAN, BROWN, [illegible], AND LONGMANS.

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MDCCCXLVII.

List

OF THE

OFFICERS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

ELECTED FEBRUARY 1847.

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Assistant-Secretary.

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

Curator.

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

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Notice to the Binder.

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GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 19, 1847.

REPORT OF THE COUNCIL.

In laying before the Geological Society of London their Annual Report for the past year, the Council have the satisfaction of being enabled to announce that their numbers still continue to increase, thereby affording satisfactory evidence of the continued interest felt in the progress of geological science and in the Society over whose welfare they preside.

During the year 1846, 29 new Fellows have been elected, and have paid their admission-fees and contributions, besides 3 who had been elected in former years, but had not paid their admission-fees, making, with the addition of one Foreign Member, an increase of 33 new Members. During the same period there were 9 deaths and 13 resignations, making a decrease of 22 to be deducted from 33, and showing a total increase of 11 in the numbers of the Society during the past year, and raising its number from 883 to 894.

During the year 1846 a slight excess of expenditure over income was incurred, to the amount of £11 14*s.* 9*d.* This must be solely attributed to the expense of preparing the Catalogue of the Library, having greatly exceeded the sum allowed in the estimates of the preceding year.

The number of living compounders has increased during the past year from 123 to 128, one compounder having died and six compositions having been received during that period, all of which, in accordance with the established practice of the Society, have been invested in the funds. The total amount received from these 128 compounders in lieu of annual contributions has been £4032, and the estimated value of the funded property of the Society has been raised from £2961 5*s.* 6*d.* (the amount stated last year) to £3150 5*s.* 6*d.*, the price of Consols having remained the same, viz. 94.

The Council have to announce that a donation of £5 to the Society from Sir Thos. Philipps has been appropriated towards defraying the Library expenses.

They have also to announce, that, in compliance with the often-repeated wishes of many Members, they have caused a Catalogue of the Library, including the Charts and Maps, to be prepared, and that it has been completed since the last Anniversary. They trust that the assistance and convenience thereby afforded to those who avail themselves of the works contained in the Society's Library, will be considered as a sufficient compensation for the expense incurred, which, from the uncertain and peculiar nature of the work, has, as they have already observed, exceeded the estimated sum.

The Council also have to announce that they have found it necessary to revise the rules and regulations respecting the borrowing of books from the Library. They trust that a perusal of these regulations, inserted in every volume of the Library, will convince the Society that they have been framed with a view to suit the convenience of, and afford every facility to readers desirous of consulting and of borrowing works from the Library, while at the same time the Council have endeavoured not to overlook the duty imposed upon them of providing for the due preservation of the property of the Society.

They have much satisfaction in announcing, that, in consequence of duplicate copies of the following works having been presented to the Library by the following Members, viz.

Agassiz's Poissons Fossiles, by Mr. Horner;
Sowerby's Mineral Conchology, by Mr. Greenough;
Goldfuss's Petrefacta Germaniæ, by Mr. Greenough;
Lindley's Fossil Flora, by Mr. Bowerbank;
Cuvier's Ossemens Fossiles, by Sir R. Murchison;
De Koninck's Animaux Fossiles, by Mr. D. Sharpe;
D'Orbigny's Palæontologie Française, by Mr. Moore;

there will now be one copy constantly in the Library, while another will be allowed to circulate among the Members.

The Council have to announce the completion of the second volume of the Quarterly Journal of the Geological Society, and the publication of the first part of Vol. III., in conformity with a resolution of the Council of the 2nd Dec. 1846, that the publication of the Journal should be continued for another year on the same plan, terms and conditions as during the past year; for although the Council confidently hope that this form of publication will be continued, they have not considered it desirable to decide on its publication except from year to year; they are unwilling to dismiss this subject without expressing their regret that so many of the Members of the Society do not take the Journal, as in consequence of the sale being limited their means of publishing the Transactions are materially crippled. The Index to Vol. IV. of the Proceedings has also been published.

The Council have also to announce the publication of the third part of Vol. VII. of the Transactions; and with reference to the heavy amount of stock of former volumes on hand, they have resolved, in order to promote its sale, that the parts published previous to June 1840 (viz. Vol. II. pt. 2, to Vol. V. pt. 3 inclusive) shall, after reserving fifty copies in the hands of the Society, be offered to the Fellows and the public at one-half of the present prices respectively. They trust that the effect of this measure will be to disseminate the contents of these volumes more widely, and to give a greater stimulus to the pursuit of geological investigations.

They have much pleasure in announcing the valuable donation from Mr. Weekes of his bust of Prof. Sedgwick, which has been placed in an appropriate niche in the old Meeting-room; and they are glad to avail themselves of this opportunity of testifying their admiration of this excellent work of art, conveying as it does, such a striking likeness of our eminent Associate.

It is with much regret that the Council have to announce, that in consequence of the numerous avocations undertaken by Prof. Ansted, which were found to be incompatible with the efficient discharge of his duties towards this Society, they should have been deprived of his valuable services. The necessary steps have been taken towards supplying the vacancy as effectively and as expeditiously as possible.

Mr. Nichol, the Clerk and Resident Officer of the Society, having discharged the duties of his office to the perfect satisfaction of the Council, they have resolved that a gratuity of £20 be presented to him as an expression of the sense they entertain of the zeal and diligence with which he has carried on the duties of his office during the period of seven years and a half.

In conclusion, they have to announce that they have awarded the Wollaston Palladium Medal for the present year to Dr. Ami Boué, for the zeal, intelligence and perseverance with which he has devoted himself, both in the field and in the study, to the attainment and diffusion of geological knowledge during the last thirty years; for his valuable and original investigations in Scotland, the south of France, Italy, the mountain regions of Bavaria, Wurtemberg, Switzerland and the Tyrol, Austria, Illyria, Hungary, Transylvania, &c.; for his scientific researches in European Turkey; for his industry in collecting materials and his skill in arranging them, as exemplified in his geological maps, particularly those of Europe and the World, and in numerous other publications, all tending to facilitate the study and advance the progress of geology and its kindred sciences; and that they have awarded the balance of the proceeds of the Donation Fund for the present year, amounting to £30, to M. Alcide d'Orbigny, to assist him in the publication of his palæontological works now in progress.

Report of the Museum and Library Committee.

British Collection.

The British part of the collection is in course of arrangement by Mr. Sowerby; the Silurian section is completed, and the Devonian and Carboniferous nearly so. The valuable collection of Mr. Hennah has been incorporated with this part of the series; the work is necessarily one of labour and time, and the Committee beg to express their satisfaction at the progress made by the Curator.

They recommend that such original types of published species as are in possession of the Society, should be distinguished by an appropriate mark, and that a separate catalogue of them be kept. Also that lists of such published species as are not in the collection, should be suspended in the Museum, and that Members be requested to assist in supplying the desiderata.

The Committee have seen with great pleasure that the Irish and Scotch collections are being incorporated with the English.

They recommend that a large portion of the rock specimens, which are of little value in the British division of the collection, be gradually removed, to make room for other specimens of more consequence.

It is very desirable that more glass cases should be provided for the larger specimens, which are at present lying about the room, liable to injury. The cases placed in one of the windows have proved very useful, and they recommend that the other windows be similarly made use of. Deeper cases however are required for some of the larger specimens; and there are many situations where they might be placed with advantage.

The glass cases on the stairs, added since the last Annual Meeting, have proved of great service.

Foreign Collection.

The Foreign collection is in an unavoidable state of confusion, in consequence of the room being over-crowded; a large number of valuable specimens are lying exposed for want of drawers, and others are nearly inaccessible.

The Committee recommend most strongly that steps should be taken to provide drawers for all of them, that the Rocks be separated from the Fossils, and the collection weeded of specimens of no value; the number of simple minerals in that room ought to be transferred to the Mineral collection in the Library.

Among the most important additions to this part of the collection during the year, have been the Gothland collections, presented by Sir Roderick Murchison, those from Scinde by Captain Vicary, and from Australia by Mr. Jukes.

The Committee suggest that the collections would be much more valuable for reference if the Foreign and British collections were so placed as to admit of easy consultation at the same time. They think that this might be done, without intermixing the specimens, by placing the greater geological groups in sequence; thus the British Palæozoic might be followed by the Foreign Palæozoic collection, and the Oolitic, Cretaceous and Tertiary arranged in like manner. It appears desirable that this should be considered at present, as Mr. Sowerby is now going through the British collection in a manner which causes great changes to be made in the cabinets, and because new cases must be provided for part of the Foreign collection.

The Committee have to add, that such an arrangement would be equally advantageous to the Curator and to students of the collections.

The Curator has found great advantage in the aid afforded by the assistant lately employed, and has thus been relieved from much mechanical labour. The Committee recommend that this arrangement should be permanently continued.

Library.

The Committee congratulate the Society on the improved state of the Library, especially in the publication of the Catalogue : the books are now all in available order, and the arrangement of them with reference to the Catalogue is completed. Great additional space has been gained by a better economy of shelves. A large number of pamphlets and other works have been bound, and many incomplete works have been completed. The Committee recommend that the binding of the pamphlets in volumes be continued, and that certain valuable works, which it has been found impossible to complete, be bound in their present condition with blank leaves for deficient pages. Also that steps be taken to complete the copy of the *Palæontologie Française*.

As soon as the present vacant space is filled up, the Committee recommend that the duplicate works, and certain works seldom referred to, be placed on the shelves in the Council Room.

DANIEL SHARPE.
EDWARD FORBES.
J. S. BOWERBANK.

Comparative Statement of the Number of the Society at the close of the years 1845 *and* 1846.

	Dec. 31, 1845.		Dec. 31, 1846.	
Compounders		123		128
Residents		250		253
Non-residents		437		439
		810		820
Honorary Members	20		20	
Foreign Members	49		50	
Personages of Royal Blood	4	—73	4	—74
		883		894

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1845 *and* 1846.

Number of Compounders, Residents and Non-residents, December 31, 1845			810
Add, Fellows elected during former years, and paid in 1846	Residents.... 2		
	Non-residents. 1		
		— 3	
Fellows elected, and paid, during 1846	Residents.... 17		
	Non-residents. 12		
		—29	
		—	32
			842
Deduct, Compounder deceased		1	
Residents ,,		2	
Non-residents ,,		6	
Resigned		13	
		—	22
Total number of Fellows, 31st Dec. 1846, as above..			820
Number of Honorary Members, Foreign Members, and Personages of Royal Blood, December 31, 1845....			73
Add, Foreign Member elected in 1846			1
Total as above			74

Number of Fellows liable to Annual Contribution at the close of 1846, *with the Alterations during the year.*

Number at the close of 1845		250
Add, Elected in former years, and paid in 1846		2
Elected and paid, during 1846		17
Non-residents who became Residents		10
		279
Deduct, Deceased	2	
Resigned	13	
Compounded	6	
Became Non-resident	5	
	—	26
Total as above		253

DECEASED FELLOWS.

Compounder (1).

Charles Worthington, Esq.

Residents (2).

John Bostock, M.D. | Sir J. S. Sebright, Bart.

Non-residents (6).

John Cole, M.D.
Rev. Richard Hennah.
Charles T. Kaye, Esq.
John Norris, Esq.
The Dean of Windsor.
Thomas Winter, Esq.

The following Persons were elected Fellows during the year 1846.

January 7th.—George Thornton, Esq., Brighton; and Henry Scale, Esq., St. John's Wood Road.

January 21st.—Alfred Tyler, Esq., Warwick Lane; and B. H. Galland, Esq., Cheltenham.

February 4th.—P. W. Barlow, Esq., Manchester Buildings; and George Buist, LL.D., Bombay.

February 25th.—G. E. H. Vernon, Esq., Whitehall Place; and Julius Jeffreys, Esq., Norfolk Crescent.

March 11th.—Thomas H. Braim, Esq., Australia.

April 8th.—Joshua Richardson, Esq., Neath, South Wales; and James Matheson, Esq., M.P., Cleveland Row.

April 22nd.—John G. Perry, Esq., Old Burlington Street; and Capt. Otter, R.N., H.M.S. Sparrow.

May 6th.—Sir Thomas Phillips, Temple; Joseph Hooker, M.D.; Rev. T. W. Jenkyn, D.D., Torrington Square; Francis Forster, Esq., Bangor, N. Wales; James Foster, Esq., Stourton Castle, Staffordshire; and Arthur Grote, Esq., Clapham Park.

May 20th.—Rev. J. G. Cumming, Isle of Man; and C. H. L. Woodd, Esq., Hillfield, Hampstead.

June 3rd.—J. W. Salter, Esq., Park Place, Camden Town; Charles Maclaren, Esq., Edinburgh; William Chambers, Esq., Edinburgh; and J. C. Conybeare, Esq., Chancery Lane.

June 17th.—George A. MacDermott, Esq., Chesterton Hall, near Newcastle-under-Lyne; and Thomas Macdougall Smith, Esq., Chapel Place, Westminster.

November 18th.—Prof. L. D. B. Gordon, Glasgow.

Dec. 2nd.—Rt. Hon. Sir E. Ryan, Kensington; George E. Dennes, Esq., Vine Street, Golden Square; J. B. Birch, Esq., Parliament Street; and William Bainbridge, Esq., Newcastle-on-Tyne.

December 16th.—William Twining, M.D., Bedford Place.

The following Person was elected a Foreign Member.

February 4th.—M. F. Dubois de Montpéreux, Neuchâtel.

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

British and Irish Specimens.

Carboniferous Limestone Fossils and Rock Specimens from the Isle of Man; presented by the Rev. J. G. Cumming, F.G.S.

Cast in Hastings Sand of a supposed gigantic Footstep; presented by the Rev. E. Tagart, F.G.S.

Specimens of *Tellina* and *Ostrea* from March in Cambridgeshire; presented by H. M. Lee, Esq.

Fossil shells from the Kimmeridge Clay of Hartwell, Buckinghamshire; presented by John Lee, LL.D., F.G.S.

Collection of Devonian shells and Crinoidal remains, made by the late Rev. Richard Hennah and the Rev. W. V. Hennah; presented by the Rev. W. V. Hennah.

Specimens of Crinoidal remains; presented by the Earl of Enniskillen, F.G.S.

Spiral appendages of a Spirifer in Chert, from Ashford; presented by James Tennant, Esq., F.G.S.

Pecten and *Pentacrinites* in Sandstone; presented by W. Richardson, Esq., F.G.S.

Specimens of Hastings Sand from near Tunbridge; presented by Messrs. Prestwich and Morris, Fs.G.S.

Specimens of *Unio* from the Iron Mines of Caermarthenshire; presented by W. L. Wrey, Esq., F.G.S.

Cast of Head and Paddle of a new species of *Plesiosaurus*; presented by S. Stutchbury, Esq., F.G.S.

Foreign Specimens.

Specimens of Copper Ores from South Australia; presented by F. S. Dutton, Esq.

A series of Fossils from the Nummulite Limestone of India, and Fossil bones, &c. of Ruminants from Scinde; presented by Capt. Vicary and General Sir C. Napier.

A portion of an Elephant's tooth from the Island of Gozo; presented by Jas. Smith, Esq., F.G.S.

Leptæna euglypha, from the Mendip Hills, and a Fossil Conus from Malta; presented by A. Majendie, Esq., F.G.S.

Coal from Formosa; presented by Sir G. Staunton, Bart., F.G.S.

Specimens of Rocks of Round Island and Serpent's Island, north of the Mauritius; presented by Capt. Beaufort, R.N., Hon. Mem. G.S.

Collection of Upper Silurian Fossils from Gothland, and Lower Silurian Fossils from Scania, &c.; presented by Sir R. I. Murchison, V.P.G.S.

Sigillaria from the Coal Measures of South Joggins, Nova Scotia; presented by Charles Lyell, Esq., F.G.S.

Collection of Fossils and Rocks from South Australia and Van Diemen's Land; presented by J. B. Jukes, Esq., F.G.S.

Collection of Tertiary Fossils from Koomie, Smyrna, Samos, &c.; presented by Lieut. T. A. B. Spratt, R.N., F.G.S.

Fossil Frogs from the neighbourhood of Bombay; presented by G. Clarke, Esq.

Fucoids in Quartzose Sandstone, Table Mountain, Cape of Good Hope; presented by Mr. Geddes Bain.

Specimens of Fish and Crustaceans from Juni Bay, Mount Lebanon, and Fossils and Minerals from the Dead Sea; presented by Capt. Newbold, R.N.

Silicified Ostrea and Wood, and Minerals from Georgia; presented by George White, Esq.

Cast of Skull of *Sivatherium Perimense*, from Perim Island; presented by A. Bettington, Esq., F.G.S.

Charts and Maps.

The Physical Atlas, by H. Berghaus, LL.D., and A. K. Johnson. Part 1; presented by A. K. Johnson, Esq., F.G.S.

The Charts published by the Admiralty during the year 1845; presented by Capt. Beaufort, R.N., by direction of the Lords Commissioners of the Admiralty.

Ordnance Townland Survey of the County of Kerry, in 113 sheets; presented by Major-Gen. Colby, R.E., by direction of the Lord Lieutenant of Ireland.

Carte Pittoresque des Chemins de Fer de la Belgique, par M. Ph. Vandermaelen.

Carte et Tableau Statistique des Chemins de Fer en Belgique, dressée par M. Ph. Vandermaelen.

Carte Itinéraire, Historique et Statistique des Chemins de Fer de l'Europe Centrale, dressée par G. P. de Pistoia.

Carte des Routes existantes avant 1795, exécutées depuis, sous les Régimes Français et Neerlandais, 1846.

Atlas Administratif et Statistique de la Belgique, Carte No. 18.

Carte des Chemins de Fer de l'Europe; presented by M. Ph. Vandermaelen, F.G.S.

Map of Lycia, Milyas and the Cibyratis, by Lieut. T. Spratt, R.N.; presented by Mr. J. Van Voorst.

Section of the strata of Alston Moor, by Wm. Wallace; presented by the Author.

Miscellaneous.

A Clinometer; presented by R. B. Grantham, Esq., F.G.S.

A Marble Bust of the Rev. Prof. Sedgwick, by H. Weekes; presented by H. Weekes, Esq.

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.
Agricultural Magazine, The Editor of the.
American Academy of Arts and Sciences.
American Philosophical Society.
Ansted, Prof. D. T., F.G.S.
Association of American Geologists.
Athenæum, Editor of the.
American Journal, Editors of the.
Austin, Messrs. Thomas.

Bain, Geddes, Esq.
Barraude, M. J.

Beaufort, Capt. R.N., Hon. Mem. G.S.
Bettington, A., Esq., F.G.S.
Binney, E. W., Esq.
Bowerbank, James, Esq., F.G.S.
British Association for the Advancement of Science.

Calcutta Journal, Editors of.
Catullo, Prof. T. A.
Chemical Society of London.
Clarke, G., Esq.
Colby, Major-Gen., F.G.S.
Cumming, Rev. J., F.G.S.

Dana, J. D., Esq.
D'Aoust, M. V.
Darwin, Charles, Esq., F.G.S.
Daubeny, Prof., M.D., F.G.S.
De Koninck, M. L.
De la Beche, Sir H. T., For. Sec. G.S.
D'Orbigny, M. Alcide, For. Mem. G.S.
Dunker, D. W.
Dutton, F. S., Esq.

Enniskillen, Earl of, F.G.S.

Faraday, Michael, Esq., F.G.S.
Forbes, Prof. E., F.G.S.

Geneva Society of Nat. Hist.
Geological and Polytechnic Society of the West Riding of Yorkshire.
Geological Society of France.
Gilliss, Lieut. J. M.
Grantham, R. B., Esq., F.G.S.
Greenough, G. B., Esq., F.G.S.
Grey, Right Hon. Earl.
Griffith, Richard, Esq., F.G.S.
Gumprecht, Dr. T. E.

Hausmann, Prof. J. F. L., For. Mem. G.S.
Hennah, Rev. W. V.
Horner, L., Esq., Pres. G.S.

Institution of Civil Engineers.
Ireland, Lord Lieutenant of.
Jobert, M. A. C.
Johnson, A. K., Esq., F.G.S.
Jukes, J. B., Esq., F.G.S.

Kelaart, E. F., M.D., F.G.S.
Kutorga, Dr. S.

Lee, John, LL.D., F.G.S.
Lee, H. M., Esq.
Leeds Philosophical Society.
Linnæan Society.
Logan, W. E., Esq., F.G.S.
London Geological Journal, Editor of the.
London Institution.
Lyell, Charles, Esq., F.G.S.

Majendie, A., Esq., F.G.S.
Mantell, G. A., LL.D., F.G.S.
Michelin, H., Esq.
Microscopical Society.
Modena Society.
Morris, John, Esq., F.G.S.
Moore, J. C., Esq., Sec. G.S.
Müller, Herr John.
Murchison, Sir R. I., F.G.S.

Napier, Gen. Sir C.
Newbold, Capt.
New York Lyceum of Nat. Hist.
Noble, Daniel, Esq.
Nyst, M. P. H.

Orlebar, A. B., Esq.

Philadelphia Academy of Natural Science.
Phillips, Prof. J., F.G.S.
Pictet, M. F. J.
Pilla, Herr L.
Prestwich, Josh., jun., Esq., F.G.S.

Reeve Brothers, Messrs.
Rennie, G., Esq., F.G.S.
Richardson, W., Esq., F.G.S.
Rose, Prof. Gustav, For. Mem. G.S.
Royal Academy of Berlin.
Royal Academy of Brussels.
Royal Academy of Munich.

Royal Agricultural Society of England.
Royal Asiatic Society.
Royal Astronomical Society.
Royal Geographical Society.
Royal Polytechnic Society of Cornwall.
Royal Society of Copenhagen.
Royal Society of Edinburgh.
Royal Society of London.

Scarborough Philosophical Society.
Sharpe, D., Esq., F.G.S.
Silliman, Prof., M.D., For. Mem. G.S.
Sismonda, Prof. Angelo.
Smith, James, Esq., F.G.S.
Solly, Edward, Esq., F.G.S.
Sowerby, J. de Carle, Esq.
Spratt, Lieut. T., R.N., F.G.S.
Staunton, Sir G., Bart., F.G.S.
Strasburg Natural History Society.
Strickland, H. E., Esq., F.G.S.
Stutchbury, S., Esq., F.G.S.
St. Petersburgh Mineralogical Society.
St.Petersburgh Imperial Academy.

Tagart, Rev. E., F.G.S.
Taylor, R., Esq., F.G.S.
Taylor, R. C., Esq., F.G.S.
Tcheffkine, General.
Tennant, Mr. James, F.G.S.
Trimmer, Joshua, Esq., F.G.S.

Vandermaelen, M. Ph., F.G.S.
Vicary, Capt.
Volborth, Dr. A. Von.
Von Meyer, Herr H.
Voorst, Mr. J. Van.

Wallace, William, Esq.
Whittlesey, C., Esq.
Wicksteed, Thomas, Esq.
Williamson, W. C., Esq.
White, G., Esq.
Wrey, W. L., Esq., F.G.S.
Woods and Forests, Chief Commissioner of.

Yorkshire Philosophical Society.

Zejsznera, M. L.
Zoological Society.

List of Papers *read since the last Anniversary Meeting, February 20th,* 1846.

Feb. 25th.—On a Calcareous Bed in the Thames, by George Rennie, Esq., F.G.S.

———— On the Tertiary or Supracretaceous Formations of the Isle of Wight, by Joseph Prestwich, jun., Esq., F.G.S.

March 11th.—Geological Report on a portion of the Beloochistan Hills, by Capt. N. Vicary; communicated by Sir R. I. Murchison, F.G.S.

———— On Markings in the Hastings Sand Beds near Hastings, by the Rev. E. Tagart, F.G.S.

March 25th.—On the Geology of the Falkland Islands, by C. Darwin, Esq., F.G.S.

———— Notice on the Coal-Fields of Alabama, by Charles Lyell, Esq., F.G.S.

April 8th.—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 R. I. Murchison, F.G.S.

April 22nd.—On the Subdivision of the genus Terebratula, by John Morris, Esq., F.G.S.

———— Description of the Dukinfield Sigillaria, by E. W. Binney, Esq.

———— On Erect Fossil Trees in Cape Breton Coal-Field, by Richard Brown, Esq.

May 6th.—On the Wealden Strata exposed by the Tunbridge Wells Railway, by J. Prestwich, jun., Esq., F.G.S., and John Morris, Esq., F.G.S.

———— On the Newer Deposits of the Southern States of North America, by Charles Lyell, Esq., F.G.S.

———— On Footmarks of Birds in the New Red Sandstone, by John Cunningham, Esq., F.G.S.

May 20.—Description of a New Species of Plesiosaurus, by S. Stutchbury, Esq., F.G.S.

———— On Foot-marks in the Coal Measures of Pennsylvania, by Charles Lyell, Esq., F.G.S.

———— Description of an Upper Molar Tooth of *Dichobune cervinum*, from Binstead, Isle of Wight, by Richard Owen, Esq., F.G.S., Hunterian Professor of Anatomy in the Royal College of Surgeons.

———— On the Wealden Beds of Brora, Sutherlandshire, by Alex. Robertson, Esq., F.G.S.

June 3rd and 17th.—On the Silurian and Associated Rocks in Dalecarlia, by Sir R. I. Murchison, F.G.S.

June 17.—Description of a Fossil Chiton from the Silurian Rocks, by J. W. Salter, Esq., F.G.S.

———— Notice of the occurrence of the *Elephas primigenius* at Gozo near Malta, by James Smith, Esq., of Jordan Hill, F.G.S.

Nov. 4th.—Notice on the existence of Purbeck Strata with remains of Insects, at Swindon, Wilts, by the Rev. P. B. Brodie, F.G.S.

———— Additional Remarks on the Deposit of Œningen in Switzerland, by Sir R. I. Murchison, F.G.S.

———— On the extinct Fossil Viverrine Fox of Œningen, by Richard Owen, Esq., F.G.S., Hunterian Professor of Anatomy in the Royal College of Surgeons.

———— On the Geology of the Island of Lafû, by the Rev. W. B. Clarke, F.G.S.

November 18th.—On the Laws of Development of Existing Vegetation, and the application of these laws to certain Geological Problems, by John Walton, Esq.

———— Remarks on the Geology of the Islands of Samos and Eubœa, by Lieut. T. Spratt, R.N., F.G.S.

———— On the Fossils collected by Lieut. Spratt, R.N., in the Islands of Samos and Eubœa, by Edward Forbes, Esq., F.G.S., Professor of Botany in King's College, London.

December 2nd.—On the Coal Plants of Nova Scotia, by C. J. F. Bunbury, Esq., F.G.S.

———— On Slaty Cleavage, by Daniel Sharpe, Esq., F.G.S.

December 16th.—On the Fossiliferous Slates of North Wales, Westmoreland and Cumberland, by the Rev. AdamSedgwick, F.G.S., Woodwardian Professor in the University of Cambridge.

January 6th, 1847.—On the Classification of the lowest Fossiliferous Rocks of North and South Wales, by Sir R. I. Murchison, F.G.S.

——— On the Island called the Calf of Man, by the Rev. J. Cumming, F.G.S.

——— Notes on some portion of the Geology of the neighbourhood of Bombay, by G. Clarke, Esq.

——— On the Fossil Remains of Frogs in the Deposits of Bombay, described by Mr. Clarke, by Richard Owen, Esq., F.G.S., Hunterian Professor of Anatomy in the Royal College of Surgeons.

——— On the Geology of the neighbourhood of Bombay, by Mr. Conybeare; communicated by W. J. Hamilton, Esq., Sec. G.S.

January 20th.—On a new Clinometer, by R. B. Grantham, Esq., F.G.S.

——— On the slow Transmission of Heat through Clay, by Mr. Nasmyth; communicated by the President.

——— On the Wave of Translation, in Connection with the Northern Drift, by the Rev. William Whewell, D.D., F.G.S., Master of Trinity College, Cambridge.

February 3rd.—On the London Clay, by Joseph Prestwich, Jun., Esq., F.G.S.

——— On recent depressions of Land, by James Smith, Esq., of Jordan Hill, F.G.S. (commenced).

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

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

It was afterwards resolved:—

1. That the thanks of the Society be given to Leonard Horner, Esq., retiring from the Office of President.

2. That the thanks of the Society be given to Robert Hutton, Esq., and Sir R. I. Murchison, retiring from the Office of Vice-President.

3. That the thanks of the Society be given to Sir H. T. De la Beche, retiring from the Office of Foreign Secretary.

4. That the thanks of the Society be given to Prof. Daubeny, M.D., the Marquis of Northampton, Lieut.-Col Sabine, Henry Warburton, Esq., and the Very Rev. the Dean of Westminster, retiring from the Council.

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

OFFICERS.

PRESIDENT.

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

VICE-PRESIDENTS.

Sir P. G. Egerton, Bart., M.P., F.R.S.
Charles Lyell, jun., Esq., F.R.S. and L.S.
Prof. Owen, F.R.S. and L.S.
Rev. Prof. Sedgwick, F.R.S.

SECRETARIES.

William John Hamilton, Esq., M.P.
John Carrick Moore, Esq.

FOREIGN SECRETARY.

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

TREASURER.

John Lewis Prevost, Esq.

COUNCIL.

J. S. Bowerbank, Esq., F.R.S.
C. J. F. Bunbury, Esq., F.L.S.
Charles Darwin, Esq., F.R.S.
Sir H. T. De la Beche, F.R.S. and L.S.
Sir P. Grey Egerton, Bart., M.P., F.R.S.
Hugh Falconer, M.D., F.R.S. and L.S.
Prof. E. Forbes, F.R.S. and L.S.
G. B. Greenough, Esq., F.R.S. and L.S.
William John Hamilton, Esq., M.P.
William Hopkins, Esq., F.R.S.
Leonard Horner, Esq., F.R.S. L. & E.
Robert Hutton, Esq., M.R.I.A.
Charles Lyell, jun., Esq., F.R.S. and L.S.
G. A. Mantell, LL.D., F.R.S. and L.S.
John C. Moore, Esq.
Sir R. I. Murchison, G.C. St.S., F.R.S. and L.S.
Prof. Owen, F.R.S. and L.S.
Samuel Peace Pratt, Esq., F.R.S. and L.S.
John Lewis Prevost, Esq.
Rev. Prof. Sedgwick, F.R.S.
D. Sharpe, Esq., F.L.S.
H. E. Strickland, Esq., M.A.
S. V. Wood, Esq.

TRUST ACCOUNTS.

Receipts.

	£.	s.	d.	£.	s.	d.
Balance at Banker's, 1st January, 1846, on the Wollaston Donation Fund				31	11	6
Balance at Banker's, Geological Map Fund				53	15	0
Received on account of the Geological Map (sold)	47	10	0			
Dividends on the Donation Fund of 1084*l*. 1*s*. 1*d*. Red. 3 per Cents.	31	11	6			
				79	1	6
				£164	8	0

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

JOHN PRESTWICH, Jun., } *Auditors.*
SAMUEL PEACE PRATT, }

Feb. 3, 1847.

Payments.

	£.	s.	d.	£.	s.	d.
Cost of Palladium Medal awarded to Mr. Lonsdale	1	10	0			
Balance of Proceeds awarded to Mr. Lonsdale	30	1	6			
				31	11	6
Paid on account of Geological Map:—						
Arrowsmith, for 25 copies	36	1	0			
Mr. Greenough, balance of 1845	17	14	0			
				53	15	0
Balance at Banker's, Trust Account				79	1	6
				£164	8	0

Valuation *of the Society's Property; 31st December* 1846.

Property.

	£.	s.	d.	£.	s.	d.
Due from Messrs. Longman and Co.				65	7	7
Balance in Banker's hands				317	14	1
Balance in Clerk's hands				8	19	11
Funded Property, 3347*l*. 14*s*. Consols				3150	5	6
Arrears of Admission Fees	39	18	0			
Arrears of Contributions prior to 1846, considered good	6	6	0			
Arrears of Contributions of 1846	44	2	0			
				90	6	0
				£3632	13	1

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

Debt.

	£.	s.	d.
Due to Messrs. R. and J. E. Taylor	57	3	6
Balance in favour of the Society	3575	9	7
	£3632	13	1

Feb. 3, 1847. *Signed*, J. L. PREVOST, Treasurer.

INCOME.

	£.	s.	d.	£.	s.	d.
Balance at Banker's, January 1, 1846	338	5	2			
Less composition to be invested..........	31	10	0			
	306	15	2			
Balance in hands of Clerk, Jan. 1, 1846 ..	8	7	8			
				315	2	10
Compositions received	157	10	0			
Do. at Banker's, as above	31	10	0			
				189	0	0
Do. received in December after Consols closed				31	10	0
Arrears of Admission Fees..............	23	2	0			
Arrears of Annual Contributions	31	10	0			
				54	12	0
Admission Fees of 1846.........................				233	2	0
Annual Contributions of 1846				771	4	6
Dividends on 3 per Cent. Consols				93	3	9
Sale of Transactions				129	10	3
Sale of Transactions in separate Memoirs............				26	7	1
Sale of Proceedings				8	3	0
Journal, Vol. I., Publisher's allowance on sale				7	11	0
Sale of Journal, Vol. II..........................				198	1	5
Library :						
Sale of Catalogue....................	3	10	0			
Donation from Sir T. Phillips	5	0	0			
				8	10	0
				£2065	17	10

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

Signed, JOHN PRESTWICH, JUN. } AUDITORS.
Feb. 3, 1847. SAMUEL PEACE PRATT, }

Expenditure.

	£.	s.	d.	£	s.	d.
Compositions invested				189	0	0
General Expenditure :						
Taxes and Rates	35	11	4			
Fire Insurance	9	0	0			
House Repairs	4	1	0			
Furniture Repairs	18	18	11			
New Furniture	46	7	4			
Fuel	34	13	0			
Light	22	8	2			
Miscellaneous House expenses, including Postages	51	13	0			
Stationery	23	6	9			
Miscellaneous Printing	13	12	0			
Tea for Meetings	27	6	5			
				286	17	11
Salaries and Wages :						
Vice-Secretary	120	0	0			
Librarian and Curator (3 qrs. of a year)	97	10	0			
Clerk	100	0	0			
Porter	80	0	0			
House Maid	33	4	0			
Occasional Attendants	8	0	0			
Collector	27	8	0			
				466	2	0
Library, Printing Catalogue, &c.				148	18	6
Museum				3	13	6
Diagrams at Meetings				21	15	0
Miscellaneous Scientific Expenditure				5	14	6
Contributions of 1846 repaid				5	5	0
Publications :						
Transactions	163	14	2			
Transactions, Separate Memoirs, Publisher's Commission	1	0	9			
Journal, Vol. I., Index, Presentation Copies, &c.	40	11	6			
Journal, Nos. 5, 6, 7 and 8	406	11	0			
				611	17	5
				1739	3	10
Balance at Banker's, Composition received in December, after Consols shut, to be invested				31	10	0
				1770	13	10
Balance at Banker's, Dec. 31, 1846	286	4	1			
Balance in Clerk's hands	8	19	11			
				295	4	0
				£2065	17	10

Estimates *for the Year* 1847.

INCOME EXPECTED.

	£	s.	d.	£.	s.	d.
Account due by Messrs. Longman and Co. in June				65	7	7
Arrears (See Valuation-sheet)				90	6	0
Ordinary Income for 1847 estimated:						
Annual Contributions (240 Fellows)				756	0	0
Admission Fees:						
Residents (13)	81	18	0			
Non-residents (12)	126	0	0			
				207	18	0
Dividends on 3 per Cent. Consols				97	10	0
Sale of Transactions, &c.				100	0	0
Sale of Quarterly Journal				300	0	0
				£1617	1	7

J. L. PREVOST, Treasurer.

Feb. 3, 1847.

EXPENDITURE ESTIMATED.

	£.	s.	d.	£.	s.	d.
Bill due to Messrs. R. and J. E. Taylor				57	3	6
General Expenditure:						
Taxes and Rates	35	11	4			
Fire Insurance	9	0	0			
House Repairs	30	0	0			
Furniture Repairs	15	0	0			
New Furniture	15	0	0			
Fuel	35	0	0			
Light	25	0	0			
Miscellaneous House Expenses	50	0	0			
Stationery	25	0	0			
Miscellaneous Printing	15	0	0			
Tea for Meetings	30	0	0			
				284	11	4
Salaries and Wages:						
Assistant Secretary	120	0	0			
Librarian and Curator	130	0	0			
Clerk	100	0	0			
Porter	80	0	0			
House Maid	33	4	0			
Occasional Attendants	12	0	0			
Collector	30	0	0			
				505	4	0
Library, Binding and Additions				50	0	0
Museum				30	0	0
Diagrams at Meetings				25	0	0
Miscellaneous Scientific Expenditure				10	0	0
Publications, Quarterly Journal				460	0	0
,, Transactions				100	0	0
,, Proceedings, Index to Vol. IV.				18	0	0
				1539	18	10
Balance in favour of the Society				77	2	9
				£1617	1	7

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

19TH FEBRUARY, 1847.

AWARD OF THE WOLLASTON MEDAL AND DONATION FUND.

AFTER the Reports of the Council and Committees had been read, the President delivered the Wollaston Palladium Medal, awarded to Dr. Boué, to Sir Roderick Murchison, addressing him as follows:—

SIR RODERICK MURCHISON,

In presenting to you, as the representative of your friend Dr. Boué of Vienna, the Wollaston Palladium Medal, I cannot better set forth his claims to the honour than by repeating the terms of the award of the Council. This distinction has been conferred on him "for the zeal, intelligence and perseverance with which he has devoted himself, both in the field and in the study, to the attainment and diffusion of geological knowledge during the last thirty years; for his valuable and original investigations in Scotland, the south of France, Italy, the mountain regions of Bavaria, Wurtemburg, Switzerland and the Tyrol, Austria, Illyria, Hungary, Transylvania, &c.; for his scientific researches in European Turkey; for his industry in collecting materials and his skill in arranging them, as exemplified in his geological maps, particularly those of Europe and the World, and in numerous other publications; all tending to facilitate the study and advance the progress of Geology and its kindred sciences."

So comprehensive an enumeration of the claims of Dr. Boué to the gratitude of geologists,—so ample an exposition of the grounds on which the Council have conferred this distinction upon him, may probably be considered sufficient without my adding another word; but as Dr. Boué is a very old personal friend, I hope I shall be excused if I dwell a little longer upon some of his merits, and give expression to my admiration of his indefatigable zeal, activity and success in the pursuit of science. I first knew him as a medical student at Edinburgh, where, in the lecture-room of Professor Jameson, and in sight of the interesting geological features of the neighbourhood of that city, he first imbibed a taste for our science. While in Scotland, he traversed almost every part of it, as a botanist and geologist; and in his inaugural dissertation for his doctor's degree in 1817, he pointed out the influence of geological structure on the flora of a country, illustrated by examples drawn from Scotland. Soon after he left Edinburgh he published his '*Essai Géologique* *sur l'Ecosse,'* a most remarkable work to have been accomplished in so short a time by one individual, a young man, especially considering the state of the science at that time. He was then, too, labouring under the disadvantage of having been imbued with the system of Werner, at that time exclusively taught by Professor Jameson: "J'ai suivi," he says in his introduction, "dans mon travail les principes de son école." But in justice to my excellent friend Professor Jameson, it must be said, that although he then taught an erroneous creed, he inspired his scholars with a devotion to science which led to their conversion to a sounder faith, as the same devotion to the cause of sound Geology afterwards led their master; and in the same sentence from which I quote the above words, his attached pupil says, "J'ai mis à profit les intéressantes leçons de M. Jameson." But Dr. Boué was too acute and able a man to continue long fettered by the dogmas of any school; he read the volume of nature himself, without the aid of the Freyberg Professor as an interpreter, and he had the merit of being one of the first who pointed out to continental geologists the unsoundness of the Wernerian hypotheses. Humboldt frequently alludes to this first work of our distinguished Foreign Member, in his 'Essai sur le Gissement des Roches,' and always with approbation; and even the severe MacCulloch speaks of it with comparative respect.

Dr. Boué next brought out various Memoirs on the Geology of France and Germany, the fruits of his researches during several summers occupied in exploring these countries; and in these he was the first to maintain that the Muschelkalk and Quadersandstein of the Germans were not identical with any English formations, but distinct beds. These memoirs were embodied in his 'Geognostical Picture of Germany.' He undertook the difficult and dangerous task of exploring European Turkey, which occupied him several years, the results of which he published in an elaborate work, which gives the first authentic account of the geology of this little-known region. His various journeys were undertaken at his own expense: he never accepted any public appointment, although the Chair of Geology at Geneva was offered to him some years ago through the influence of Professor De la Rive and others. Dr. Boué was one of the founders of the Geological Society of France in 1830; he and M. Elie de Beaumont were its first Secretaries; he was Vice-President in 1834, when he gave a "Resumé des Progrès des Sciences Géologiques pendant l'Année 1833," which occupies the whole of the fifth volume of the Bulletin of the Society; and in 1835 he was elected its President. He is now resident at Vienna, pursuing his geological researches with unabated ardour. I received a letter from him three days ago, in reply to that in which I announced to him the award of the Wollaston Medal; he regrets his inability to be present to receive it, and he adds, that he is deeply sensible of the unexpected honour that has thus been conferred upon him.

On receiving the Medal, Sir Roderick Murchison replied as follows:

Sir,—The well-merited eulogium you have just pronounced on the scientific labours of Dr. Boué enumerates merits more than enough to entitle any geologist to our highest honour; but permit me to say, that notwithstanding the length of that list of labours, carried on as they were at his own expense and without fee or reward, there is still one subject to which you have not adverted, and which I can estimate the importance of from my own observations,—I mean the researches of our Foreign Associate, seventeen or eighteen years ago, in the Eastern Alps and Carpathians, which led to a most able parallel between these chains.

In examining the former, I derived such essential advantages from an original Geological Map of that region prepared by Dr. Boué, a copy of which was sent by him to this Society, that it gives me peculiar pleasure thus publicly to state, on the part of my fellow-labourer and myself, that, on the question of the age of the Gosau deposits, our antagonist has proved more correct than ourselves; for we now acknowledge that these strata, at least a large part of them, do not exhibit, as we had supposed, a transition into the tertiary series, but form, as Dr. Boué had asserted, a portion of the cretaceous system.

Hoping to revisit Austria in the ensuing summer, (and what pleasure it will give me, I need scarcely say, if my old friend Professor Sedgwick again unites with me,) I shall indeed, Sir, have the sincerest gratification in conveying to Dr. Boué our Wollaston Medal, which I am sure he will doubly value, when he refers to the names of the eminent foreign geologists who, in common with himself, have received this token of the approbation and esteem of their British contemporaries.

The President next addressed Sir Henry De la Beche, Foreign Secretary of the Society, as follows:—

Sir Henry De la Beche,

In the bequest by which Dr. Wollaston established our "Donation Fund," he empowers the Council to apply the annual proceeds, in whole or in part, "in aiding or rewarding the researches of any individual or individuals, of any country." By virtue of that power, and ever anxious to act in accordance with the liberal desire of Dr. Wollaston, the Council have this year awarded the balance of the proceeds, after providing the Medal, amounting to Thirty Pounds, to M. Alcide d'Orbigny, to assist him in the publication of his palæontological works now in progress.

The researches of M. Alcide d'Orbigny have contributed new material to all departments of Natural History. During his eight years' sojourn in South America, he devoted himself entirely to the service of science; and his great work, the 'Voyage dans l'Amérique Méridionale,' will be an enduring monument of his labours. But it is for the services he has rendered to Geology through the application of his zoological knowledge to the determination and description of fossil remains, that we have especially to be grateful. His 'Paléontologie Française' is a work as important to the English as to the French geologist. That part which relates to the cretaceous strata is nearly completed, and forms in itself one of the finest and most extensive palæontological monographs extant. The descriptions therein given are full and well drawn up, and the figures which accompany them are unrivalled for beauty of execution. It is in the hope of contributing towards the continuation and completion of this great undertaking, that the Council now offer to M. d'Orbigny such assistance as lies within their means. Important as is the Cretaceous section of the 'Paléontologie Française,' the continuation of the Oolitic division, as yet only commenced, would be, if possible, even of more consequence to our science in England. A monograph of recent and fossil Crinoidea is another of M. d'Orbigny's works, which has as yet proceeded but a short way, and I scarcely need say how valuable such an essay would be, if complete. The memoirs of this distinguished naturalist upon the fossils of South America, on the secondary fossils of Russia, and many others of minor extent, all bear testimony to his talents and industry, and to his ardent zeal for science. Few living naturalists have sent forth such a mass of valuable work, in the descriptive and iconographical departments of Palæontology; and, perhaps, none but himself would have the courage to contemplate such a gigantic undertaking as the 'Paléontologie Universelle des Coquilles et des Mollusques,' combined with a complete history of existing species, recently announced, and even commenced by M. Alcide d'Orbigny.

Sir Henry de la Beche said in reply:—I entirely concur in all the remarks which you, Sir, have just made respecting the merits of M. Alcide d'Orbigny, and the importance to our science of promoting, by all the means in our power, the publications in which he is engaged; and I highly value the privilege, which my official position in the Society gives me, of being the channel for such a communication to M. d'Orbigny as the present.

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

ANNIVERSARY ADDRESS OF THE PRESIDENT,

LEONARD HORNER, Esq., V.P.R.S.

Gentlemen,—I have again the satisfaction of being able to congratulate you on the prosperous state of the Society. At no period has it been in a condition of more effective usefulness; our numbers are greater than at any former Anniversary; we never had a larger proportion of our Fellows actively engaged in various departments of geological science; our finances are in so sound a state, that we live within our income, and are able to publish the papers read at our meetings quickly and with ample illustrations; our collections of books, maps and specimens have been augmented by many valuable donations in the past year, and they are becoming more and more available to those who desire to consult them. We have had no meeting since our last Anniversary without one paper at least of considerable interest, often more than one; and several valuable memoirs are in the possession of the Council, and others in course of preparation by the authors, which will be read during the remainder of the present session. Our discussions have been carried on with the same talent, animation and earnestness by which they have usually been characterized, combined with that good humour and kind feeling between those maintaining different views, which have prevailed at all times, from the earliest days of the Society.

We have never met on these occasions without having had to lament the loss, by death, of some of our Members; but happily, this year we have not been deprived of more than half the number of those whose deaths it was the painful duty of the Council to announce to you at our last Anniversary.

John Bostock, M.D., although not actively engaged in geological inquiries, was a valuable member of our Society for many years. His name stands high in the medical profession as a physiologist, and he devoted much of his time to chemical research. His scientific pursuits embraced a wide field; he took a warm interest in the objects of this Society, particularly in its early days, and he was elected President in 1826. We have in our Transactions a short paper by him, read in January 1835, giving the results of an analysis he had made of the water of a boiling spring in the volcanic island of St. Paul in the Indian Ocean.

The Rev. Richard Hennah was the eldest son of the Vicar of St. Austle in Cornwall; and after having taken his Bachelor's degree at Oxford, became his father's curate. The place where they resided was in one of the richest mining districts of Cornwall, which gave both a taste for mineralogical pursuits; they formed a choice collection of the minerals of the county, especially the ores of copper and tin, a collection that was well known to all in that county who had similar tastes. In 1804 he was appointed Chaplain to the Garrison of Plymouth, and he held the appointment until his death in 1846, in the 81st year of his age.

Although he had little opportunity of extending his geological researches beyond the country in the neighbourhood of his residence, we are indebted to him for much valuable information respecting the fossils of the Plymouth Limestone, which during many years he had examined with great diligence and success. He announced his discovery of organic remains in that rock in a letter to Mr. Warburton in the autumn of 1814, afterwards published in the fourth volume of the First Series of our 'Transactions'; and on the 2nd of April 1819, a paper by him was read, afterwards published in the fifth volume, in which he describes a considerable variety of the remains of Mollusca and of Zoophytes found in various places. In April 1822 he published 'A Succinct Account of the Lime Rocks of Plymouth.' Previously to his researches, doubts were entertained whether that limestone was fossiliferous. Thus, in the above letter to Mr. Warburton, Mr. Hennah says, "It has hitherto been a point in dispute whether the limestone at Plymouth does or does not contain organic remains." He probably had not then read the 'Illustrations of the Huttonian Theory,' for otherwise he would have seen that Mr. Playfair had, twelve years before, discovered a shell in the limestone, at the very spot from which he was then writing. In accordance with a fundamental principle of that theory, that all the strata, even the most ancient, are composed of the detritus of pre-existing rocks, Dr. Hutton maintained that organic bodies might be discovered in what in those days were called the primary strata; and Mr. Playfair, in his 'Illustrations,' announces (and he appears to have considered it a triumphant proof of the soundness of that principle) his discovery of a shell in the limestone at Plymouth. He thus describes it:—"On the sea-shore, on the east side of Plymouth Dock, opposite to Stonehouse, I found a specimen of schistose micaceous limestone, containing a shell of the bivalve kind: it was struck off from the solid rock, and cannot possibly be considered as an adventitious fossil. Now, no rocks can be more decidedly primary than those about Plymouth. Though, therefore, the remains of marine animals are not frequent among the primary rocks, they are not excluded from them; and hence the existence of shell-fish and zoophytes is clearly proved to be anterior to the formation even of those parts of the present land which are justly accounted the most ancient*." M. De Luc visiting Plymouth in 1805, writes thus:—"There I saw the section of the strata of a limestone much resembling the most ancient secondary limestones of the Alps, which contain but very few marine bodies; I observed none in this stone†." Dr. Berger and M. Louis Albert Necker visited Plymouth in 1810, and Dr. Berger thus speaks of the limsetone, in his paper published in the 1st volume of the First Series of our Transactions, p. 103:—"At Plymouth the cliffs on the shore are of limestone, which I examined leisurely. I did not discover in it any impressions of organic bodies, and I did not hear that they have ever been found in it; at least, if any do exist, they are very scarce." Dr. Thomas Thomson sought carefully for them, but without success‡. Yet these rocks belong to that series which, under the division called "Plymouth Group," Mr. Phillips, in his work on the Palæozoic Fossils of the counties of Cornwall, Devon, and West Somerset, describes as containing 28 species of Corals, 9 species of Crinoidea, 120 species of Shells, and 9 species of Crustacea. No doubt the far greater proportion of these bodies are from localities where they are not only abundant, but could not be missed by even a casual observer; for in one quarry alone, at Newton, Mr. Austen found 139 organic forms specifically distinct, which he has described in a memoir in the 6th volume of our Transactions. It is true, that

* Page 164.

† Geological Travels, ii. 342.

‡ Annals of Phil. vol. ii, p. 248, 1813.

those in the limestone of Plymouth are not very easily discovered; but the geologists of those days had not yet found out that it is not in the fresh fracture of a crystalline limestone, but on its weathered surface that we are to search for the included fossils with most hopes of success, particularly as regards Corals. It was this which first revealed the secret to Mr. Hennah: he tells us, that on the weathered surface of large blocks he found "the varied figures of Madreporites, which left no doubt on his mind respecting the nature of their contents," and thus encouraged, he succeeded in obtaining "unquestionable proofs" that the limestone enclosed "very numerous and striking varieties of organized remains of marine animals*." To him, therefore, the science is indebted for the evidence of this fact, and for the first delineation of the fossils. Mr. Hennah's claims upon the consideration of geologists, nevertheless, do not rest on his published memoirs, as to his unremitted exertions are due the preservation and accumulation, in one series, of the various organic remains which the public works conducted during his long residence in Plymouth laid open. These collections were most freely rendered available to science, and the loan of them to Mr. Lonsdale, Professor Sedgwick, and Sir R. Murchison, afforded one of the principal sources for determining the relative geological age of the Devonshire limestones. That valuable collection was on his death presented by his son, the Rev. William Hennah, Incumbent of East Cowes, to this Society; the greater part is now in our possession, and the Corals are now at Bath under examination by Mr. Lonsdale, from whom we shall at no distant period receive what will doubtless be a most able report upon them, and which will greatly enhance their value. As the collection contained many duplicates, Mr. Lonsdale, who is ever ready to make great sacrifices for the advancement of science and for the interest of this Society, notwithstanding the very delicate state of his health, went at the request of the Council from Bath to Plymouth, and made the selection; this donation has been perhaps the most valuable acquisition in our Museum during the last year.

But I should not do full justice to Mr. Hennah, were I to confine my observations to his merits as a palæontologist. I had not the pleasure of his personal acquaintance, but Professor Sedgwick, who knew him well, has supplied me with some particulars, from which it may be fairly inferred, that if Mr. Hennah had been able to travel, he would, in all probability, have been a still more extensive contributor to the progress of Geology. I will give the information with which Professor Sedgwick has favoured me in his own words:—"I first saw Mr. Hennah at Plymouth in 1819; at that time he had made a fine collection of the neighbouring fossils, and he had a good general notion of the position of the Plymouth limestone, viz. that it was *over* the slate between Plymouth and Dartmoor, and *under* the slates farther south. Like all older geologists, he believed that the granite was primitive, and that the Cornish slates were among the oldest stratified rocks of the world; hence he had not a true notion

* Succinct Account, pp. 6, 20, 30.

of the place of the Plymouth limestone in the British Series; but he *did* know the near resemblance of several species of his Plymouth fossils to those of the mountain limestone. More than this, he had traced the line of Plymouth limestone into White Sand Bay on the Cornish side of the great estuary, and he had done this by help of fossils. For the mass of limestone thins off, and you can only follow its line by help of some very insignificant reddish calcareous bands with a few fossils (especially encrinites) which he identified with those in his Plymouth limestone. This was really good geological work; and remember it was done before 1819, when he was becoming old and had not the leisure for travelling;—remember too the existing state of knowledge. In 1836 I followed the fossil bands from Plymouth to Fowey, Veryan, &c., and thence to the slates north of the Lizard Serpentine. I was in fact only following out what was a corollary from the work of Hennah before 1819. In 1836 De la Beche had not touched the south-west coast of Cornwall, so my work was original in one sense; but it was, I say, suggested by Hennah's work, and I only took the subject up where he had left it off."

The two eminent persons I have mentioned lived to an advanced period of life; but he whose loss I have now to speak of has been taken from us in the vigour of manhood.

Mr. Charles Turton Kaye was born in London in 1812, and from school went to the East India Company's College at Haileybury in 1829, where he distinguished himself and gained the Classical Medal at his first examination in 1830. In the spring of 1831 he proceeded to India, having obtained an appointment in the civil service, in the presidency of Madras. In the College of Fort St. George he obtained the thousand-pagoda prize for proficiency in the native languages. He was at first employed in the revenue department, and was shortly afterwards appointed Assistant to the Accountant-General of Madras; but in 1838 he received the more important appointment of a Judge at Cuddalore, on the Coromandel coast. Hitherto his attention had been more directed to literature than to science, and accidental circumstances appear to have led him to geological studies. In conjunction with his friend Mr. Brooke Cunliffe, also resident at Cuddalore, now a Fellow of this Society, he examined in 1841 a neighbouring district, which is remarkable from containing fossil wood in great abundance, and where they collected a considerable number of other organic remains. They afterwards obtained many specimens of fossils from a limestone in the neighbourhood of Pondicherry and Trichinopoly. Mr. Kaye came to England on leave of absence in the spring of 1842, bringing the collection with him which he presented in his own name and that of Mr. Cunliffe to this Society. He drew up a short memoir, describing generally the structure of the country from which he had obtained the fossils, which was read on the 29th June 1842; and that memoir, together with two reports, the one by Sir Philip Egerton "On the Remains of Fishes," the other by Professor E. Forbes "On the Fossil Invertebrata of the Collection," have, as you are aware, been recently published, forming the third part of the seventh volume of our 'Transactions.' Professor Forbes tells us that the collection is in every point of view of the highest interest, and that the fossils are as beautiful as they are interesting. The total number of species of Invertebrata is 178, of which 165 are Mollusca, 2 Articulata, 8 Echinodermata, and 3 Zoophytes, the greater proportion being from Pondicherry, or, more properly speaking, from South Arcot, being more within the English than the French territory. The evidence afforded by these fossils as to the age of the beds in which they are contained, makes it clear that they are cretaceous; that in two of the localities in which they were found the beds are equivalent to the Upper Greensand and Gault, and in the other to the lowest division of the cretaceous system in Europe. We are thus indebted to Mr. Kaye for some additional precise and valuable information respecting fossiliferous deposits in Southern India, the great importance of which in a geological point of view must be allowed, when we consider the comparatively limited extent of our knowledge respecting the distribution of animal life in the seas of the tropics during the secondary period. We know little more than what we have learned from the valuable memoir of Captain Grant on the district of Cutch, published in the fifth volume of our 'Transactions,' and from these researches of Mr. Kaye. Although unpracticed in geological investigations, he undertook to follow out the hints afforded by Captain Newbold, and overcame all difficulties, through his sagacity and ardent love of science. His collections in our Museum are a monument of his zeal. During his stay in England he neglected no opportunity of getting together whatever information was likely to aid him in the prosecution of his researches. He returned to India in October 1845, prepared to investigate the interesting district upon the structure of which he had already thrown so much light; but he was shortly afterwards attacked by a disease which terminated his existence in July last, in the 34th year of his age.

I have now to advert to the decease during the past year of one of our Foreign Members, George Gottlieb Pusch. He was a German by birth, but entered, about the year 1816, into the Imperial mining service of Russia, in the kingdom of Poland. The preface to the first volume of his work, entitled a 'Geognostical description of Poland and the Northern Carpathians,' is dated Warsaw, 1829; and in this M. Pusch modestly explains the object he had in view, after ten years of assiduous personal researches. We who are surrounded by many facilities and terms of comparison, may well admire the courage with which a solitary miner, living among the hills of the Mittelgebirge, between Warsaw and Cracow, should have ventured to grapple with the herculean task of putting together the geological description of a kingdom, which should embrace every variety of its deposits and rocks, from the oldest transition formations to the most recent alluvia. With scarcely any valid landmarks to guide him, as established by preceding geologists, M. Pusch so carefully examined this region, that he not only produced an excellent description of its physical geography, relative heights, and mineral constitution, but also developed the ascending series of sedimentary deposits through each great period. The second part of this work, published in 1836, was accompanied by a general geological map of Poland and the North Carpathians, illustrated by local maps, plans and sections; and when I state that this general map contains fifty distinct colours or signs, indicating the various sedimentary strata, and seven colours for the eruptive rocks, besides distinct indications of all the mines, I may convey some idea, however inadequate, of the indefatigable industry of this author.

In the publication of this work, M. Pusch had the merit of fully appreciating the dependence of correct geological results on an accurate acquaintance with fossils. Not contented with simply employing the old generic names of Schlotheim, which when he was educated were considered to be adequate to the explanation of the age of rocks, he mainly grounded his reasoning and inductions on the principle of "strata identified by their specific fossils;" and in drawing a parallel between the Polish formations and those which had been well-established in other countries, he specially appealed to the geology of England and Wales. It would be unreasonable to expect perfection in a work prepared under the great obstacles to which I have alluded, and which, from there being no German press in Poland, was necessarily printed in another kingdom. But notwithstanding his insulated state, M. Pusch clearly laid down the geological outlines of the kingdom of Poland and the adjacent provinces of Podolia and Gallicia, and instituted numerous comparisons which have stood the test of subsequent inquiries. Thus, for example, after describing the transition limestone of Podolia, he suggested that its overlying red sandstone being older than the carboniferous rocks, must be of the age of the Old Red Sandstone of England; and although we are now informed by Sir R. Murchison * that some of the transition limestones which Pusch had compared with the limestone of Sweden are not, like the latter, of Silurian, but of Devonian age, still it is evident that our deceased Associate very nearly reached the truth by the above-mentioned comparison.

In working out the relations of the secondary rocks, M. Pusch devoted a considerable portion of his time to the description of that enormously thick and widely spread series of sandstone, conglomerate, shale, and impure limestone, which constitutes the northern and eastern flanks of the Carpathian chain, under the name of "Carpathian Sandstone," and in this effort he was ably seconded by the Austrian geologist, the late M. Lill von Lilienbach. Indicating its various members upon his map by eight distinct colours and letters, M. Pusch considered the whole group of Carpathian sandstone (though with doubts) to be an intervening mass between the Lias and the cretaceous strata; or in other words to represent the lower part of the Jurassic rocks, whilst he associated with its upper portion the saliferous deposits of Wielieczka, &c. Now, although most of

* Russia and the Ural Mountains, vol. i. p. 39.

the present geologists, including Von Buch and Murchison*, have placed the Carpathian sandstone with its fucoids and nummulites in the Cretaceous system, it must be stated, that M. Pusch having re-examined the ground and fossils in 1830, in company with Professor Zeuschner, came also to the conclusion, that this disputed group might be an equivalent of the greensand series. But as this opinion is expressed in the appendix only to his work, the reader must consult it in order to interpret correctly the classification laid down upon the general map, and the changes adopted by the author, and further to understand the extent to which he admitted the comparisons between the Alps and Carpathians, a memoir on which had at that time been just published by Boué and Keferstein. Seeing, however, that the differences of opinion which prevailed seventeen years ago have not even yet been thoroughly adjusted, in reference to the age of the Carpathian sandstones, and that Professor Zeuschner thinks there are alternations of limestone with Jurassic fossils, let us hope that those geologists who are competent to the task will endeavour to delineate the natural limit between the Cretaceous and Jurassic systems of that region; and in comparing them with their equivalents in the Eastern Alps and the North of Italy, will indicate the different *species* of *Nummulites* which characterize each subformation, and point out to what horizon this striking family of Zoophytes descends in the vertical scale of the secondary formations. Until these distinctions be established, the age of deposits cannot be determined by the presence of Nummulites only; for we know that some species exist in the Eocene tertiary, and others throughout the chalk and greensand; and it is even contended that these fossils also alternate in the Jurassic series. The last congress of Italian naturalists have therefore done well in offering a premium to the naturalist who will best answer this interesting question, and will clearly mark the first appearance of Nummulites, and the diversity of their species in succeeding periods. In short, this desirable end must be accomplished, before the labours of Von Buch, Boué, Lill von Lilienbach, Pusch, and Sedgwick and Murchison, can be brought into accordance with the more recent observations of Zeuschner, Pilla of Pisa, and other writers.

Again, since M. Pusch's researches were carried out, the salt formations on the northern flank of the Carpathian sandstone have been clearly shown by their imbedded fossils to belong to the Miocene tertiary age†; but on this point, whilst he might well be misled by the appearance exhibited by the natural sections of such saliferous masses dipping beneath the secondary Carpathian sandstone, we must not forget that he more nearly approached the truth than any of his predecessors, most of whom, led by English and other European analogies, considered the salt rocks of Wielieczka to be of the age of the New Red Sandstone. Such indeed has been the destiny of all former conclusions which have been exclusively based either

* See Russia and the Ural Mountains, vol. i. p. 265.

† *Ibid.* vol. i. p. 290.

on lithological analogies, or even upon the apparent order of superposition; since it is now well known, that formations frequently lie in inverted positions in those parts of the world wherein the rocks have undergone violent disturbances.

This triumph of palæontology over all other evidences is indeed the peculiar feature of modern geology; and M. Pusch was one of the labourers in the field who have been conspicuous in achieving it. His work on the Palæontology of Poland, published in 1837, was a valuable addition to all that had preceded it, and is much more copious and detailed than the contemporary inquiries of Dubois de Montpereux and Eichwald, who severally described the organic remains of certain parts only of the same country.

It was for these contributions to physical geology and palæontology, that in the year 1841 M. Pusch was elected a Foreign Member of our Society; and when it is recollected that he achieved these results in a region remote from those persons who could best aid him, and gave to us an original Map of the subsoil of a previously unclassified country, I may truly say, that few of our honorary associates have had stronger claims upon our grateful remembrance. For the last few years of his life, M. Pusch had been almost exclusively employed in the tedious and oppressive minutiæ of the administration of the Polish Mines, particularly in the direction of the Coal works on the eastern or Polish limit of the Silesian coal-field.

Progress of Geology.

I will now endeavour to bring before you an outline of some of the more prominent features in the onward movement of the science we cultivate, during the last year. That progress is so rapid, that while it is gratifiying in one sense, it causes a feeling of disappointment almost amounting to despair; for it outstrips the efforts of the most active and industrious to keep pace with, leaving a consciousness that, even within our own domain, if we are to know anything well, we must remain ignorant of much that we should be glad to be acquainted with. And so connected are the various departments of the wide field of Geology, that we are thus constantly doomed to feel the disadvantage of our imperfect acquaintance with other branches of our subject, in working out that which is the special object of our study.

The separate works and the memoirs contained in periodical publications by the geologists of Europe and of the United States of North America have been so numerous, that I might fill my pages by giving only a summary *Catalogue Raisonnée* of the subjects treated of; but as an address so composed would be equally wearisome to me to write and to you to listen to, I have thought it better to follow the same course I did last year, by dwelling on some of those subjects of general interest which are most attractive to myself, and to which consequently I have paid most attention. I will however first advert to some of the larger and more general works.

Among the most valuable of these, I am disposed to name first the

'Memoirs of the Geological Survey of Great Britain.' This is the first volume only of a work which we must all hope will speedily be followed by many more; because they cannot fail to supply us with a large body of facts, carefully collected by most competent observers, which will not only make us more accurately acquainted with the structure of our own country, of which a great part may be said to be known to us as yet only in its principal outlines, but will materially aid in the determination of many of the great problems of Geology. I consider the advantages to be derived from this new institution of our Government, in an economical point of view, important as they will be, subordinate to the higher objects of science it is calculated to promote.

In my Address of last year I adverted to the new importance that had been given to this national establishment, instituted nine years ago, and to the able men by whom the work is to be conducted. With scarcely any exceptions, all geological inquiries have been the fruits of individual research. From the extent of such inquiries, every geologist working by himself, and endeavouring to make out the structure of a country and describe the phænomena in detail, must labour under considerable disadvantages; but in the Geological Survey of Great Britain, there is a combination of forces which we have never, in this country at least, seen applied to the promotion of any one department of science. No department perhaps requires so many different descriptions of force to be brought to bear upon it. The Ordnance Trigonometrical Survey led the way by the preparation of that indispensable requisite in geological inquiries, an accurate Map on a large scale, so ably begun under the direction of General Mudge, and not less ably carried on by his successor General Colby—both early Fellows of this Society. For the more general Survey we have geologists of great practical experience, who have established a high reputation; and when the structure of each region is to be worked out in detail, the special knowledge of the mineralogist, the chemist, the natural philosopher, the zoologist, the comparative anatomist, the botanist, and the palæontologist, will be brought to bear, as required, by means of men of high authority in each branch, and their labours will be illustrated by artists of great skill, all attached to the Survey; forming together a corps of scientific men, for the accomplishment of a great work, not surpassed, I believe, by any similar establishment in any other country.

The Journal of Mr. Darwin, as Naturalist in the Surveying Voyage of the Beagle, contained such an amount of new and important information as to excite a universal admiration of his talents as an observer; and had he given us nothing more, he would by that work have supplied ample evidence of his industry and zeal, notwithstanding almost continual suffering from ill health for several years. But, besides some separate memoirs, he has contributed to our science, as you know, his valuable treatise on Coral Reefs, and that on Volcanic Islands. These however had not exhausted his store, for during the last year he has produced another volume of the highest interest, his 'Geological Observations on South America,' containing in its closely printed pages an amount of reading equal to two-thirds of his Journal. In his first work we had the outlines of these geological observations, but in that recently published we have the outlines filled up with most valuable details, together with many new facts, general observations and deductions, which will be read with much profit by every geologist. In the sequel of this Address, I shall allude more particularly to some of the more striking features of this work.

We received last spring a valuable work from our distinguished Foreign Member, M. Elie de Beaumont—his 'Leçons de Géologie Pratique.' It is an important publication, as giving us the views and opinions of one of the most eminent geologists of France up to a late period, for these Lectures were delivered only three years ago. He informs us that they were given orally, but taken down in short-hand, and revised by himself for publication. Such of you as are not already acquainted with the work will readily believe that a Course of Lectures by so able, so accomplished, and so experienced a geologist, must contain much that is interesting and valuable; and those who seek for minuteness of detail and amplitude of illustration will not be disappointed.

He tells us that he took the *Agenda* of Saussure, published half a century ago at the end of the fourth volume of the 'Voyages dans les Alpes,' as the basis of his plan, but that the present more advanced state of the science had made it necessary for him frequently to leave his guide. Nevertheless, he says,—and it is a proud homage to the genius and sagacity of the great Swiss geologist,—the facts since collected have scarcely ever led him to controvert Saussure, for that philosopher "possessed in an eminent degree the instinct and the presentiment of truth." At the conclusion of his first Lecture he pays another tribute to the great master whom he justly holds up as an example to the pupils he is instructing, in the following terms: "When we read the 'Agenda' with attention, we are surprised how appropriate the greater number of the questions are to the present time. The 'Agenda' are at once the most judicious and the most stimulating guide to observation which the geologist can follow. All that is wanting is to complete them, to extend them, to modify them in some particulars; to establish certain relations between facts less insulated now than they were in his time; and there is perhaps no way in which Geology can be presented to us in a manner more interesting and more instructive. It is that which I shall endeavour to follow in this Course, in which it will be my aim to present known facts in such a way as is most proper for conducting to facts yet to be discovered*."

This last year has also supplied us with a work long wanted, a 'Manual of Chemical and Physical Geology,' by Dr. Gustav Bischof, Professor of Chemistry in the University of Bonn, already well known to us by several interesting chemico-geological researches in the neighbouring volcanic region of the Eifel; and particularly by his work entitled 'Physical, Chemical, and Geological Researches on the

* Page 44.

Internal Heat of the Globe.' There has been no field hitherto more in want of able cultivators than that of Chemistry applied to the elucidation of geological phænomena, one which my able and lamented friend, our former Secretary, Professor Edward Turner, had just entered upon with so much success, when he was taken away from us in the prime of life. We ought therefore to hail with satisfaction the appearance of this work by Professor Bischof. "The earth," he says, "so far as we are acquainted with it, is a great laboratory, wherein, since the creation, chemical processes have been uninterruptedly going forward, and will go on, so long as the earth continues in its orbit round the sun. If we seek to investigate the structure of the earth, if we endeavour to explain the phænomena it presents, and the changes which are unceasingly taking place upon it, we must enter the domains of Chemistry and Natural Philosophy." The first part, that recently published, treats of the aqueous phænomena within and upon the earth; "a knowledge of them," he observes, "of the substances which waters take up, and of the processes to which they mutually give rise, leads us to an explanation of the most important and mighty changes which the earth has undergone, and is still subject to, and to the origin of the sedimentary formations." The second part will treat of the origin of the materials of which these formations are composed, of the crystalline rocks, their constituent parts and their decompositions; of the substances filling the cavities in amygdoloids, of pseudomorphisms, &c.; and a particular attention will be devoted to a subject hitherto little attended to, the lithological differences between primary and secondary formations.

In my Address to you last year, I dwelt so much upon the older series of rocks that I was unable to offer more than a few observations on the recent additions to our knowledge of the tertiary and more modern formations, and on terrestrial changes now in progress. I entered, it is true, at some length upon the subject of boulder formations and erratic blocks, and on some recent discoveries of changes in the relative levels of sea and land, but I did not touch upon the many valuable observations, communicated to us within a short time, on the alterations which the surface of the earth has undergone subsequently to the deposit of the more modern tertiary beds, in the period which approaches historical times, as well as on the terrestrial changes which have since occurred and are now in progress. On the present occasion, I shall confine my review almost exclusively to those contributions received in the last two years, which have enlarged our knowledge of the more modern periods of geological chronology, and even to a small number of these; for I believe that it will be more agreeable to you that I should dwell upon some of the great questions opened up by the authors of the works to which I refer, than that I should occupy your time by brief outlines of the general contents of many works. I will also, in the present as in my last year's Address, abstain from reference to the papers read in this room; not from any want of a due appreciation of their value, but because I deem it superfluous. You heard them read and discussed; they are already in part published, and the rest will shortly appear in our 'Journal.'

The attention of geologists has of late years been more habitually directed to a careful and minute examination of the phænomena of modern changes; and I believe that our theories of the appearances which the older parts of the earth's structure exhibit will be sound in proportion as they are in accordance with the laws which we see governing the modifications that are now in progress. It is in this spirit that Sir Henry De la Beche has devoted nearly twenty introductory pages in his late valuable Memoir, 'On the Formation of the Rocks of South Wales and South-Western England,' to an explanation of existing causes of terrestrial change, in order that his reasonings on the details he is about to describe may be more intelligible and satisfactory. "It may be advisable" he observes, "before we inquire into these facts, to take a brief view of the effects of igneous action, and of the deposit of mineral matter, chemically or mechanically, from or by means of seas, estuaries, and lakes, as they are at present known to us. By comparing this knowledge with the geological facts observed in the district, we shall see how it enables us satisfactorily to account for them, and how far other reasoning may be necessary." As an example of his application of this mode of reasoning, which indeed pervades the whole memoir, I will give the following instance: he is describing a hard indurated slate in the lowest parts of the Silurian system, containing graptolites, and, according to the analysis of Dr. Playfair, so much as five per cent. of carbon, and says, "It would appear that black mud was a common sediment of the time, the colour chiefly due to carbon, which we might infer was derived from vegetable matter. Of what kind that vegetable matter may have been, there would appear no direct evidence; and though we might be disposed to infer that marine plants may have furnished a large part of it, when we regard the quantity of fine sediment of the time and its extent, we should look, in accordance with the mode in which such sedimentary matter is furnished in the present day, to land, its disintegration, and its removal by rivers and running waters to the sea, as among the chief sources of the non-carbonaceous part of this black mud. Hence, and considering the conditions under which the remains of plants are likely to be preserved, it would probably be premature to look more than to plants generally, not altogether excluding animal matter, for the carbon required." Thus he contemplates, with every degree of probability, the existence of a continent, intersected by rivers, clothed with vegetation, and subject to atmospheric sources of disintegration as our present continents are, at that distant period when the materials of the oldest of our sedimentary rocks, the base of our vast series of geological formations, were accumulating at the bottom of a sea.

The lowest stratum of the lowest sedimentary deposit constitutes the limit beyond which we cannot trace the operation of those agencies which are still modifying the structure of the earth; it is the true starting-point of all our speculations into the past history of the globe that rest on authentic evidence; there the proper work of the geologist begins. There must necessarily have been a state of our earth when no sedimentary strata existed, for they could only be formed by the disintegration of pre-existing rocks: the smallest fragment contained in them is an indisputable witness of the truth of this fundamental principle in geology. We know what the mineral nature of these rocks must have been, from the mineral nature of the strata that have been formed out of them; but beyond that, all is obscure: under what forms the materials of these rocks were aggregated, what masses the aggregations constituted, how, in short, the round earth was then composed, are speculations that must be left to cosmogonists, for they are not within the province of the geologist. But if there are fragments in the oldest sedimentary deposits, and if these fragments, whether angular or rounded, are similar to those now forming under our eyes, we legitimately infer that the agents that formed both were alike: if the deposits contain the remains of animals and plants, we also legitimately assume, that the elements necessary for their existence were the same as those which now support animal and vegetable life; it would be unphilosophical to reason on any other principle. The deposition of the oldest sedimentary rocks is therefore the commencement of geological chronology; from that point we trace successive steps in creation, a sequence of changes, to our own time; that far-distant period forms the subject of the first chapter of the voluminous history of the earth, a history recorded in documents of unerring truth; written, it is true, in a language so rich and copious as to be very difficult to learn, but to interpret and arrange these documents is the business and the privilege of the geologist.

M. Elie de Beaumont, in the lectures to which I have referred, has taught his pupils that the only hope of arriving at a right interpretation of the past, is by a careful study of the phænomena subject to our observation, and of the laws by which modern changes in the constitution of the materials of the earth's crust, and in the arrangements of its several parts are governed. One of the first and most striking things that arrests our attention and excites our wonder, in the study of the earth's structure, is the evidence it affords of the immensity of past time, of the incalculable periods that have elapsed during the slow and gradual progress of its formation. Thus M. Elie de Beaumont begins by showing the great duration which we must often assign even to the superficial covering of vegetable soil and alluvium; and he enters at considerable length into this subject in a very instructive manner. Thus, for example, he shows that the covering of vegetable soil, thin though it be, is often proved to be of great antiquity; by the evidence of ancient tumuli, of cyclopean structures and druidical monuments, built on that covering, which has undergone no change since their foundation; that is, for a period of at least 2500 years, and without our being then able to assign any limit to its anterior existence. As another class of evidence, he refers to the instances of the great age of dicotyledonous trees, which M. DeCandolle has brought forward; one of which, a Cypress near Oxaca in Mexico, he estimates to be nearly 6000 years old. "The effects produced," he says, "by the agents now operating on the external surface of the globe, agencies to which some apply, exclusively, the term *actual causes*, constitute a term of comparison, which is indispensable to enable us to appreciate the effects which have been produced by analogous agents in times past. These operations, the effects of the laws of natural philosophy and chemistry, ought ever to be present to the mind of the geologist in his practical observations, because a multitude of circumstances which present themselves in the study of the rocks that compose the earth's surface disclose the operation of some of these agents. Indeed, without we take them into account, it will be impossible to form a just conception of the nature of the greater proportion of rocks, or arrive at a thorough understanding of them."

THE RECENT PERIOD.

Before proceeding to notice some of the more important accessions to our knowledge during the past year, respecting geological phænomena that belong to the most modern period of the earth's history, some of them operations now in progress, I will offer a few remarks on the terms employed to designate certain geological periods.

The sense in which the term "recent" is to be understood, as applied to geology, has not yet been defined. All who use it include, of course, the changes now in progress; but the degree of its extension into time past is by no means a settled point. By some geologists it is confined to the period of which we have authentic records, and has been called the historical period; by others it has been named the *human* period, meaning thereby, that it embraces all the time that has elapsed since the creation of the first pair of the human race; an epoch however which we have as yet discovered no means of fixing with anything approaching to certainty; and some, as for instance Mr. Darwin in his late work on the Geology of South America, apply the term "recent" to alluvial deposits containing remains of mollusca that are all existing species, but also containing remains of extinct mammalia. Whether any of these animals co-existed with man, that is, with man, not merely as existing in the same country, but then existing on any part of the earth's surface, we have no certain knowledge.

But it is not to the term "recent" only that this want of precision is chargeable; the same uncertainty prevails with regard to the terms by which other geological periods are designated, when used, as they are generally understood, to define a certain division of time in the history of *the whole earth*. The indefiniteness is perhaps most apparent in regard to the tertiary deposits, and especially in the more modern of these. In the early days of systematic geology there were only two grand divisions of the stratified rocks, the primary and secondary; the progress of the science called for the separation of the upper portion of the latter into another grand division, the tertiary; and its further progress has shown, that there are subdivisions in the latter that point to great successive changes on the earth's surface, within comparatively modern periods. In 1833 Mr.

Lyell published the third volume of his 'Principles of Geology,' and he there brought forward a division of the tertiary formations into four groups, founded on "the comparative proportion of living species *of shells* found fossil in each *," which he termed Eocene, Miocene, Older Pliocene, and Newer Pliocene. He adopts the same divisions in the second edition of his 'Elements of Geology,' published in 1841, then adding a fifth division, the "Post-Pliocene, including the fossiliferous strata of the Recent, or human period." † "I have adopted the term Post-Pliocene," he says, "for those strata which are sometimes called modern, and which are characterized by having all the imbedded fossil *shells* identical with species now living;"—he takes no account of their containing, or being free from, remains of extinct *mammalia*. The proportions of living species of shells in each division he states to be as follows :—

Post-Pliocene..........	99 to 100	per cent.
Newer Pliocene........	85 — 90	„
Older Pliocene	60 — 70	„
Miocene	20 — 30	„
Eocene	1 or 2	„

A definite order of superposition, from the eocene upwards, was of course implied as an essential condition of the classification throughout the whole range of deposits. The term *pleistocene* had been proposed by Mr. Lyell three years before, for his fourth division; although he dropped it himself, it has since been occasionally used by other writers.

These terms have usually been understood to mean certain periods or measures of past time. If they apply *to time*, they apply to every part of the earth's surface; that is, as generally understood, at the time pliocene deposits were forming in Europe, *it was pliocene time all over the world*. If we inquire how this scale of geological chronology has been formed, we find that it has been graduated by the results of the examination of deposits in *certain localities*, by different observers, and by a careful comparison of the remains of mollusca contained in these deposits, with those now living *in the neighbouring seas*.

The application of the terms pliocene, miocene, &c. *to time generally*, presupposes that the numerous causes which led to the extinction of existing species and favoured the introduction of new species, had been going on over the whole globe, both in respect of kind and degree, although not necessarily simultaneously in different regions; that is, that the same changes might be brought about in periods of longer duration in one region than in another: that the causes operated in one region on certain species, in another on analogous or representative species; the general effect being, that *an uniformity in the character of the result*, during the epoch in question, was produced all over the globe. Facts already collected appear to some geologists to lead to this conclusion; they maintain that if we extend the period of time sufficiently, a certain class of changes will have taken place, having

* Preface, p. xiii. † Vol. i. page 210.

such a community of character as to constitute an epoch in time generally, and that it is in this sense we are to understand the pliocene, miocene, and eocene periods respectively. This view may be confirmed by the accumulation of a widely-extended and multifarious body of evidence; but some of the principal causes of the extinction of existing species, and of the introduction of new species, are of a kind that might have come into operation in one portion of the globe, while other parts remained unchanged by similar causes; therefore the synchronism of formations in distant parts of the globe cannot be conclusively determined by evidence that is in its nature inconstant. This leads us naturally to inquire, what the circumstances are on which the distribution and habits of different species of mollusca depend.

Professor E. Forbes has shown, that the distribution of marine animals is determined by three great primary influences, and is modified by others that may be termed secondary or local. The primary are, climate, composition of the sea, and depth: the secondary are, the nature of the sea-bottom, that is, whether it consist of sand or rock, be gravelly or weedy; tides and currents, and the influx of fresh water. It is generally admitted by geologists, that at all periods down to our own times, the surface of the earth has been subject to extensive elevations and subsidences; that plains and lofty mountains have risen where formerly there was sea, and that plains and mountains have subsided and been covered with deep water. It is evident that such elevations and depressions, producing variations in the relative proportions of sea and land, and not only in the extent but in the elevation of the land, must have caused great changes in atmospheric temperature, in the temperature of the sea, in the depths of water, in sea-bottoms, in the direction of currents, and in the influx of fresh water, on different parts of the superficies of our earth, and even on the same parts at different times. But such alterations in the proportions of land and sea could not be synchronous over the whole earth, nor is it probable that in two distinct areas they would be alike in amount or in kind.

Let us, for example, suppose two parts of the ocean (A and B) far distant from each other, under such similarity of condition as to temperature, depths of water, sea-bottom, &c., as to be favourable to the existence of the same or representative species of mollusca; of littoral species, of those inhabiting zones of moderate depth and of deep sea species; let us further suppose earthy deposits going on in each part, and inclosing the remains of the dead mollusca that lived on the rocks and sands and amidst the groves of fuci of its bottom. Let us now suppose subterranean action so to raise the bottom of the part A as to cause shallow water above it: immediately, or soon after, the mollusca capable of existing only in deep water would perish and become extinct in that part, others fitted for shallow water would begin to prevail, and newly-directed currents, caused by the altered form of the land, might bring other species, and the remains of these several new species would, in their turn, be inclosed in the deposits going on in the shallow sea. Let us suppose the number of species that become extinct to amount to 16 per cent. Let us further suppose another change in the neighbourhood of the shallow sea, an elevation of the land to such an extent that perpetual snow would rest on mountains and form glaciers; a change of temperature in the atmosphere and in the adjoining sea would then take place, and such mollusks as were fitted to live only in a mild temperature would perish and become extinct; the same might happen from changes in the sea-bottom by the influx of detritus from the land; and new species adapted to the altered conditions would prevail. Let us suppose that the number of species that become extinct by this second change of conditions, also amounted to 16 per cent.; this last state of things continuing unchanged for a long period, a new exertion of subterranean force raises up the bed of the shallow sea into dry land, and fissures exhibit sections of its structure. A future geologist examines the fossiliferous beds, and he finds a lower series with not more than 68 per cent. of the species living in the adjoining sea; a series of beds above these with about 84 per cent., and these last capped by a series in which all the mollusca are species then existing in the neighbouring sea. He thus finds a series of Older Pliocene, Newer Pliocene, and Post-Pliocene deposits; for he has no proof that the species he considers extinct are living in any other part of the earth.

But while these changes have been going on throughout a long period in this part of the ocean (A), the other part of the ocean (B) has continued without any other change than a greater accumulation of sedimentary deposits on its bottom. But that sea-bottom is in process of time elevated at once into dry land, and when examined by a future geologist, he finds the strata containing littoral species of shells, those that live in zones of moderate depth and some that inhabit deep water, some peculiar to sandy some to rocky bottoms. He goes out with his dredge into the neighbouring seas, and makes a large collection of shells from various depths; and on comparing the two, he finds all the fossil remains in the strata to be species then living in the adjoining sea, and he classes the whole series of beds as post-pliocene. But the changes of conditions in the distant part of the ocean A, and the constancy of conditions in the part B were synchronous; and thus it would appear that, taking the proportions of living species of shells in the beds of the two parts as a standard, older and newer pliocene deposits were forming in the part A, and post-pliocene in the part B at one and the same time, in distant parts of the earth. If therefore the above reasoning be correct, it seems to follow, that while proportions of living species of shells constitute a sound principle for discriminating changes of time, when accompanied by changes of condition, *over limited areas*, two pliocene deposits at distant parts of the earth's surface may not be certain evidence of synchronism. In support of these views, I will quote the concluding sentence of the fourth chapter of Mr. Darwin's new work, to which I shall afterwards refer at some length, viz.—"The facts here given show how cautious we ought to be in judging of the antiquity of a formation from even a great amount of difference between the extinct and living species in any one class of animals; we ought even to be cautious in accepting the general proposition, that change in organic forms and lapse of time are at all necessarily correlatives*."

So also if animals inhabiting shells are subject by revolutions in climate, or other causes, to remove from one region to another, and such we know to be the case, that removal may take place after the shells of several generations of the species may have been imbedded in sediment. The species may become extinct in the first region, and prevail for a long time in that to which they had removed, and their shells may, in like manner, become imbedded in stone. Thus strata in distant places, although characterized by shells of the same species, may not be of synchronous formation.

I make the foregoing observations however with great diffidence, I throw them out as suggestions for consideration; they relate to matters of great complexity and difficulty, but which are of fundamental importance in our researches into the earth's history, and they are in a very unsettled and uncertain state. The opinions I have now hazarded are, in some degree, at variance with those of a geologist of great authority, one from whose conclusions I very rarely differ, and never without doubting the soundness of my own judgment. Thus, Mr. Lyell, after comparing the tertiary formations of North America and Europe, of which he has treated in his 'Travels,' and in papers published in our Journal, has come to the conclusion that the Eocene and Miocene formation of the United States, as determined by the relative proportions of recent and extinct species of fossil shells, are truly contemporaneous in age with the deposits termed by him Eocene and Miocene on this side of the Atlantic. With some species identical with those of the neighbouring seas, they contain a great number of forms which he regards as "representative." The synchronism he considers to be established not only by agreement in the relative position and the characters of the whole fossil fauna, but by the same kind of evidence as that which induces geologists to consider the coal-fields of the United States and the cretaceous strata as equivalents in time and position with the groups similarly designated in Europe. The numerous points of agreement in the palæontology of the successive tertiary and post-pliocene formations of America and Europe he believes to have been brought about by the predominant influence of climate controlling the minor effects of local geographic revolutions, and causing a near approach to a uniform rate of fluctuation in the organic world throughout the whole northern hemisphere, from the Eocene to the recent periods.

By whatever names we designate geological periods, there appear to exist no clearly defined boundaries between them in reference to the whole earth; such a marked line may be seen in particular localities, but every year's experience, and our more intimate acquaintance with the phænomena exhibited in different countries, and with the distribution, structure and habits of animals and vegetables, teach us that there is a blending, a gradual and insensible passage from the lowest to the highest sedimentary strata, particularly in respect of

* Geology of South America, p. 105.

fossil remains. The terms we employ to designate formations can only be considered as expressing the general predominance of certain characters, to be used provisionally, as a convenient mode of classifying the facts we collect, whilst that knowledge is accumulating which, in after ages, will unravel the complicated changes that belong to the successive periods into which the history of the structure of the whole earth may be divided.

GEOLOGICAL CHANGES NOW IN PROGRESS.

Among the most remarkable of those recorded during the past year, none is more instructive, from the magnitude of its operations, than the formation of the alluvial plain of the Mississippi, of which we have received an account from Mr. Lyell, the result of inquiries and personal observation made by him during the spring of last year, along a considerable part of the course of that river from its mouth to the junction of the Ohio. He brought before the British Association last September the principal facts he had collected, and the conclusions he had been led to deduce from them, respecting the progress of that vast accumulation of sedimentary matter, and he has referred to them in greater detail in the seventh edition of his 'Principles of Geology,' just published.

The alluvial matter brought down by this river and its tributaries has formed a tract of level land, which extends from the embouchure in the 29th degree of latitude to Cape Girardeau in the state of Missouri, fifty miles above the junction of the Ohio, in latitude 37° 20′, a distance, in a direct line from S. to N., of 576 miles. The width of the plain varies considerably, between thirty and eighty miles, which last dimension it attains in lat. 34°; and it has been estimated by Mr. Forshey to occupy an area of 31,200 square miles, with a circumference of about 3000 miles; thus exceeding the area of Ireland. That part of the plain which, according to the usual language of geographers, would more properly be called the delta, viz. all that lies below the point where the highest arm, or the Atchafalaya, branches off from the Mississippi, is estimated at nearly one-half of the whole area, or 13,600 square miles. This delta, which spreads out into a vast level region, extending beyond the general coast, is in form very unlike the delta of the Nile, for the main stream does not divide into two separate branches to form the two sides of a triangle, nor is there the curvilinear base towards the sea; a tongue of land protruding fifty miles into the Gulf of Mexico, through which the main river flows until near its extremity, where the water is discharged into the sea by four main channels, or Passes as they are called. The plain at Cape Girardeau is not more than 200 feet above the sea-level, so that the rise is only about *four inches* in a mile. Mr. Lyell states the rise at *three inches* in a mile, but he takes the distance at 800 miles, following the sinuosities of the river. Small as this is, it is much greater than the rise in the valley of the Nile from the sea. That alluvial plain is 420 miles in extent from the first cataract to the apex of the delta; from that last point to the Mediterranean, in a direct line, is about 102 miles; the base between the eastern and western branches of the river being 187 miles. The fall from the first cataract to the sea is only two inches in a mile*, and M. Elie de Beaumont states that the bed of the river at Cairo, which is sixteen miles above the head of the delta, is 16 feet 4 inches above the Mediterranean, which gives a fall of 1·9 inch in a mile†.

According to Mr. Lyell, the deposit of the Mississippi "consists partly of sand originally formed upon or near the banks of the river and its tributaries, partly of gravel, swept down the main channel, of which the position has continually shifted, and partly of fine mud slowly accumulated in the swamps. The further we descend the river towards its mouth, the finer becomes the texture of the sediment‡." A large portion of this alluvial deposit, together with the fluvio-marine strata now in progress, near the mouth, is intermixed with much vegetable matter, derived from the prodigious quantity of drift-wood floated down every summer during the freshets. "In excavating at New Orleans, even at the depth of several yards below the level of the sea, the soil of the delta contains innumerable trunks of trees, layer above layer, some prostrate, as if drifted, others broken off near the bottom, but remaining still erect, and with their roots spreading out on all sides, as if in their natural position. In such situations, they appeared to indicate a sinking of the ground, as the trees must formerly have grown in marshes above the sea-level§."

The east and west boundaries of the alluvial region, for about five degrees of latitude above the head of the delta, consist of bluffs or cliffs, from 50 to 250 feet in perpendicular height, which continue as far north as the borders of Kentucky, not far below the head of the plain. "They consist in great part of loam, containing land, fluviatile, and lacustrine shells, of species still inhabiting the same country. These fossil shells occurring in a deposit resembling the Loess of the Rhine, are associated with the bones of the mastodon, elephant, tapir, mylodon, and other megatherioid animals; also a species of horse, ox, and other mammalia, most of them extinct species. The loam rests at Vicksburg and other places on Eocene or lower tertiary strata, which in their turn repose on cretaceous rocks." As these bluffs are composed of alluvial and freshwater deposits, we may suppose that they were once overflowed by the river, at a time when the relative level of the Mississippi was very different. During the upheaval of the country, the river may have gradually carried away by denudation large portions of the loam, reducing the alluvial plain to its present level, and leaving bluffs bounding the region from which a large quantity of matter has been removed. Mr. Lyell appears to be of opinion that, in modern times, the levels of the great plain of the Mississippi have been chiefly altered by movements of subsidence, such as those which in 1811–12 gave rise to new lakes and what is called "the sunk country" near New Madrid in Missouri. That it was subsidence rather than upheaval is, he thinks, "established by the fact, that there are no protuberances of upraised alluvial soil projecting above the level surface of the great plain. It

* Newbold, Geol. Proceedings, vol. iii. p. 783.
† Leçons de Géologie Pratique, tome i. p. 476.
‡ Principles of Geology, 7th edit. page 216.
§ Ibid. page 214.

is true that the gradual elevation of that plain by new accessions of matter, would tend to efface every inequality derived from this source; but we might certainly have expected to find more broken ground between the opposite bluffs, had local upthrows of alluvial strata been of repeated occurrence*."

Of the depth of the alluvial deposits spread over this vast region we as yet know little. Mr. Lyell was informed by several engineers that borings 600 feet deep were made near Lake Pontchartrain, north of New Orleans, in which the bottom of the alluvial matter is said not to have been reached. It is possible that the upper part of the plain may have been formed by the gradual raising of the river's bed by accumulating detrital matter, as that of the Po and other rivers has been; but it is probable, I think, that the greater part has been formed by the discharge of the alluvial matter into the sea, at the mouth of the river, together with deposits on each side when the stream, swollen by floods, periodically overflowed its banks: that at one time this basin of the Mississippi was an arm of the sea, penetrating into the land, which has been gradually filled up, the mouth of the river advancing as the accumulation went on, to its present position. If the alluvial matter be of such vast thickness, as the sinkings at Lake Pontchartrain seem to indicate, I do not see how it could have been accumulated in any other way, unless indeed we suppose an uninterrupted slow subsidence of the valley for a vast period of time. This supposed bay or deep inlet may have been of considerable depth throughout its whole length, or it may have had a bottom gradually shallowing northward; and the nature of the bottom, whether deep or shelving, would of course determine the amount of thickness of the accumulating matter, and the rate of advancement of the mouth of the river southward. As a basis for calculating the time that may have elapsed since the alluvial plain began to be formed, Mr. Lyell assumes that the newly deposited soil has a depth over the whole area of the delta, comprising 13,600 square miles, equal to that which has been penetrated vertically north of New Orleans, or 600 feet; that is, similar to the average depth which has been ascertained to prevail in the waters of the Gulf of Mexico, between the southern point of Florida and the Balize, or mouths of the Mississippi; but for the sake of facility of calculation, he assumes it to be one-tenth of an English mile, or 528 feet.

From experiments made by Dr. Riddell of New Orleans, Mr. Forshey, and Dr. Carpenter, on the mean annual solid contents suspended in the water of the Mississippi, and from observations on its mean width, depth and velocity, and thence the mean annual discharge of water, the number of cubic feet of solid matter annually brought down by the river has been estimated; that is, the finer matter only, that which is suspended, and not taking into account the coarser materials, which, throughout the delta and over a great part of the plain above, from its very slight inclination, would probably amount to very little. The estimated annual quantity being spread over the computed area of the delta, that is, 13,600 square

* Ibid. page 216.

miles, would be of such a thickness, that to accumulate it to a depth of one-tenth of a mile, a period of 67,000 years must have elapsed; and supposing the alluvial matter in the plain above the delta to have only one-half the above-estimated depth, and to be only of the same area as the delta (although it is somewhat greater), and that the solid contents of the year were spread over the united area, a period of 100,500 years would be required for the formation of the whole plain. The proportion of the thickness that would be derived from the coarser unsuspended materials and the drift wood, vast in amount as the latter is every year, Mr. Lyell holds to be more than compensated in the calculation, by the quantity of suspended matter which would not fall down before the river-water was carried far out to sea. The depth of the alluvial soil above the head of the delta is, in the absence of borings, estimated from this, that the river is continually shifting its course in the great plain, cutting frequently to the depth of 100, and sometimes to the depth of 250 feet.

This calculation can only be considered as a first attempt to give an approximate numerical value to a part of one of the periods in geological chronology, and that period the most modern in the series. Throughout the whole range of geological changes, from the lowest sedimentary stratum to that of deposits within the historical time, an attentive study of the phænomena of each impresses us with a conviction, almost amounting to a demonstrated truth, that a vast lapse of time is indicated by each great successive change—periods however to which we can assign no definite amount, from the absence of the necessary data by which we can obtain an unit. But if a geological change be in progress in our own time, such as the deposit of an alluvial soil by a river, and we are able to estimate the amount, say one foot in thickness, between two fixed periods A and B, B being the earlier period, if the total deposit be 50 feet thick, and be of an uniform composition and character throughout, it is fair to infer that each of the 49 feet below B must have required the same time for its deposition as that between A and B; unless it can be shown that there are circumstances which would cause an acceleration or a retardation of the process. If, as in Egypt, there were in the valley of the Mississippi monuments of human art of remote antiquity, the age of which was pretty accurately known, round which the alluvial matter was accumulated, the monuments resting on a soil of the same nature, we should have a better measure, a standard scale of some accuracy, to begin with; and if we had sections or borings at various points in the valley, by which we could ascertain the depth and nature of the alluvial deposit, and whether the bottom of the valley was level or sloped gradually from the Gulf of Mexico to the head of the plain, we should be able to form a tolerably correct estimate. As it is, the above calculation can only be considered as a reasonable deduction from the limited data we have yet obtained; and it will no doubt serve as a stimulus to future observers to collect materials for the working out of a problem so interesting and important, not only in the valley of the Mississippi, but in other localities favourable for such inquiries.

Mr. Lyell, in his 'Travels in North America,' published within the period of the review I am now taking, has given us another measure of time, also within the most modern period of geological chronology, in his observations on the recession of the Falls of Niagara, by the slow but incessant action of the water on the rocks over which it flows. The order of succession, and the geological age and position of these rocks have been ably described and illustrated by Mr. James Hall in his 'State Survey of New York,' to the accuracy of which descriptions Mr. Lyell has borne testimony. As the strata are various in their nature and hardness, there must have been a great inequality in the rate of wear at different parts; and not from that cause alone, but also from the inclined position of the strata. From the observations that have been made as to the amount of waste within a known period, Mr. Lyell is inclined to think that a foot a year would be the most probable rate, if the retrograde movement could be assumed to have been gradual. From the causes above stated, it would probably be sometimes slow and sometimes rapid; but if we take a foot for the mean annual waste, as the length of the ravine, which has been demonstrably worn by the river, from Queenstown to the present position of the Falls, is seven miles, 36,960 years must have elapsed between the present time and the period when the Niagara formed a cataract over a precipice at Queenstown. Many of the species of fluviatile and terrestrial testacea now living in that region must have been created before that period, for Mr. Lyell has shown, and he was the first to collect the evidence of the fact and to appreciate its importance, that before the river began to cut out the ravine, it must have flowed over a plain of alluvial soil in which the remains of existing land and river shells had been deposited, the remains of its former banks having been discovered by him on both sides, at the top of the cliffs which now bound the river course.

In the recently published work on Lycia by Lieut. Spratt and Professor Forbes, the latter gives a chapter on the geological structure of that part of Asia Minor, which contains some interesting facts relating to changes now in progress. The land has been subject to elevations and depressions, not only in very modern geological times, but even within a period not very remote in the historical epoch. A sarcophagus stands in the water in the Bay of Macri, the site of the ancient Telmessus, which is bored by marine animals to a third of its height, indicating a subsidence and subsequent rising of the land, like that on which the ruins of the temple of Jupiter Serapis stand, in the Bay of Naples, but with this difference in the circumstances of the two cases, that there are no volcanic foci known to have been in activity in the historic æra in that part of Asia, none nearer than the island of Santorin in the Archipelago, a distance of nearly 200 miles westward; but earthquakes almost annually convulse the country.

The port of the ancient city of Patara is closed up by accumulations of sand, and Cannus, which was a seaport in the time of Strabo, is now two miles inland, and its harbour is a freshwater lake, from whence the waters have a fall to the sea.

A great part of the plain of Pamphylia is composed of modern travertine, beds of which are forming at the present time, from the prevalence of springs loaded with carbonate of lime held in solution by carbonic acid, as is common in countries bordering on volcanic regions. This travertine, where it reaches the coast, forms cliffs from 20 to 80 feet high, and at various distances inland there is a repetition of heights resembling the line of cliffs. Along the shores of Lycia there is an extensive formation, now in progress, of a conglomerate composed of water-worn pebbles, interstratified with beds of mud and sand, cemented into a hard rock by calcareous infiltrations, but yet so preserving the external appearance of a shingly beach, that boats are in danger of striking against a rock, where those unacquainted with the coast are expecting to run them up on a loose yielding bed.

By the blocking up of the mouths of some of the rivers, by shifting sands, lagoons and marshes are formed; the water is at first salt, but if the barrier endures long enough, it becomes fresh, and is peopled with freshwater mollusca. Thus at Macri, where such changes have taken place within the historical period, as already stated, lagoons of this kind are filled with myriads of the *Cerithium mammillatum,* a mollusk capable of enduring great changes in the quality of its native element. These alternations of salt, brackish and fresh water, must produce deposits with corresponding changes of character, so that, as Mr. Forbes observes, a section of the plain would doubtless show many alternations of such strata; and he adds this important remark:—"The history of life upon our globe, the in-coming of new species and the perishing of old ones, is only the history of elevations, depressions, and temporary conditions, varied by an occasional convulsion, differing only in degree from those which have determined the zoo-geological features of the coast of Lycia."

A case analogous to such modern formations is described by Mr. Forbes as occurring in the older pliocene freshwater beds in the island of Cos, and which exhibits a phænomenon of great importance in palæontology, one particularly instructive to those who have a tendency to multiply species on insufficient grounds:—"The freshwater beds in Cos contain mollusca of the genera *Paludina, Melanopsis,* and *Neritina,* distributed in three distinct horizons, throughout the vertical thickness of the stratum, each horizon in the series being characterized by a peculiar form of Paludina and of Neritina, not present in the other two; and in the two lower horizons there are two species of Melanopsis peculiar to each. They have the appearance of very distinct well-marked species, but on careful examination it is evident that they are of the same species, presenting varieties caused by the animals having lived in alternations of fresh and salt water." He then enters into a minute explanation of the operation of these changes of condition, and thus concludes:—"Such an explanation is consistent with what we now know of the modes of variation among freshwater mollusca, which, at first glance, appeared to afford strong support to the notion of a transmutation of species in time."

When certain peculiar marks on the surface of slabs of new-red-sandstone were held by Dr. Buckland to be the scattered irregular inequalities raised by the pelting of a shower of rain on a surface of yielding argillaceous sand, his theory was received with no small incredulity; and some smiled at what they held to be an overstraining of his known ingenious fertility in applying ordinary occurrences in the explanation of geological phænomena. But the sagacity and soundness of his theory of these appearances has now been generally admitted. Mr. Lyell not only observed similar impressions of rain-drops on the surface of beds of new-red-sandstone in New Jersey, but he saw them recently formed on a deposit of red mud, thrown down at the mouth of the river Patapsco near Baltimore, of which he was able to bring away some consolidated layers; and he says that, in addition to the smaller cavities due to rain, there are larger ones, on these layers, more perfectly circular, about the size of large currants, which have been formed by air-bubbles in the mud. On the shore of the Bay of Fundy he found that the upper part of the mud had been baked hard by a hot summer sun, to a depth of several inches, and in its consolidated state exactly resembled, both in colour and appearance, some of the red marls of the new-red-sandstone formation of Europe. In some places it was pitted over with small cavities, which he was told were formed by a shower of rain which had fallen eight or ten days before, when the mud was still soft. In like manner he observed the impressions of footmarks which have been met with in several situations in Britain, in Germany, and in Connecticut in North America, illustrated by the same muddy shore of the Bay of Fundy. "I observed," he says, "many worm-like tracks, made by Annelides which burrow in the mud; and, what was still more interesting to me, the distinct footmarks of birds in regular sequence, faithfully representing in their general appearance the smaller class of ornithichnites of high antiquity in the valley of the Connecticut before described*." He ascertained that the markings were the recent footprints of a Sandpiper (*Tringa minuta*), and he was able to bring away two slabs of the hardened mud with these impressions, which he has deposited in the British Museum. What was highly important, as showing the identity of origin of these recent footmarks with that of the impressions on the ancient sandstones, he ascertained that similar footprints existed in inferior laminæ of the hardened mud. He also observed instances of those ramifying elevations on the surface of slabs, of which we had last year a description and drawing by Dr. Black, in the account he gave us of a very fine specimen from Cheshire, in the Museum of the Manchester Geological Society, accompanied in that specimen by numerous footprints; the casts of old cracks standing out in relief. On the shore of Georgia he observed footmarks in progress of preservation; they had been left by racoons and opossums on the sand during the four hours immediately preceding, and were already half filled with fine blown sand; showing the process by which distinct casts of the footsteps of animals have been formed on a stratum of quartzose sandstone.

* Travels in North America, vol. ii. p. 168.

In my address last year I referred to the instances given by Mr. Darwin of an elevation of the land on the western coast of South America. Those referred to had occurred after the creation of species of mollusca now living in that region, but they do not afford any evidence of belonging to the recent period, but must be referred to the pleistocene epoch, and as such I shall have occasion to speak of them in an after-part of the present Address. In the work recently published by Mr. Darwin, he gives a detailed description of several instances of elevations that have taken place in recent times, presenting the same characters as those of earlier date; and expresses his opinion that this movement of the land, although subject to intervals of rest, is now, as it has been at all former periods of geological time, one of the main causes of the revolutions to which the surface of the earth is unceasingly subject. "The time, I believe, will come," he says, "when geologists will consider it as improbable that the land should have retained the same level during a whole geological period, as that the atmosphere should have remained absolutely calm during an entire season*."

The island of San Lorenzo near Lima is upwards of 1000 feet high, and in one part of it there is a ledge of rock, containing an accumulation of recent shells two feet in thickness, and above a mile in length; the highest part of which is 85 feet above high-water mark, the shells being in nearly the same proportional numbers with those on the existing beach. Several of the univalves have evidently lain long at the bottom of the sea, for their insides were incrusted with balani and serpulæ. In the midst of these shells Mr. Darwin found a piece of woven rushes, and another of nearly decayed cotton string, undistinguishable from similar things found in the burial-grounds of the ancient Peruvians. These discoveries, and the whole appearance of the bed of shells, seemed to him to render it almost certain that they were accumulated on a true beach, since upraised 85 feet, after the Indians inhabited Peru. The island of Lemus, in the Chonos Archipelago, was suddenly elevated by an earthquake in 1839. An English resident stated to him that a part of the island of Chiloe had been raised four feet in four years, and that the change had been gradual. The island of Mocha, 70 miles north of Valdivia, was uplifted two feet during an earthquake in 1835. At Valparaiso, between the years 1614 and 1834, there had been a rise of the land of 19½ feet, of which between 10 and 11 appeared to have been subsequent to 1817. The elevation had been by insensible degrees, with the exception of the year 1822, when the great and celebrated earthquake of that year raised the land suddenly three feet over a considerable extent, and a slow rise of the land is considered by residents there to be now in progress. There is also evidence of subsidence on parts of the coast for some distance south and north of Callao.

Few countries present on so great a scale the operations of atmospheric agency in disintegrating and transporting the materials of the land as Central Russia does. The inferior solid rocky structure of the country, as we learn from the recent work of Sir R. Murchison, is seldom

* Page 26.

exposed; the surface, to a considerable depth, being composed of clay, sand, gravel and boulders. These, over great tracts, are the detrital matter that was accumulated on the then sea-bottom, during the glacial period, the period of the northern drift. Where there are elevated plateaux of these incoherent materials, the ground, during the excessive heat and drought of summer, splits into vast cracks, which often reach a great depth. These, in winter, are filled by accumulations of snow and ice; the thaw of the spring loosens the earthy matter, and a gulley is formed, which widens as it approaches the steep sides of the plateaux, and in the course of a few seasons becomes a broad and deep ravine, through which melted snow, mud and sand, and occasional blocks and boulders, are transported into an adjacent river. These ravines are of such frequent occurrence over large tracts of country, that the quantity of matter carried into the streams must be enormous; this is afterwards transported to lower levels, or to the distant embouchures of the larger rivers, to form the rapidly increasing delta of the Volga, or to silt up the Sea of Azof by the settlements from the muddy waters of the Don. In the spring, large portions of the surface in Russia are covered by water, from the melting of the snow, the higher lands emerging like isles or promontories; "and when it is considered," says Sir R. Murchison, "that such enormous volumes of water have for ages flowed off to the sea through deposits, for the most part incoherent, we can well account for the increase of the deltas within the historic period, at the mouths of all the chief or south-flowing rivers. So great indeed must have been the increment of matter in the Caspian, the Black Sea, and the Sea of Azof, that we must not be surprised to find very essential distinctions between the features of the present lands near the mouths of such rivers, and those which prevailed during the earlier days of their occupancy by man. Thus, freshwater shells common in the Volga have been found at about 300 feet below the city of Astrakhan, which is built upon the mud of that river. By its daily-increasing delta, the Caspian is constantly encroached upon and diminished in area, the shallow water already extending to 40 and 50 miles south of the present embouchure*."

It is interesting thus to trace the progress of change which the solid materials of the globe are destined to undergo, in that vast cycle of decay and renovation which we know from irresistible evidence to have been in progress during all geological periods, and which, if we are to speculate on the future by what we have learned by the past, and by what is going on under our own observation, is likely to continue. Granite pinnacles, upheaved in Scandinavia, were in distant ages split and shivered into fragments by the expansive power of freezing water; and these fragments, collected in moraines, were pushed along by the downward movements of glaciers, and at length reached the sea of the glacial period; at a time when Central Russia was submerged, as we know from very clear proofs, to a depth of at least a thousand feet†. By the transporting powers of water and ice, these fragments of Scandinavian rocks were spread over the sea-bottom, hundreds of miles

* Murchison's Russia, p. 572.

† See my Anniversary Address of 1846, p. 60.

southward. In process of time that sea-bottom, thus formed to a great depth of clay, sand, gravel and boulders, was elevated to the surface, level or unequal according as the elevating force acted with uniform or variable intensity, and formed the land of Central Russia. The incoherent materials, after a long period of repose in the new-formed land, are again subjected to atmospheric agency, broken into smaller fragments or worn down into impalpable mud, to be suspended in water and floated to the mouth of the Volga, or to settle at the bottom of the Caspian in a stratified deposit. There they form a new ground on which mollusca live, whose shells will become buried in the slowly forming stone; and this stone covering a region where we know internal heat to be active, may become metamorphic, and assume a compact or crystalline structure. Thus the same matter which was once a constituent of a granite in the Alps of Scandinavia, after undergoing numberless changes in form and structure, through an incalculable period of time, changes however identical with those which we now see in progress, may be hereafter raised up in Asia as the elements of a schistose rock; in like manner as our oldest sedimentary strata must have been derived from the disintegration of pre-existent granites, or other forms of unstratified rock, of which the land was then composed.

You may probably recollect having read, in the newspapers of the autumn of 1845, an account of a quantity of dust having fallen from the atmosphere on the Orkney Islands; it was also said to have fallen to the thickness of an inch on ships in that part of the North Sea. It was supposed to indicate a volcanic eruption of ashes in Iceland; and the conjecture was proved to be correct; for, on the 2nd of September of that year, the great volcanic mountain of Hecla, after a repose of nearly 80 years, again burst forth. On the same day, a quantity of dust fell on a Danish ship in lat. 61° N., and longitude 7° 58′ W. of Greenwich. It blew at the time strong from the N.W. by W. From this point Hecla is 533 miles distant.

We learn from the work of Mr. Ebenezer Henderson*, that between the years 1004, the earliest record, and 1768 inclusive, there had been 23 eruptions, the intervals varying from 6 to 76 years. Sir W. Hooker in his work on Iceland, writing in 1810, says that the last eruption of lava was in 1766, and that it lasted from the 15th of April to the 7th of September, but that flames unattended with lava appeared in 1771 and 1772, since which period neither fire nor smoke had appeared. Sir George Mackenzie, however, describing his ascent of Hecla in 1810, states that on removing some of the slags at the summit, those below were too hot to be handled, and on placing a thermometer among them it rose to 144°†.

Since the eruption in 1845, the island has been visited by French and German geologists, and we shall no doubt receive ere long a detailed account of their observations. On the 26th of October last, M. Dufrenoy laid before the Academy of Sciences at Paris a letter he had received from M. Descloizeaux, who in company with M. Bunsen had visited Hecla last summer. He mentions a change in the height

* Journal of a Residence in Iceland.

† Travels, p. 248.

of the mountain, which seems to indicate a falling in of a portion of the summit. The mountain, he says, is a very regular cone, with a slope of from 25 to 30 degrees; the height of the loftiest part they estimated by barometric measurement at 1400 metres (4593 English feet), but this he says is 157 metres (515 feet) less than former trigonometrical measurements; and although, from some defects in their means of observation, he considers 1400 metres only as an approximate height, he does not think that the error, if there is one, can have amounted to so much as 157, and that therefore there has been a considerable breaking down of the sides of the crater. Sir George Mackenzie describes "the middle peak" of Hecla as forming one side of a hollow, evidently a crater; adding that the whole summit is a ridge of slags, and that the hollows on each side appear to have been so many different vents from which the eruptions have from time to time issued, but that they saw no indications that lava had flowed from the upper part of the mountain*. According to M. Descloizeaux, the crater at the summit is almost circular, with an external talus of scoriæ, having an inclination of from 33 to 35 degrees; thus it is evident the form has changed since the visit of Sir George Mackenzie and his companions, Dr. Holland and Dr. Bright, and it is probable that the higher sides have fallen in, thus accounting for the diminution of height. The exterior part of the cone M. Descloizeaux describes as traversed by fissures containing fumeroles which deposit sulphur; and as the bottom of the crater was covered with *old* snow, it was clear that the eruption of 1845 was not from the main crater, but, like the more recent ones of Etna, from the side of the mountain. On one side M. Descloizeaux observed two craters connected by a very narrow ledge, one of them 600 feet in diameter, and the other half that dimension. He does not give the height from which the eruption took place, but describes the stream of lava that was poured forth to have been directed W.S.W. From the place where it burst forth, to its termination in the plain below, he estimates its length to be 16 kilometres, which is nearly equal to 10 English miles; its greatest breadth at 2 kilometres (about $1\frac{1}{4}$ mile); and its thickness ranges, he says, from 15 to 25 metres; that is, from 49 to 82 feet. This is an enormous mass, but it is insignificant in comparison with that which flowed from the neighbouring mountain of Skaptár Jokul in 1783; there were then two streams, one 50 miles in length, with a breadth of from 12 to 15 miles, the other 40 miles long and 7 miles broad, both 100 feet in thickness†. But in regard to this stream of 1845, there is an important fact communicated by M. Descloizeaux, viz. that they found the inclination of the stream very variable throughout, "from 0 degree to 25°"—an observation of great interest as regards the theory of the formation of volcanic mountains. He further describes its structure as follows:—"The stream is in no part homogeneous; it consists throughout of isolated blocks, often of very considerable volume, accumulated with a certain degree of symmetry, the congeries resembling an immense ribbon, at the edges of which is a talus, with an inclination between 35 and 40 degrees; and the interior

* Id. page 248.

† Lyell's Principles of Geology, 7th Ed. p. 408.

exhibits a multitude of small longitudinal and parallel ravines, having often a depth of 5 or 6 metres ($16\frac{1}{4}$ to $19\frac{1}{2}$ feet). The centre of the stream still, in July 1846, contained numerous fumeroles in which were beautiful transparent crystals of muriate of ammonia, and large fibrous masses of the same salt, together with a vast quantity of muriate of iron." The rugged surface here described is, as you are aware, a very usual accompaniment of lava streams, arising from the cooling and subsequent cracking by the heat of the inferior fluid mass, and beneath this fissured crust there might be a continuous stream of homogeneous lava, which in cooling would become columnar, and a cross section of the stream would in that case probably exhibit a mass of basaltic pillars, capped by an amorphous layer, and that surmounted by a congeries of blocks, the fissured surface of the stream, just as we see numerous instances in Auvergne, and in many districts where the older trap rocks have flowed in broad streams. M. Elie de Beaumont, in his very elaborate and interesting researches on the structure and origin of Etna, maintains that, in accordance with M. Von Buch's theory of craters of elevation, the beds composing the nucleus of the central mass of Etna have been raised to their present inclination, from a position approaching nearly to horizontality; and appears to be of opinion that no homogeneous stream of lava could consolidate into stone on a surface having an inclination of more than 7 or 8 degrees*. M. Descloizeaux states, as already mentioned, that in some places the stream from Hecla has an inclination of as much as 25 degrees; but if the parts so inclined are composed only of blocks and scoriæ, if underneath there be not a bed of homogeneous lava, that amount of inclination would not be opposed to the theory of M. Elie de Beaumont. We must hope that the detailed descriptions of the French and German observers will throw much light on the structure of this vast expansion of melted stone. I understand that M. Waltershausen is one of those who went from Germany, and his seven years' study of Etna renders him peculiarly qualified to describe the phænomena and compare them with those with which he is so well acquainted.

In the Proceedings of the Royal Academy of Berlin for December 1845, there is an account of a paper read by Professor Ehrenberg, containing the result of a microscopic examination of the dust that fell on the Danish vessel; and in the Proceedings for May last there is a supplement to that paper, describing his examination of some ashes that had been erupted from Hecla on the day above-mentioned. Translations of these notices are given in the last number of the Quarterly Journal of this Society. In these notices, Professor Ehrenberg identifies the dust that fell on the ship with the ashes erupted from Hecla, and they afford another instance of that very remarkable fact, previously made known to us by the same philosopher, viz. the presence of the siliceous shells of infusoria in ashes ejected from volcanos in many different countries. He found thirty-seven different species of these minute organisms, not one of them decidedly new, and all of them peculiar to fresh water. Fifteen are living forms known to exist at present in Iceland.

* Description Géologique de la France, tome iv. p. 176.

There are two obvious conjectures as to their origin: the one is, that surface waters may percolate deep into the earth and penetrate to the volcanic focus, and we know from the celebrated case in South America mentioned by Humboldt, that large masses of subterranean fresh water have been brought within the reach of volcanic force; and the mud, or Moya, which was thrown up from the interior of the earth during the earthquake of Riobamba in 1797, contained siliceous shells of infusoria. The other conjecture is, that old sedimentary beds, containing infusorial remains, lying within the reach of the volcanic force, may have been shivered to atoms, and blown out at the orifice. We know that the shells of species of infusoria that cannot be distinguished from those now living have been found in sedimentary deposits of very old date; and Ehrenberg informs us that infusorial remains have been found in beds of the coal-formation near Dresden.

M. Flourens communicated to the Academy of Sciences on the 16th of November the results of some observations of MM. Descloizeaux and Bunsen last July, on the intermittent boiling springs of the Geyser and *Strockr**, the latter being within 140 yards of the Great Geyser†. The observations were on the temperature of the water, in the great column or well of each, made by suspending thermometers at different depths, at different times before and after eruptions. The Great Geyser has a depth of 22 metres (72 feet), and the experiments showed that the temperature of the column diminished gradually from the bottom upwards, and that the maximum temperature at the bottom before a great eruption was 127°·6 Centigrade (260°½ Fahr.), and the minimum 122° (251°½ Fahr.) after an eruption. The temperature of the water at the surface was 85°·2 (185° Fahr.), when that at the bottom was 127°.

After an eruption, the lowest thermometer stood at 121°·6 (251° Fahr.); nine hours afterwards at 123°·6 (254½° Fahr.). Between 11 o'clock A.M. of the 6th July and 2·55 P.M. of the 7th, there was no eruption, so that there had been an interval of nearly twenty-eight hours; and the water at the latter time, at the bottom, was 127°·6 (261½° Fahr.); a quarter of an hour afterwards there was a slight eruption.

The Strockr is a circular well 44½ feet deep, with an orifice of about 8 feet which rapidly diminishes downwards, and at about 27¼ feet from the surface the orifice is only 10¼ inches. The column of water between the eruptions has a mean depth of 27½ feet, so that its surface, which is in a constant state of ebullition, is generally from 10 to 13 feet below the surface of the ground. The temperature of the water at the bottom varied from 112°·9 to 114°·2 (235° to 237½° Fahr.), and the same temperature continued throughout a depth of about 20 feet, when it began to sink, and at the surface of the water the thermometer stood at 100° (212° Fahr.).

* It is called Strokkus in the Comptes Rendus, but Henderson calls it Strockr, and says the name is derived from the verb "strocka," to agitate, or bring into motion.

† Henderson's Iceland, page 69.

These observations on the temperature of the water are highly curious and important. We have a temperature of 261° of Fahr. at the bottom of a free open column of water, in which thermometers could be suspended on a line dropped from the surface, while it might have been expected that as soon as a film of water at the bottom was raised to a higher temperature, it would ascend, and be replaced by a colder and heavier film, and that thus a constant current would be established throughout the column, until the whole arrived at a temperature of 212°, when ebullition would commence and continue. The pressure of the column of water may perhaps account for the high temperature at the bottom, especially if the free circulation be impeded by the sides of the well not being vertical, and still more by projections in the sides causing contractions of its diameter. But the experiments of M. Donny of the University of Ghent, published in the 17th volume of the Memoirs of the Royal Academy of Sciences and Belles Lettres of Brussels, on the Cohesion of Liquids, may perhaps be considered as throwing some light on this phænomenon of the Geyser. By a series of carefully conducted experiments M. Donny has shown :—

1. That the constancy of the boiling point of water, under the ordinary atmospheric pressure, depends upon its containing a considerable quantity of air;

2. That there is a marked difference between the boiling point of water containing air, and of water freed from air;

3. That a small quantity of air, dissolved in water, is sufficient to attenuate greatly *the cohesion existing between the molecules of the water*;

4. That when water is freed from air, as far as that is possible, the cohesion of the molecules is so increased, that a higher temperature is necessary to overcome it, and that the boiling point is very considerably raised.

M. Donny succeeded in raising the temperature of water so freed of air to 135° Centigrade (equal to 275° of Fahr.), under the ordinary atmospheric pressure, without its exhibiting any symptom of ebullition; showing, that the cohesion of the molecules was nearly equal to the pressure of three atmospheres on water containing air. This is a fact most important to bear in mind in reasoning upon many geological phænomena, particularly those connected with the solution of silica.

The further researches of M. Donny, recorded in the same memoir, appear also to offer an explanation of the violent and intermittent eruptions of the Geyser; for he states that if water deprived of air be exposed to so considerable an increase of temperature as to overcome the force of the cohesion of the molecules, the production of vapour is so instantaneous and so considerable as to cause an explosion. As water long boiled becomes more and more deprived of its air, M. Donny attributes the sudden bursting of the boilers of steam-engines to the same cause.

The Pleistocene (Newer Pliocene) Period.

The Essay of Professor Edward Forbes in the first volume of the Memoirs of the Geological Survey of Great Britain, "On the connexion between the distribution of the existing Fauna and Flora of the British Isles, and the Geological Changes which have affected their area, especially during the epoch of the Northern Drift," is an admirable example of the light to be derived from other branches of natural history in the prosecution of geological inquiries, of the application of animal and vegetable physiology, and a knowledge of the habits and distribution of animals and plants, to the elucidation of very difficult problems in Geology. The memoir is so interesting and attractive throughout, so suggestive of great views, that I am tempted to dwell upon it at some length.

The principal theory which it is the object of this essay to establish is based on the assumption of the existence of *specific centres*, that is, of certain geographical points from which the individuals of each species have been diffused; and their consequent descent from a single progenitor, or from two, according as the sexes might be united or distinct. The author further declares, as his opinion, that "the abandonment of this doctrine would place in a very dubious position all evidence the palæontologist could offer to the geologist, towards the comparison and identification of strata, and the determination of the epoch of their formation." Having assumed the doctrine of specific centres as true, the problem he proposes to solve is, *the origin of the assemblages of the animals and plants now inhabiting the British Islands.* The enumeration of the species and the distribution of our indigenous animals and plants, according to our author, have been worked out by the united labours of many British naturalists, more completely perhaps than those of any other country; but he considers that the history of their respective birth-places or origin is still to be made out. Within the limited area of the British Isles, there are a great number of animals and plants which are not universally dispersed, but are congregated in such a way as to form distinct regions or provinces, which have remained unchanged as long as there are any records. The vegetation presents five well-marked Floras, four of which are restricted to definite provinces, whilst the fifth, besides exclusively claiming a part of the area, overspreads and commingles with all the others.

The author is of opinion that there are only three modes in which an isolated area may become peopled by animals and plants: 1st, by special creation within that area; and there is every reason to believe that that mode had but little influence in determining the vegetation and animal population of the British Isles: 2ndly, by transport to it; and for many reasons he considers that to be an insufficient mode: and 3rdly, *by migration* before the isolation of the area; and this last he believes to have been the mode by which the British Isles have chiefly acquired their existing flora and fauna, terrestrial and marine, and that it took place subsequently to the Miocene epoch. I shall first shortly describe the *Five Floras.*

I. The West Irish Flora.—The mountainous districts of the west and south-west of Ireland are characterized by botanical peculiarities, which depend on the presence of a few prolific species of the families *Saxifrageæ*, *Ericaceæ*, *Lentibulariæ*, and *Cruciferæ*, the high lands in the north of Spain being the nearest point on the Continent where these plants are native, especially in the mountains of the Asturias, and the species are all members of families having seeds not well adapted for being wafted through the air across the sea.

II. The Devon Flora.—In the south-east of Ireland and south-west of England, there is a flora which includes a number of species not elsewhere seen in the British Isles, and which is intimately related to that of the Channel Islands and the neighbouring parts of France; and in the Channel Islands they are associated with a number of plants which are not natives of England or Ireland. In the south-east of Ireland, the number of plants of this Gallican type is greatly diminished, while such as are present are species met with also in the south-west of England. This second flora is accompanied by terrestrial mollusca of the same climatal stamp.

III. The Kentish Flora.—In the south-east of England, the vegetation is distinguished by the presence of a number of species common to this district and the opposite coast of France; and the peculiar character of the entomology and that of the pulmoniferous mollusca, including several species, are intimately connected with this flora. It is evidently derived from the north-western provinces of France.

IV. The Alpine Flora.—The summits of our lofty mountains yield a variety of plants not found elsewhere in the British Islands; the species of them are most numerous on the Scotch mountains; they are comparatively rare on those of Cumberland and Wales, diminishing progressively southwards. These alpine plants are all identical with the plants of more northern ranges, as the Scandinavian Alps, where however there are species associated with them which have not been found in the British Islands. In Ireland also, a few of these alpine or sub-alpine plants of Scandinavian origin are found. The fauna of our mountain regions, so far as it is developed, bears the same relation to more northern countries, and the absence of peculiar pulmonifera is as good evidence, in the opinion of our author, as the presence of Scandinavian forms of insects.

V. The General Flora.—This is everywhere present, alone, or in company with the others—is identical as to species with the flora of Central and Western Europe, and may be properly styled *Germanic*. " Every plant universally distributed in these islands is Germanic; every quadruped common in England, and not ranging to Ireland or Scotland. The great mass of our pulmoniferous mollusca have also come from the same quarter. Certain botanical and zoological peculiarities are presented by the eastern counties of England. In every case we find these to depend on Germanic plants and animals arrested in their range. The number of species of the Germanic type diminishes as we go westwards, and increases when we cross the German Ocean. On the other hand, the peculiarities of the Irish and Scottish faunas and floras depend either on the presence of animals and plants which are not of the Germanic type, or on the absence of English species, which are." There are some species of plants which seem to indicate a derivation from a more northern point in the Germanic region, than that from whence the main parts of the assemblage came.—In describing these five floras, of which the above is a general outline, the author enumerates an extensive series of instances of species in support of his views.

It thus appears, that the chief part, at least, of the British flora has migrated hither from various regions of the continent of Europe nearest to our shores, extending from Scandinavia to Spain; in other words, that, long after the organisms now constituting the living flora and fauna of these islands were called into existence, Great Britain and Ireland were a part of the continent of Europe. The identity of structure of France and England at the Straits of Dover, and for a considerable distance westward, has long been admitted by geologists to be a proof of the former continuity of the two countries, and the remarkable similarity in the structure of the land on both sides of the more western parts of the English Channel leads to a similar conclusion, viz. that France and England were formerly one country, as far west as the extremity of Cornwall. This is rendered more than probable by the evidence of mineral structure, and Professor Forbes, in this essay, confirms that view by botanical and zoological testimony; not however as regards France only, for he stretches the once continuous land so much further west as to unite Ireland with Spain.

We have now to consider the great and important changes in the configuration of the western shores of Northern Europe, at several distant and successive epochs, which this examination of our flora and fauna leads us to infer, and with a high degree of probability. These changes, involving repeated disruptions, subsidences, and elevations of the land, constitute the more strictly geological parts of this essay, and as such I will dwell upon them more fully. And first, with regard to the period within which these events took place.

The creation of the progenitors of the existing flora and fauna of these islands must have taken place, according to our author, subsequently to the close of the Eocene epoch of the tertiary series, and before the commencement of the historical period, or that during which man has been a known inhabitant of the earth. There is abundant evidence, he thinks, that both the flora and fauna of such parts of these islands as were above water during the Eocene period, must have had a climate far warmer than is suitable to their present terrestrial inhabitants; and the great deposits of peat, formed in part of the remains of vast forests, which probably, during the earliest stages of the true historical epoch, covered a great part of the existing area of the British Isles in many places, overlie *fresh-water* marls of the post-tertiary epoch, occupying depressions in pleistocene marine deposits; and he goes on to prove that it was during the post-tertiary epoch that the migration of *the general* *flora*, that is, the most modern of the five floras, must have taken place.

I shall now endeavour to trace, in succession, the alterations in the configuration of the land connected with each of the distinct floras; geological changes, be it remembered, of a very modern date in comparison with the elevations, subsidences, fractures and contortions which produced the phænomena exhibited by the older formations.

The First, or West Irish Flora.—The author believes that during the deposition of the Miocene tertiaries, a sea, probably shallow, inhabited by an assemblage, almost uniform, of marine animals, extended throughout the Mediterranean region, across the south of France, along the west of Spain, and stretched beyond the Azores. He founds this belief on the uniform zoological character of this sea, from personal examination of Miocene fossils. He believes, that at the close of the period, the whole of the bed of this Miocene sea was pretty uniformly elevated in the region of the Central Mediterranean and West of Europe. He then enunciates a new and somewhat startling opinion, viz. that "a great Miocene land,*" bearing the peculiar flora and fauna of the type now known as Mediterranean, extended far into the Atlantic, past the Azores; and calling up botanical evidence in support of his views, he states that the western boundary of this land, formed by deposits in the sea during the Miocene period, but then an upheaved continent, is now marked by the great semicircular belt of Gulf-weed, ranging between the 15th and 45th degrees of north latitude, and constant in its place. He adduces in support of this bold hypothesis, the testimony of Dr. Harvey (whom he designates as one of the first of living authorities in marine botany) as to the nature of the Gulf-weed, the *Sargassum bacciferum*, who considers it an abnormal variety of the *Sargassum vulgare*, an opinion assented to by Dr. Joseph Hooker, who has had great opportunities of studying the Gulf-weed. Now the *Sargassum vulgare*, Professor Forbes says, is essentially a coast-line plant, growing on rocks with a very limited vertical range; and he believes that the progenitor of the Gulf-weed was attached to the shores of the post-Miocene continent, and that its present abnormal condition is to be ascribed to the submergence of that ancient line of coast. "The fact that there is a well-marked belt of Miocene coast-line in North America, (as shown by Mr. Lyell,) and that the mollusca of that belt indicate a representative, not identical, fauna in that region,

* This term "a Miocene land" is equivocal, and is calculated to convey an erroneous idea of the author's meaning. It would have been more correctly given if he had said, a land consisting of rocks formed during the Miocene period, and subsequently upheaved above the surface of the sea. There is a similarly ambiguous expression used in a subsequent passage, where the author speaks of "a belt of Miocene coast-line in North America," meaning a coast-line of rocks formed under the sea during the Miocene period. A "Miocene land," in correct geological language, means land that existed during the Miocene period, on which the land animals and plants then existing lived, and which bounded the sea and freshwater lakes in which the aquatic animals and plants of that period lived; and such land might consist of rocks of any, and of several, antecedent epochs.

proves that during the Miocene period there was an Atlantic gulf separating the new world from the old, and favours the notion that the coast-line of a post-Miocene European land would be somewhere in the central Atlantic, about the position of the great Fucus bank. The probability of the existence of such a land is further borne out by the fact, that the floras of the groups of islands between the Gulf-weed bank and the mainland of the old world are all members of *one* flora, itself a member of the *Mediterranean* type. In the Madeira group, the Canaries, Cape de Verde islands, and other East Atlantic islands, there are marine tertiary strata, apparently of Miocene age, probably parts of one system of land that was once continuous, for their botanical and zoological characters agree as part of one province. Their floras are all closely related to those of the nearest mainland, and are also mutually related, through endemic plants, to each other. We learn from Humboldt, that Madeira and Teneriffe contain plants in common with Portugal, Spain, the Azores, and the north-west coast of Africa.

Nothing certainly can mark more strongly than this instance, how, in our endeavours to trace the past history of our earth, a new light may dawn in a quarter the least expected ; for certainly nothing *à priori* seemed more improbable, than that an examination of the botanical nature of the floating Gulf-weed should suggest the possible extension in former ages of the continent of Europe into the middle of the Atlantic. The author himself designates his hypothesis as a startling one ; and from its novelty and boldness it may perhaps be so characterized. It is true, that between the Gulf-weed and the shores of Europe and Africa that are opposite to it, there is a great depth of water, not less than 700 fathoms, or 4200 feet, as I am informed by a high authority; but that cannot be considered by the geologist as a valid objection. There are beds of the Miocene epoch at a height of 6000 feet above the sea-level in the Lycian Taurus, and the bed of the sea must therefore have been elevated not only to that amount, but to whatever more must be added for the depth of sea in which the beds were deposited. If at all periods there have been elevatory movements, there is no improbability in supposing subsidences of equal amount to have occurred. Mr. Darwin has shown, in the recent work to which I have referred, that, during a modern part of the secondary period, there must have been a subsidence, in mass, to the amount of several thousand feet of the greater part of the continent of South America, a subsequent elevation, and again subsidence ; so that neither in point of extent of area moved, nor of depth of subsidence, is the hypothesis of Professor Forbes unsupported by proofs of similar movements in other parts of the world.

It is thus to a period subsequent to the close of the Miocene epoch, and after the deposits formed in the sea of that epoch had been raised up to form dry land, that our author traces the origin of what he considers the most ancient part of our island flora, that represented by the relics of it on the western coast of Ireland, an assemblage of plants small as to number of species, but most of them playing an important part in the mountain vegetation of the region, and they are all species which at present are forms either peculiar to or abundant in the mountains of Spain and Portugal, and especially in the Asturias. At this period, he believes Ireland and Spain were united, and that the plants in question extended over land, which then occupied that part of the ocean that lies between the Asturias and the west of Ireland, but which flora he supposes to have been afterwards during the glacial epoch isolated, and in great part destroyed; such species as survived being the most hardy and able to bear the lowered temperature.

The Second, or Devon Flora.—The great extent of land, formed, in part at least, of the elevated bed of the Miocene sea, was destined to give way again to the return of the ocean, either by subsidence or denudation, probably by both causes, leaving many evidences however of its former existence. The destruction of this land the author conceives to have been in progress during the deposition of the beds of the Pliocene epoch, but that the opening up of the English Channel had only begun, and towards the west; for this flora, exhibiting features of transition between the great flora of Central Europe and that of the Southern or Mediterranean region, had its origin, he believes, in that part of France included in the ancient provinces of Brittany and Normandy.

The Third, or Kentish Flora.—The condition of things our author believes to have undergone little change from what they were during the passage of the Devon Flora, while the migration of this flora was in progress, unless, perhaps, a still further scooping out of the English Channel from the west.

The Fourth, or Alpine Flora.—A very considerable change occurred about this time. A great subsidence must have taken place, so as entirely to change the relative proportion of sea and land, and which must have been very different in the region now under consideration from that which at present exists. A great part of the British Isles the author believes to have been then covered by the sea, so that our mountains were comparatively low islands. If we extend, he says, a line from the coast of Norfolk westward across Ireland, and eastward so as to strike against the Ural chain, all north of that line he believes to have been at this epoch under the sea; that is, the whole of central and northern Europe, bounded by land, since greatly uplifted, which then presented to the water's edge those climatal conditions for which a sub-arctic flora destined to become alpine was specially organized. This, he says, was the sea of the *Glacial period*, when the climate of the whole of the northern and part of central Europe was far colder than it is now. It exhibited conditions, physical and zoological, similar, indeed nearly identical, to those now to be met with on the north-eastern coasts of America, within the line of summer floating ice. It was during this epoch, he believes, that Scotland and Wales, and part of Ireland, then groups of islands in this ice-bound sea, received their alpine flora, and a small portion of their fauna. The period of time that elapsed while the sea covered the region above described, he terms *The Glacial Epoch*, using that term to express the ice-charged condition of that sea, and the prevalence of severe climatal conditions throughout a great part of the northern hemisphere,—conditions which probably, he thinks, did not prevail during its earlier stage, and the gradual disappearance of which marked its close.

The remains of the marine animals found in the strata deposited in this sea prove its glacial or arctic character. Remnants of that ancient sea-bottom, stratified and unstratified masses of clay, sand and gravel, often of great thickness, more than a hundred feet, and great superficial extent, are to be met with in many parts of Great Britain and Ireland. These beds when carefully examined are found to contain in many places fossil marine testacea, usually scattered, rolled, and broken, but in particular localities entire and undisturbed, presenting undoubted evidence of the animals they inclosed having lived and died on the spot. About 124 species of Mollusca have been found in these beds in the British Isles, and, with few exceptions, they are all forms now existing in the British seas, but indicating a state of climate colder than that prevailing in the same area at present; and among them are species now known as living only in European seas north of Britain, or in the seas of Greenland and Boreal America. The prevalence of these forms, indicating a lower temperature in the testacea of the British glacial deposits, cannot be ascribed to their having lived in greater depths; for as far as our author has seen, there is no British case of an upheaved stratum of the glacial formation containing organic remains, evidently untransported, which may not have been formed at a less depth than 25 fathoms, and it is probable that between 10 and 15 fathoms would more frequently approach the truth. Further, there is abundant evidence that over a great part of the area occupied by these glacial beds, the uppermost portions, composed of sand and gravel, contain fossils belonging to littoral species, and indicating a much less depth of water than existed previously, during the deposition of the inferior marls.

The deposition of the beds in the glacial sea, the author considers to have been synchronic with that of the newer pliocene beds in the tertiary deposits of Sicily, Rhodes, and other parts of the Mediterranean basin; and from the existence of certain species of shells in these beds, characteristic of the southern bounds of the glacial beds in Britain, he infers that during the newer pliocene, or pleistocene epoch, there was a communication open between the Mediterranean and Northern seas. He also infers from a great amount of varied and concurrent zoological evidence, that during the glacial period, land existed in high northern latitudes, that either united or brought into very close approximation the continents of Europe and North America. There could not then have been, he says, such a separating abyss between Northern Europe and Boreal America as now divides them; the sea, through a great part, must have been a shallow sea, and somewhere, probably far to the north, there must have been either a connexion or such a proximity of land as would account for the transmission of a non-migratory terrestrial, and a littoral marine fauna.

There is in this part of this ingenious essay, a want of that clear statement of the author's views as to the mode of migration of the alpine flora, which we find when he treats of that of the other floras. He tells us that the plants of this flora could not have been inhabitants of the ancient west of Europe, but of Scandinavia. "The alpine floras of Europe and Asia," he says, "so far as they are identical with the floras of the Arctic and Sub-Arctic zones of the old world, are fragments of a flora which was diffused from the north, either by means of transport not now in action on the temperate coasts of Europe, or over continuous land which no longer exists." But he had already stated, that during the glacial epoch, when Scotland and Wales, and part of Ireland, received their alpine flora and a small portion of their fauna, they were groups of islands in an ice-bound sea; and that in an after-state of things these islands were upheaved and converted into mountains, and the plants of the colder epoch survived only on the mountain regions which had been so elevated as to retain climatal conditions similar to those which existed when those regions were low ridges or islands in the glacial sea. Thus the only modes of migration, according to this view of a group of islands, must have been by currents or by the transporting agency of icebergs; and from what he states (p. 351), in speaking of the origin of the alpine floras of the Alps and Carpathians, and some other mountain ranges, it is evident that, though not directly expressed, an iceberg is the mode of transport that is chiefly in the author's mind in that part of his essay. Icebergs have been seen partially covered with alluvial soil, on which plants were growing. Are we therefore to suppose, that the alpine flora was transferred from the land now called Scandinavia to that now called Britain, by such icebergs as chanced to carry plants with soil sufficient to preserve their vitality, and as chanced to be stranded on the islands? This mode of transmission appears to have been felt to be unsatisfactory and inadequate by the author, for towards the conclusion of the essay we find the following passage:—"The phænomena of the glacial formations, the peculiarities in the distribution of the animals of that epoch, and in the relations of the existing fauna and flora of Greenland, Iceland, and Northern Europe, are such as strongly to impress upon my mind, that the close of the glacial epoch was marked by the gradual submergence of some great northern land, along the coasts of which the *littoral* mollusks, aided by favouring currents, migrated, whilst a common flora became diffused over its hills and plains. Although I have made icebergs and ice-floes the chief agents in the transportation of an Arctic flora southwards, I cannot but think that so complete a transmission of that flora as we find in the Scottish mountains was aided perhaps mainly by land to the north, now submerged." I am inclined to the opinion, that this last view of the author, the former existence of land towards the north pole, from which there was a continuous communication with the land of our island, is the more probable hypothesis; and many phænomena of the northern drift, especially the difficulty of conceiving any other source for the origin of the vast mass of detrital matter, water-worn stones and boulders, which are found in the northern drift that do not belong to the rocks that lie immediately beneath it, but must have come from a distance, all point to the former existence of northern land now submerged. If during the existence of the glacial sea, "it was the epoch of glaciers and icebergs, of boulders and groovings," there must have been a mountainous northern land with deep valleys in which the glaciers could be formed, and terminating in the sea, so that icebergs could be detached; the mountains supplying the fragments of rock that were rounded into boulders and ground into gravel, sand and mud, and also the fragments fixed in the icebergs which caused the groovings. How otherwise can we suppose the cold of the glacial epoch to have been created, except by the existence of a continent of greatly elevated land in high northern latitudes? Can we suppose the existing land of Norway and Sweden adequate to produce such effects?

The Fifth, or General Flora.—At the close of the glacial period, our author believes another great change to have taken place; that the bed of the glacial sea was gradually upheaved, and along with it the islands that were scattered in that sea, the elementary parts of the future Britain and Ireland, so that continuous land arose where sea had been before and where sea again is, the area of the present German Ocean forming then extensive plains over which the great mass of the existing flora and fauna of the British Isles migrated from the Germanic region of the continent. How far northwards this land extended it is now impossible to say, but we find fragments of it bordering the seaside, even to the farthest parts of the mainland of Scotland. It linked Britain with Germany and Denmark, and a corresponding plain united Ireland with England. As a great part of the area, previously occupied by water, now became land, the banishment of a number of species necessarily took place, many of which, in consequence of the change of conditions arising from the causes of their expulsion, retired for ever.

In the 'History of British Fossil Mammals and Birds' by Professor Owen, to the recent publication of which I briefly referred in my address of last year, we have the full expression of his belief of the irresistible demonstration afforded by the fossil remains which form the subject of that valuable work, that during the period now under consideration Great Britain and Ireland formed continuous land with France. He informs us, that in his endeavour to trace the origin of our existing mammalia, he has been led to view them as descendants of a fraction of a peculiar and extensive mammalian fauna which overspread Europe and Asia, at a period geologically recent, yet incalculably remote and long anterior to any evidence or record of the human race: that the fact of the Pliocene Fossil Mammalia of England being almost as rich in generic and specific forms as those of Europe, leads to the inference that the intersecting branch of the ocean which now divides this island from the continent did not then exist, as a barrier to the migration of the Mastodons, Mammoths, Hippopotamuses, Rhinoceroses, Bisons, Oxen, Horses, Tigers, Hyænas, Bears, &c., which have left such abundant traces of their former existence in the superficial deposits and caves of Great Britain: that the idea of a separate creation of the same series of Mammalia in and for a small contiguous island cannot be entertained; and that the idea of their having swum across a tidal current of sea twenty miles in breadth is equally inadmissible.

I have thus endeavoured to trace the successive geological changes, the upheavals and subsidences of the land, which by strong evidence, botanical and zoological, have been shown to have occurred in this western part of Europe during the more modern of the tertiary periods. But we have not yet traced the more recent changes which Professor Forbes points out in this essay, up to the historical period. We have seen that most of our existing plants and animals can boast a direct lineal descent from ancestors that flourished long before man set foot on these islands, probably before the creation of the human race; certainly before the formation of the German Ocean, or the English and Irish Channels. These seas have great inequalities of depth, but in some places the soundings are as much as nearly 100 fathoms. They were probably formed by the double and concurrent operation of subsidences of the land, and by the wearing action of tides and waves on other parts of the land, cracked, fractured, and loosened as it probably would be by these subsidences. We know that the sea has worn away large tracts of land within our own experience, and that lands on which forests of existing trees grew, have subsided below the level of the sea, on many parts of our coasts. "The formation of the German Ocean and Irish Sea, and new lines of coast, events calling new influences into play, introduced the existing population of our seas. Part of our glacial testacea had been extinguished, part retired to more congenial arctic seas, and a few disappeared from the coasts of Europe, while they continued inhabitants of the shores of America. A considerable number, however, returned to the seas of their ancestors, where they became and remain the associates of numerous forms, some newly called into being to people the new-formed seas, some coming with favouring currents from the warmer seas of the south. Among the latter were a number of forms which had not always been strangers to the British seas. During the genial times preceding the glacial epoch, more than fifty species of testacea, inhabitants at present of our seas, lived in them whilst the Crag beds were in process of formation, but disappeared under the chilly influences of the sub-arctic epoch which succeeded."

On this post-pliocene plain, this upheaved bed of the glacial sea, there must have existed extensive freshwater lakes, from the relics we find of them. In Ireland and the Isle of Man, there are numerous basins of freshwater marls resting on depressions of the upheaved glacial sea-bed, containing shells of existing testacea, along with entire skeletons and many detached bones and horns of the extinct gigantic Irish Elk, the *Megaceros Hibernicus*, which in the opinion of Professor Owen was the contemporary in our islands of the Rhinoceros, Mammoth, and other extinct mammalia, during the period of the formation of the newest tertiary freshwater fossiliferous strata. These freshwater marls are overlaid by peat with its included ancient forests, so that the time when the Megaceros lived was anterior to that of the forests which aided in the formation of the great peat bogs. The land that contained these lakes and supported these extinct animals was in great part worn away between England and Ireland, as it was between Germany and England, during the comparatively modern geological epoch, in all probability by the same destructive forces. That subsidence was one cause may be legitimately inferred, for we have abundant proof in the raised beaches on our shores, that the land was subject to the action of internal forces; and masses of the post-pliocene plain of great extent and thickness are found on the western shores of Britain, in the Isle of Man, and in Ireland.

The theory which it is the object of this essay to establish, is founded, as I have already said, upon the assumption of "the existence of specific centres, that is, of certain geographical points from which the individuals of each species have been diffused." It is further established upon the proofs, derived from various sources, of great and repeated changes in the physical geography of the western and north-western parts of Europe, that is, upon the existence in former ages of land where there is now sea, and of sea where there is now land, causing great changes of climate in these regions. The former existence of a warmer climate in northern latitudes had long been made manifest by the zoological and botanical evidence supplied by fossil organic remains; but the 'Principles of Geology' of Mr. Lyell, published in 1830, first taught geologists that it is not necessary to have recourse to extraordinary causes, to account for the former existence, in northern regions, of animals and plants that can live only in the heat of the tropics, for the extremes of climate are confined within a very limited thermometric range. He showed that such a range may be produced by differences in the relative proportions of sea and land, when taken in conjunction with considerations of latitude and of the elevation of the land above the sea-level, and that what we call an arctic climate, a temperate climate, and a tropical climate might alternately prevail in the same latitude, according as the relative proportions of sea and land, and the extent and elevation of the latter, were favourable to the one condition or the other. This fundamental doctrine is now embraced, I believe, by the greater proportion of our geologists, perhaps universally so, in this country at least. By no one, as I have reason to know, is it adopted more unreservedly than by the author of this essay; and on my remarking to him that I missed in his essay a recognition of that important doctrine, which I have always been in the habit of considering as one of the most original and important parts of Mr. Lyell's work now referred to, he replied, that believing the doctrine to be so generally known and adopted, he deemed it unnecessary to refer especially to it, and that he considers his essay in a great measure as a contribution towards the confirmation of Mr. Lyell's climatal views.

To Mr. Lyell we are also indebted for having several years ago called the attention of geologists, not only to the effects of physical conditions arising from changes in the earth's structure, on the existence, distribution and extinction of species, but also to the great changes that have taken place in the land, in many places, since the creation of species now living. Thus in chapter 11 of the first edition of the second volume of the 'Principles of Geology,' published in 1832, we find the following passages :—" We have pointed out in the preceding chapters the strict dependence of each species of animal and plant on certain physical conditions in the state of the earth's surface, and on the number and attributes of other organic beings inhabiting the same region. We have also endeavoured to show that all these conditions are in a state of continual fluctuation, the igneous and aqueous agents remodelling, from time to time, the physical geography of the globe, and the migrations of species causing new relations to spring up successively between different organic beings." " As considerable modifications in the relative levels of land and sea have taken place in certain regions since the existing species were in being, we can feel no surprise that the zoologist and botanist have hitherto found it difficult to refer the geographical distribution of species to any clear and determinate principles, since they have usually speculated on the phænomena, upon the assumption that the physical geography of the globe had undergone no material alteration since the introduction of the species now living *." In the 9th chapter of the third volume of the same work, published in 1833, the following observations occur at p. 115. Treating of *the migration of animals and plants*, he says, " A large portion of Sicily has been converted from sea to land since the Mediterranean was peopled with the living species of testacea and zoophytes. The newly emerged surface, therefore, must, during this modern zoological epoch, have been inhabited for the first time with the terrestrial plants and animals which now abound in Sicily. It is fair to infer, that the existing terrestrial species are, for the most part, of as high antiquity as the marine; and if this be the case, a large proportion of the plants and animals, now found in the tertiary districts in Sicily, must have inhabited the earth before the newer pliocene strata were raised above the waters. The plants of the flora of Sicily are common, almost without exception, to Italy or Africa, or some of the countries surrounding the Mediterranean, so that we may suppose the greater part of them to have migrated from pre-existing lands, just as the plants and animals of the Phlegræan fields have colonized Monte Nuovo, since that mountain was thrown up in the sixteenth century. We are brought, therefore, to admit the curious result, that the flora and fauna of the Val di Noto, and some other mountainous regions of Sicily, are of higher antiquity than the country itself, having not only flourished before the lands were raised from the deep, but even before they were deposited beneath the waters."

We have seen that the great geological conditions to which Professor Forbes refers are—1st, the existence of land above the waters during the Miocene epoch, and of sea between the northern coast of Spain and the British Islands ; 2ndly, the formation of deposits in that Miocene sea, and the subsequent elevation of that sea-bottom above the waters, extending over the whole Mediterranean region, and

* Pages 182 and 183.

stretching out into the Atlantic as far as the region of the Gulf-weed, and uniting Spain and Ireland; 3rdly, the destruction of the whole of that vast continent of upraised miocene deposits, with the exception of those comparatively small fragments which remain as evidence that such marine deposits were formed at that period; 4thly, the state of Great Britain and Ireland when they consisted of a group of small islands, the summits of our present mountains, surrounded by a glacial sea; 5thly, the elevation of the bed of that glacial sea, when the smaller islands rising above the surface of the water formed a continuous land of Great Britain and Ireland, connected with the continent, a plain existing where there is now the German Ocean; and 6thly, the disappearance of that Germanic plain, and the formation of the German Ocean, the English Channel, and the Irish Sea.

The agency by which these great changes were effected, is a subject on which the author does not enter. There is one passage which, without explanation, would be quite at variance with a fundamental part of his theory, for at p. 400 he states, "The floras of the islands of the Atlantic region, between the Gulf-weed bank and the old world, are fragments of the Great Mediterranean flora, anciently diffused over a land constituted out of the upheaved *and never again submerged* bed of the (shallow) Miocene sea." The author, since the publication of his essay, has stated to me in conversation that the words "never again submerged" were intended to apply only to those miocene deposits which are now above the sea-level, which have always remained above the sea-level since the time of their first elevation, as they are nowhere capped by marine deposits of a later epoch.

The disappearance of the supposed land between Ireland and Spain, which he tells us was composed of the upheaved bed of the Miocene sea, as well as that of the whole of his supposed vast continent of the same deposits, could only have been effected by subsidence. Professor Forbes is, I know, disposed to ascribe a great deal to the action of denudation, and the wearing away of land by the action of the sea, both where the waves beat upon shores, and where currents far below the surface have destructive powers. Without denying the known powerful action of the former force, nor the possible power of the latter, but of which we do not as yet know much for certain, it is contrary to all probability,—it may almost be said to be physically impossible,—that such an agency could produce the effects. For how stands the case? Without referring to the supposed land between the region of the Gulf-weed and the old world, let us take that portion only which the author believes to have united Ireland with the north of Spain, and specially with the province of Asturias. The distance is about 560 miles. Now all along the north coast of Spain from Bayonne to Cape Ortegal, there is very deep water near the shore. There is a depth of 80 fathoms within six miles of the land, and it is stated in the French Admiralty Chart, published in 1832, that within twenty-five miles of the land of the Asturias, there were soundings of 220 fathoms without finding the bottom; and the same depth was found at a distance of 280 miles.

From that point there is a shallowing of the water towards Ireland to 100, 80, and 67 fathoms, and within ten miles of Cape Clear there is still a depth of 54 fathoms. A denudation to such depths is inconceivable, but a subsidence not only to that but to much greater depths is perfectly conceivable. If, as is probable, the subsidence was gradual, then the action of the waves and of currents, for a short time at least, would come into play, while the water was still comparatively shallow, especially if the subsidence was accompanied by earthquakes or other internal forces, causing fissures and otherwise breaking up and loosening the land. Professor Forbes is of opinion, that all the operations which brought about a change of climatal conditions were gradual. He states (p. 401) that "all the changes before, during, and after the glacial epoch appear to have been gradual and not sudden, so that no marked line of demarcation can be drawn between the creatures inhabiting the same element and the same locality during two proximate periods." We may also infer that subsidence was the chief cause of the formation of the English Channel, St. George's Channel, and the German Ocean. At the entrance of the English Channel, there is a depth of from 56 to 70 fathoms, and the mid-channel shallows from thence to 28 fathoms off Beechy Head. In the distance from Dungeness to Dover, and from Boulogne to Calais, the sea-bottom is very uneven, the depth of water varying from 10 to 30 fathoms. The great inequalities in the sea-bottom, over all the region under review, are of themselves a strong argument in favour of subsidence, for it is infinitely more probable that subsidences would be unequal, than that any denuding force would produce such effects. At the south entrance of St. George's Channel there is a depth of 60 fathoms, and between Waterford and St. David's Head the soundings are from 38 to 54 fathoms. Between Dublin and Belfast Lough the soundings from the shore to the mid-channel between Ireland and the Isle of Man are from 20 to 74 fathoms, and opposite the coast of Galloway they deepen to 99 fathoms. In the German Ocean and North Sea the depths are in general not so great; but here too there are great inequalities, the soundings varying from 9 fathoms, within four miles of the shore, to as much as 76 fathoms in some places, the shallowest parts being over the extensive banks that prevail in that ocean, such as the Long Forties, the Long Bank, the Dogger Bank, and the little Fisher's Bank off the coast of Scotland. Our author's theory twice supposes the upheaval of the sea-bottom into land, viz. that of the Miocene and that of the Glacial sea, and subsidences are equally conceivable.

The most extensively continuous tertiary deposit with which we are acquainted, is that of pleistocene age on the eastern side of the southern half of the continent of South America, extending more than 1600 miles northward from Tierra del Fuego, and consisting of the great covering of gravel spread over Patagonia, and of the calcareo-argillaceous deposit that constitutes the soil of the Pampas. Much as we are indebted to M. Alcide d'Orbigny for the great additions to our knowledge of the geology of South America, contained in his account of his long residence and widely-extended observations in that country, the recent work of Mr. Darwin contains a more detailed and elaborate description, a more critical examination, if I may so express it, of the nature and probable origin of these modern tertiary formations, than any we have yet had.

The Pampean formation is throughout of a very uniform character, consisting of a reddish, slightly indurated earth or mud, often, but not always, including, in horizontal lines, calcareo-argillaceous concretions or marl. Except in a few detached localities, it is unmixed with gravel, and the traveller may pass over many hundred miles of level surface without meeting with a single pebble, or discovering any change in the nature of the soil. These marly concretions often unite into irregular strata, and over very large tracts of country the entire mass consists of a hard, but generally cavernous marly rock, resembling the less pure freshwater limestones of Europe, and called by the inhabitants *Tosca rock*. A microscopic examination has disclosed in it fragments of shells and corals ; and Professor Ehrenberg, having examined specimens of it from different localities, discovered twenty different forms of infusoria, the greater proportion being of freshwater origin, but five identical with such as are found in brackish water. It is remarkable that, except in some detached localities near the coast, the Pampean deposit is almost entirely devoid of shells, either marine, fluviatile, or land. Mr. Darwin states, that with the exception of the *Azara labiata*, a living estuary shell, occasionally, but rarely found, and sometimes imbedded in the tosca rock, this formation, within the true limits of the Pampas, although of such vast extent, affords, as far as he knows, no instance of the presence of shells. It exhibits here and there changes of colour, indicating regular lines of stratification, always horizontal ; and although it has been subjected to great and powerful elevatory forces, it nowhere exhibits any irregular movements, nor is there any appearance of much superficial denudation.

It extends, uninterruptedly, nearly 800 miles from N. to S., and about 400 miles from E. to W. In depth it varies from 30 to 100 feet. A range of mountains, attaining a height of 3340 feet, rises in the midst of the plain near the Rio Colorado, the Sierra Ventana, and the Pampean deposit comes up nearly horizontally to the northern and southern foot of these mountains, insinuating itself between the parallel ranges, at a height, in this place, of 840 feet above the sea, indicating an upward movement of the land in mass. The high plain round this range sinks quite insensibly to the eye on all sides. Mr. Darwin states that "round the Sierras Tapalguen, Guitru-gueyu, and between the latter and the Ventana, the tosca rock forms low, flat-topped, cliff-bounded hills, higher than the surrounding plains of similar composition. From the horizontal stratification, and from the appearance of the broken cliffs, the greater height of the Pampean formation round these primary hills ought not to be altogether or in chief part attributed to these several points having been uplifted more energetically than the surrounding country, out to the argillo-calcareous mud having collected round them, when they existed as islets or submarine rocks, at a greater height than the bottom of the adjoining open sea; the cliffs having been subsequently worn during the elevation of the whole country in mass*."

The most remarkable feature to the geologist, of this great Pampean formation, is the vast accumulation of the fossil remains of mammalia which it contains, chiefly herbivorous, generally of great size, and belonging to extinct genera, some even to extinct families or orders,—the Megatherium, Mylodon, Toxodon, Glyptodon, Scelidotherium, Macrauchenia, Megalonyx and Mastodon. "The greater number of them," Mr. Owen tells us, "are referable to the order which Cuvier has called *Edentata,* and belong to that subdivision of the order which is characterized by having perfect and sometimes complex molar teeth, and an external osseous and tessellated coat of mail. The Megatherium is the giant of this tribe†."

Mr. Darwin has given many interesting descriptions of the localities where these fossil bones have hitherto been found; they are all between the 31st and 50th degrees of south latitude; and numerous though the remains already discovered have been, they can form only a very small portion of what lie buried in the deposit; for they have as yet been almost exclusively found in the cliffs and steep banks of rivers. "I am firmly convinced," Mr. Darwin says, "that a deep trench could not be cut in any line across the Pampas without intersecting the remains of some quadruped." The bones occur at all depths, from the top to the bottom of the deposit; he himself found some close to the surface; near Buenos Ayres a skeleton was disinterred from a depth of 60 feet, and on the Parana two skeletons of the Mastodon were found only five or six feet above the base of the deposit.

The theory of the formation of this vast extent of indurated mud and calcareous concretions proposed by M. Alcide d'Orbigny in his 'Travels in South America,' viz. that it was produced by a vast and sudden flood,—a debacle, is shown by Mr. Darwin to be inconsistent with the various phænomena which the deposit exhibits; its structure, its concretions, the horizontal layers of tosca rock, the absence of granite and boulders, all indicating a slow and tranquil deposition,—to say nothing of the improbability of the existence of a mass of fine mud combined with carbonate of lime in a state fit for chemical segregation, ready to be transported by the debacle, and sufficient in amount to cover a space larger than the whole of France. The theory which Mr. Darwin himself suggests appears a very intelligible and probable explanation of the facts he describes. He supposes that the materials of the Pampean formation were derived from the great area of older rocks, igneous and sedimentary, in Brazil and the high country to the north and west that surrounds the plains; that they were transported by numerous streams and rivers and deposited in a vast bay, the former estuary of the Plata, extending into the low country of Banda Oriental and forming a part of the adjoining sea, in the same manner as we have seen that the delta of the Mississippi has been formed. This operation of transport, and deposit of similar materials, ap-

* Page 79. † Owen, Fossil Mammalia, Voyage of the Beagle, p. 15.

pear to have been going on in a much earlier period, for he observed extensive beds of sediment undistinguishable from the Pampas deposit underlying old tertiary rocks on which the true Pampean formation rests. He further supposes, that the bottom of that sea and estuary was gradually rising during the slow progress of the deposition, and that the animals, whose remains are buried, lived on the adjoining land, and that when either dying a natural death, or drowned by inundations, their bodies were floated off to sink in the mud, and be entombed near the spots where they had lived; for not only are entire skeletons found, but even when the bones are separated, they are often met with lying in their proper relative positions, and they never bear the marks of having been worn by attrition in a transport by floods from a distant region.

With regard to the age of the Pampean formation, it appears from the uniformity in its composition, the specific identity of the mammiferous remains over its vast area, and their occurrence throughout its whole depth, that it belongs to one geological epoch; and that from its association with shells now living in the adjoining sea, from the many proofs that the bodies of the animals were imbedded in a fresh state, and that they therefore had co-existed with the shells, it must be of the pleistocene æra. "I feel little doubt," says Mr. Darwin, "that the extinction of the large quadrupeds did not take place until the time when the sea was peopled with all, or nearly all, its present inhabitants*."

From the southern termination of the Pampean deposit at the Rio Colorado, another vast area of detrital matter, very different in its nature, but chiefly of the same age, commences; for nearly the whole of Patagonia is covered with gravel, capped by a thin irregular bed of sandy earth, and it extends across the Straits of Magellan into Tierra del Fuego. Near the coast it is generally from 10 to 30 feet in thickness, but at a distance of 110 miles inland it has a depth of 212 feet, and Mr. Darwin is of opinion that its average depth may be not less than 50 feet. It covers an area in Patagonia of 630 by 200 miles, rising from the coast to the foot of the Cordillera, a height of between 3200 and 3300 feet. Porphyries of different kinds constitute the chief mass, but there are also pebbles of other crystalline felspathic rocks, basalts, compact clay-slate and quartzose schists, all derived from the mountainous country on the west, and from the basaltic dykes or streams that occur in different parts of the inclined plane near these mountains. The absence of angular fragments, and the perfectly rounded condition of the pebbles, indicate long-continued attrition. The rarity and inconsiderable size of the streams in Patagonia make the transport and wearing by river-action improbable; "moreover," the author adds, "in the case of the one great and rapid river of Santa Cruz, we have good evidence that its transporting power is very trifling. This river is from 200 to 300 yards in width, about 17 feet deep in its middle, and runs with a singular degree of uniformity five knots an hour, with no lakes, and scarcely any still reaches: nevertheless, to give one instance of its small transporting

* Introduction to Professor Owen's 'Description of the Fossil Mammalia collected by Mr. Darwin.'

power, upon careful examination, pebbles of compact basalt could not be found in the bed of the river at a greater distance than ten miles below the point where the stream rushes over the debris of the great basaltic cliffs forming its shores: fragments of the cellular varieties have been washed down twice or thrice as far." Mr. Darwin is of opinion, that the cause of the rounding of the fragments and the spreading out and levelling of the gravel is to be ascribed to the action of the sea, as it gradually receded from the foot of the Cordillera to the present coast, by the slow upheaval of the land. He admits, however, that it is a problem of great difficulty. "By whatever means," he says, "the gravel formation of Patagonia may have been distributed, the vastness of its area, its thickness, its superficial position, its recent origin, and the great degree of similarity in the nature of its pebbles,—all appear to me well-deserving the attention of geologists, in relation to the origin of the widely-spread beds of conglomerate belonging to past epochs*." It is seen on the coast to rest on horizontal beds of older tertiary strata, which in some places form cliffs from 800 to 900 feet in height: as it is seen in the interior capping terraces formed of deposits containing shells, and as the gravel with its sandy covering is often strewed with recent marine shells, there is no doubt of its belonging, like the Pampean formation, to the pleistocene age; and in all probability they were nearly contemporaneous. In the valley of Santa Cruz, at a distance of 100 miles from the sea, and at an elevation of 1400 feet, the gravel is covered with numerous angular erratic blocks, some as much as 60 feet in circumference. These were described by Mr. Darwin in a paper read in this room, and published in the sixth volume of our Transactions, and he there attributes their position to the transporting action of icebergs, the probable origin of the erratic blocks of Northern Europe.

Elevation of the land.—We know that the land of the western coast of South America has risen considerably in our own time: we have proofs of considerable elevations in the recent period of geological time, when the country was inhabited by man, and we can trace back the continuance of the same operation of subterranean force to far earlier periods, and upon a greater scale, in various parts of that same coast; nor is there wanting evidence to show that there have been partial subsidences of the land within the historical period. But these changes of relative level of sea and land during the pleistocene period are more distinctly seen on the eastern coast: they were described by Mr. Darwin in his 'Journal,' but in his recent work he has gone into far greater details respecting them,—into a minuteness of description that was not admissible in the plan of his 'Journal,' but which is far more interesting and satisfactory to the geologist.

For a space of more than 1200 miles, from the 33rd degree of S. latitude southward, the land has been gradually elevated, as shown by a succession of terraces one above the other, with abrupt escarpments facing the sea, and separated from each other by gently sloping plains. On the coast of Patagonia, between Santa Cruz and Port

* Page 24.

Desire, there are seven such terraces, separated by plains of various breadths, sloping, though seldom sensibly so to the eye, from the summit of one escarpment to the foot of the next above. The three lower plains are respectively 100, 250, and 350 feet above the sea-level, and the highest of the other four was estimated to be 1200 feet in height. These elevated terraces and plains extend horizontally to vast distances: one ranging from 245 to 255 feet in height appears to extend with much uniformity a distance of 170 miles; another, estimated at a height of from 330 to 355 feet, extends over a space of 500 miles in a north and south line; one in the middle of the great Bay of St. George, estimated at 1200 feet in height, was seen ranging at apparently the same height for 150 miles northward, and some approximate measurements indicate an extension of the first-named terrace to 780 miles. These upraised plains are all strewed with shells of littoral species, still existing as the commonest kinds in the adjoining sea; Mr. Darwin saw them at a height of 410 feet, and he does not know, he says, that that is the maximum height of these remains. "All of them have an ancient appearance; but some, especially the muscles, although lying fully exposed to the weather, retain to a considerable extent their colours. Most of the shells are broken, and the valves are not united; but the fragments are not rounded*."

There thus appears to have been a most remarkable equability in the elevation of these several terraces over a vast area, and the periods of the denudation of the sea-cliffs, which form the escarpments of the terraces, were synchronous along wide extents of coast. It is probable, therefore, that the elevation was by slow and insensible degrees, of which there are some further proofs. Thus on some of the plains there are sand-dunes, at different levels, abounding with shells; and in none of the coast and river sections is there any fault, or abrupt dislocation, or any curvature in the strata. From the quantity of matter that must have been removed by the action of the waves on the shore to form each successive escarpment, it is no less evident that there must have been long periods of rest in the elevatory movement—that it was not constant, but intermittent, as we know to be the case in other countries, and as we find to have been the case, even within the historical period, on the western coast of this continent.

The elevations of the coast of Patagonia began after the adjoining sea was inhabited by the most common and abundant of the existing species of littoral shells, but before the introduction of living mammifers. The remains of extinct mammifers have been found in the lowest plain, in hollows worn in the gravel beds, which are filled by a reddish sandy earth, the same as that which caps the general surface of the gravel. It would be interesting to find out whether similar remains exist in the higher plains; for if they do not, it would mark, approximatively, that the introduction of the mammifers took place long after the creation of the living species of mollusca.

There are proofs no less evident of elevations of the land on the

* Page 13.

western side of the continent during the pleistocene period; that they were unequal in amount at different parts of the coast; and that the action of the subterranean force was intermittent, periods of rest intervening. Shells of the same species as are now living in the shallow waters of the shores of the Pacific, and in the same proportions as to numbers, are met with in the island of Chiloe at a height of 350 feet above the sea, near Concepcion at 625, and even, according to Lieut. Belcher, at a height which he estimated to be 1000 feet. They occur at the latter height near Valparaiso, and although diminished in number, Mr. Darwin found four species in the same locality at an elevation of 1300 feet. "These upraised marine remains occur at intervals, and in some parts almost continuously, from lat. 45° 35′ to 12° S. along the shores of the Pacific, a distance in a north and south line of 2075 geographical miles; and from the similarity in the form of the country near Lima, it is probable they occur there also, which would extend the line to 2480 miles. From the steepness of the land on this side of the continent, shells have rarely been found at greater distances inland than from two to three leagues; but the marks of sea-action are evident farther from the coast; for instance, in the valley of Guasco, at a distance of between 30 and 40 miles*." That the elevations were gradual, is shown by the shells being all littoral, or such as live at very moderate depths; and by their broken condition, and by their becoming more brittle and having a more ancient appearance the higher they are found, they afford evidence that they had formerly been cast up upon a succession of beaches. The escarpments of the successive terraces, on which shells are strewed, in the sinuosities of the valleys that open to the coast, indicate not only gradual upheavals, but intervals of rest. At Coquimbo there are five such terraces, one above another, in a height of 364 feet.

Although they relate to an earlier period of geological time than that now under consideration, I shall pass to some other parts of the work of Mr. Darwin; and I do so the more willingly, because the phænomena he describes, in the account he gives of his examination of that part of the Cordillera of Chile, are connected with great internal movements, analogous to those which have elevated the land near the coast, on both sides of the South American continent, in comparatively modern periods.

That part of the Cordillera which forms the eastern boundary of Chile is not more than about 60 miles wide; and, if we except the volcanic peaks, which occur only at distant intervals, the highest mountains do not much exceed 14,000 feet above the sea. The plain of St. Jago, at their base on their western side, is 2300 feet; that of the Pampas, on the eastern side, 3300 feet in height. "Although I crossed the Cordillera," says Mr. Darwin, "only once by the Portillo or Peuquenes Pass, and only once by that of the Cumbre or Uspallata, riding slowly and halting occasionally to ascend the mountains, there are many circumstances favourable to obtaining a more faithful sketch of their structure, than would at first be thought possible

* Pages 53–57.

from so short an examination. The mountains are steep, and absolutely bare of vegetation; the atmosphere is resplendently clear; the stratification distinct, and the rocks brightly and variously coloured: some of the natural sections might be truly compared for distinctness to those coloured in geological works*." The Peuquenes and the Portillo in the one pass, and the Cumbre and Uspallata in the other, are distinct parallel ranges, each differing considerably in composition from the other.

This part of the Cordillera consists of several parallel anticlinal and what Mr. Darwin calls "uniclinal" mountain-lines, ranging north and south: in the main exterior lines, the strata are seldom inclined at a high angle; but in the central lofty ridges they are almost always highly inclined, often vertical, and are broken by many great faults. The strata that flank the chain are traversed by innumerable dykes of igneous rocks, but these are rare in the central parts of the range.

The lowest rock is a porphyritic claystone conglomerate, sometimes between 6000 and 7000 feet thick. The imbedded fragments, which vary in size from mere particles to eight inches in diameter, are both angular and rounded, and both kinds occur in the same mass. Sometimes the rock is a true conglomerate, at other times a breccia. The fragments are claystone porphyry, a felspathic rock like altered clayslate, and occasionally, but rarely, quartz. All the varieties of conglomerate and breccia pass into each other; and by metamorphic action they are changed into porphyries, no longer retaining the least trace of mechanical origin. The fragments Mr. Darwin supposes to have been derived from masses that were ejected from a submarine crater, and those that are rounded he supposes to have been triturated in the heated and agitated water that filled the crater, from something very analogous which he observed in some of the recent volcanos of the Galapagos islands.

Besides the porphyritic conglomerates and the well-characterized metamorphic porphyry, there are other porphyries, which, though differing slightly in composition, have had a distinct origin. They contain large crystals of albite felspar and are often amygdaloidal, with nodules of agate and calcareous spar. They occur in intrusive masses, interstratified with the conglomerate in several alternations, and have all the appearance of submarine lavas, either forced in between the planes of stratification of the conglomerate, or contemporaneous with the deposit of the latter. Volcanic matter of sub-aërial origin is everywhere rare in Chile, the few still active volcanos being confined to the central and loftiest ranges. Metamorphic action has taken place to a great extent; it is seen in the gradual appearance of crystals of felspar and epidote, in the blending of the imbedded fragments of the porphyritic conglomerate, and in the disappearance of the planes of stratification.

Another variety of intrusive igneous rock, occurring in this part of the Cordillera, is that which has been called *Andesite*, consisting either of well-crystallized white albite, or soda-felspar, or of that white mineral analysed by Abich and called by him Andesine, of

* Page 176.

crystals of hornblende, with mica, chlorite, epidote and quartz. Where the mica and quartz are abundant, the rock cannot be distinguished externally from granite. A brick-red granite composed of orthitic or potash-felspar occurs in the Portillo range, which Mr. Darwin is inclined to think is of newer formation than the rock of which albite is the chief constituent.

After ascending the Peuquenes Pass to a height of 7000 feet, a vast formation of gypseous strata begins to appear. It is partly composed of beds of snow-white hard gypsum with a saccharoid fracture, and partly of a pale brown argillaceous gypsum, highly inclined, and conformable in stratification with those of the porphyritic conglomerate on which they repose. The gypseous beds are covered by a red sandstone, seen in some places to be 1000 feet thick; this again is covered by gypseous beds of equal thickness, and these in their turn are surmounted by a repetition of the red sandstone. Above the latter rock there occurs a black, compact, calcareous shaly rock of vast thickness. From these last strata Mr. Darwin collected two Ammonites, a Gryphæa, a Natica, a Cyprina, a Rostellaria, and a Terebratula, which having been examined by M. Alcide d'Orbigny, were considered by him to belong to the Neocomian stage of the Cretaceous system. Fossils collected in another part of the same formation were pronounced by M. von Buch to indicate a formation intermediate between the limestone of the Jura and the chalk, analogous with the uppermost Jurassic beds forming the plains of Switzerland. The fossils collected by Mr. Darwin were imbedded in the rock at the height of 13,200 feet, and the same beds are prolonged upwards to at least from 14,000 to 15,000 feet above the level of the sea. These strata have been greatly disturbed, dipping both west and east, the remnants of an anticlinal ridge, and they also dip towards the centre of the range.

A similar series of beds occurs on the eastern flank of the Cumbre range, but associated with numerous alternations of porphyritic and felspathic rocks, with all the characters of submarine contemporaneous lavas. The flanks of the mountain are here quite bare and steep, affording a section of a series of strata whose united thickness must be nearly 6000 feet: from the lowest to the uppermost bed of gypsum, it cannot be less than 2000 feet. There is however this important difference between the Cumbre series and that of the Peuquenes, that the limestone, containing the same fossils as that of the Peuquenes which lies there near the top of the series, at the Cumbre lies at the very base of the formation, just above the porphyritic conglomerate—that is, several thousand feet lower in the series; and it forms a stratum 80 feet thick. In the opinion of M. von Buch and M. d'Orbigny, the two formations belong to the same age. Professor Edward Forbes has likewise a strong impression that they indicate the cretaceous period, and probably an early epoch in it; and Mr. Darwin himself is of opinion, that probably the gypseous and associated beds in all the sections belong to the same great formation, and he has denominated it *cretaceo-oolite*. Similar strata have been observed farther north in Southern Peru by Mr. Darwin and M.

d'Orbigny, and there is a great fossiliferous formation fifteen degrees northward in Columbia which is considered to belong to the earlier stage of the cretaceous system. "Hence," says Mr. Darwin, "bearing in mind the character of the few fossils from Tierra del Fuego, there is some evidence that a great portion of the stratified deposits of the whole vast range of the South American Cordillera belongs to about the same geological epoch*."

One of the circumstances not the least interesting connected with the occurrence of these cretaceo-oolitic beds at this vast elevation, and in so greatly-disturbed stratification, is the evidence they afford of the elevatory and subsiding movements to which the strata constituting the Cordillera have been subjected. On this subject Mr. Darwin makes the following observations: "It is well-worthy of remark, that the shells contained in the limestone bed of the Cumbre series must have been covered up, on the *least* computation, by 4000 feet of strata. Now we know from Professor Forbes's researches, that the sea at greater depths than 600 feet becomes exceedingly barren of organic beings; hence, after this limestone was deposited, the bottom of the sea where the main line of the Cordillera now stands, must have subsided some thousand feet, to allow of the deposition of the superincumbent submarine strata. Without supposing a movement of this kind, it would moreover be impossible to understand the accumulation of the several lower strata of *coarse* well-rounded conglomerates, which it is scarcely possible to believe were spread out in profoundly deep water, and which, especially those containing pebbles of quartz, could hardly have been rounded in submarine craters, and afterwards ejected from them, as I believe to have been the case with much of the porphyritic conglomerate formation. I may add, that in Professor Forbes's opinion, the species of mollusca that have been described probably did not live at a much greater depth than 20 fathoms, that is, only 120 feet†."

But I have yet to call your attention to other and no less remarkable proofs of repeated upward and downward movements, not only of this great mountain-chain, but of the whole breadth of the continent. All the main valleys on both flanks of the Chilian Cordillera have formerly had, or still have, their bottoms filled up to a considerable thickness by a mass of rudely stratified shingle. In central Chile, the greater part of this mass has been removed by the torrents; cliff-bounded fringes more or less continuous being left at corresponding heights on both sides of the valleys. The thickness of the gravel forming these fringes ranges from 30 to 80 feet, and near the mouths of the valleys it is in several places from 200 to 300 feet. Almost everywhere the pebbles are perfectly rounded, occasionally they are mixed with great blocks of rock, and are generally distinctly stratified, often with parting seams of sand. The plain of Uspallata on the eastern side of the Cordillera, between that great range and the parallel lower range of Uspallata, at a height of 6000 feet above the level of the sea, with a breadth of from ten to fifteen miles, and extending with an unbroken surface 180 miles, is drained

* Page 234. † Page 193.

by two rivers passing through breaches in the mountains to the east. On the banks of one of them, the Mendoza, the plain is seen to be composed of a great accumulation of stratified shingle estimated at 400 feet in thickness. The origin of these accumulations of gravel Mr. Darwin considers to be inexplicable by debacles or ordinary alluvial action. He supposes that the sea formerly occupied the valleys of the Chilian Cordillera, in precisely the same manner as it now does in the more southern parts of the continent, where deep winding creeks penetrate into the very heart of, and quite through this great range; that the mountains were upraised in the same slow manner as the eastern and western coasts have been upraised within the pleistocene period; that on this view every part of the bottom of each valley will have long stood at the head of a sea-creek, into which the then existing torrents would deliver fragments of rocks, which, by the action of the tides, would be rolled, rudely stratified, and the surface of the mass levelled into successive sea-beaches; as the slow rising of the Cordillera would probably be interrupted by long periods of rest. He considers this to have been one of the most important conclusions to which his observations on the geology of South America have led him, "for we thus learn that one of the grandest and most symmetrical mountain-chains in the world, with its several parallel lines, have been together uplifted in mass between 7000 and 9000 feet, in the same gradual manner as have been the eastern and western coasts*."

On the western flank of the Uspallata range, at a height of 7000 feet above the level of the sea, Mr. Darwin discovered, in an argillaceous sandstone, a group of fifty-two stems of trees, part of them silicified, but the greater number changed into carbonate of lime, with cavities lined by quartz crystals. They project between two and five feet above the ground, and stand at exactly right angles to the strata in which they are contained, and which are inclined at an angle of 25°. Specimens which he brought home he submitted to the examination of Mr. Robert Brown, who pronounced the wood to be coniferous, partaking of the character of the Araucarian tribe, with some curious points of affinity with the Yew. The stems have in general nearly the same diameter, about fifteen inches, some twelve, others eighteen inches; they are grouped in a clump within a space of about sixty yards, and all stand at the same level. The strata in which they are contained rest on a thick bed of submarine lava; they are covered by indurated tuffs, passing upwards into a fine-grained purplish sedimentary rock, the united thickness of the argillaceous sandstone and tuffs being from 400 to 500 feet, and upon them is another mass of fine-grained basalt 1000 feet thick; and above this basalt Mr. Darwin could clearly distinguish five conformable alternations, each several hundred feet in thickness, consisting of sedimentary rocks and lavas.

What a wonderful chapter is this spot in the history of the earth! what a tale it tells of repeated elevations and depressions of the land on a vast scale, and all within a comparatively modern period in geological chronology! It is a document written in characters so clear, so intelligible, as to admit of no doubt of their true meaning. They

* Page 67.

are thus read by Mr. Darwin:—"These trees, now elevated to so great a height, have certainly been buried under several thousand feet of matter accumulated under the sea. They obviously must once have grown on dry land; and therefore what an enormous amount of subsidence is thus indicated! As the land, moreover, on which they grew is formed of subaqueous deposits, of nearly if not quite equal thickness with the superincumbent strata, and as these deposits are regularly stratified and fine-grained, not like the matter thrown up on a sea-beach, a previous upward movement, aided no doubt by the great accumulation of lavas and sediment, is also indicated." Did the limits I must observe permit, I could lay before you, from this most instructive volume, many other proofs of the oscillations through a vast vertical range to which the South American continent has been subject, from a period distinctly traceable back in this southern division of it to the oolitic period, and continuing to the present day.

One of the greatest outbursts of plutonic rocks, of syenitic granites and metallic veins, in so modern a period, with which we are acquainted, has been made known to us by Sir R. Murchison in his work on Russia and the Ural Mountains. The gold which is now collected in so great quantities on the eastern flank of the Ural Mountains has been brought to the surface in veins and disseminated through the substance of rocks in this comparatively modern period of geological history. In regard to the subsequent disintegration of these veins and rocks: "the nature of the auriferous shingle, with its subangular fragments, so completely resembles the detritus of lakes, and is so unlike the gravel formed on the shores of seas, that independent of the entire absence of any *marine* remains whatever, whether of tertiary or recent age, all along the immediate eastern flank of the Ural Mountains, there is no room for doubt that the gold detritus was accumulated during a terrestrial and lacustrine condition of the surface*."

The same author has shown by a large body of evidence, that at the time of the spreading of the northern drift over the then submerged country of European Russia, the glacial sea was bounded on the east by the then comparatively low chain of the Urals, which formed the rocky shore of a probably low continent on the east, from which powerful streams descended to the west, from the country we now call Siberia. The subsoil of that region exhibits palæozoic rocks only, covered in part by tertiary accumulations, but without any detritus of the carboniferous or Permian deposits, which cover the more ancient rocks in European Russia. This eastern country, then probably covered with forests, from its inferior elevation and the extension of the northern sea far to the south of its present limits, probably enjoying a climate considerably milder than that which now prevails, appears, from the vast quantities of their bones that are found imbedded in a fossil state over such a vast region, to have been for ages inhabited by large herds of the mammoth,

* Page 492.

rhinoceros, mastodon and aurochs. The country was then also covered to a considerable extent with freshwater lakes, the sites of which are now shown by depressions filled with the detritus in which the bones of these animals were entombed. "Whether discovered in the gravelly detritus or clay on either flank of the Urals, in the high banks of the great streams which respectively flow into Asia and Europe, or in still greater quantities on the sides of the estuaries of the great Siberian rivers upon the glacial ocean, in all cases the mammoths are found entombed in materials which, whether coarse lacustrine shingle near the mountains, or mud and sand at a distance from them, all announce in the most emphatic manner, that these great creatures lived in lands adjacent to lakes and estuaries, in which, during long ages, their bones were interred, and were sometimes carried out to sea and mingled with oceanic remains*."

The present watersheds between Europe and Asia were formed by an increased elevation of the Ural chain, at the time when these animals occupied this eastern land; and their destruction and extinction is ascribed by the author partly to the disturbance of the land by the upheaving forces, but mainly to the change of climate produced by its increased elevation, and its extension towards the north, the low lands of Northern Siberia having been raised above the water, and the shore of the sea consequently thrown much farther back within the arctic region. "In the depressions at the very foot of the chain, the mammoth skeletons are broken up, and their bones, together with those of *Rhinoceros tichorinus* and *Bos Urus*, are rudely commingled in the coarse shingle, derived from the mountains or in the clay above it. In proportion however as we advance into the plains of Siberia, or descend into the valley of the Tobol and the Obe or their affluents, these bones increase in quantity, and are at the same time in much better preservation.—The wide and low tracts of Northern Siberia, in which these remains are most abundant, were then beneath the sea, and the bones must have been drifted thither, and possibly for some distance.—All the low promontories between the Obe, the Yenesei and the Lena, which lie northwards of the ancient ridges and plateaux, were under the waters and estuaries at the periods when the mammoths ranged over the Ural, the Altai, and the adjacent region of Siberia then above the sea†."

The form of the ground where the detritus is accumulated, shows that it was deposited after the present configuration of the land had been to a great extent established, when the present valleys existed; for it fills up all the original inequalities of the inferior rocks, which in many places exhibit appearances of having been worn into holes and cavities, as if by the powerful action of water. The ground is composed entirely of the stony materials of the adjoining hills; there are no boulders of far-travelled rocks. It is usually from two to twelve feet thick, but there are accumulations of this detritus of more than fifty feet thickness. It is often covered by a thick mass of clay, and this last by peat and bog earth; so that as the

* Page 500. † Page 494–499.

Megaceros in Ireland and the Isle of Man is entombed in lacustrine deposits covered with peat, so are the extinct mammalia of Siberia in similar formations of a like age.

We learn from the recent observations of Mr. Lyell, that in the same modern geological epoch during which Siberia was inhabited by herds of the mammoth, rhinoceros and aurochs, the continent of North America was the abode of mammalia now extinct, their remains being found in deposits of gravel associated with existing species of fluviatile and terrestrial testacea, and also with marine shells of the same species as are now living in the neighbouring sea. Thus at Geneseo, in lat. 42° 50′, he saw the skull, ivory tusks and vertebræ of a mastodon, dug out of a bed of shell, marl and sand, the shells being all of existing freshwater and land species now common in that district*. He visited two other localities in Albany and Green counties in the state of New York, where the same remains had been found in similar circumstances. On the sea-shore near Savannah, he disinterred from a bed of clay the grinder of a mastodon, the clay resting immediately on sand containing marine shells of living species; and a tooth of the mylodon was found in the same spot. Farther south in Georgia, in lat. 31° 25′, two entire skeletons of the megatherium were met with. "It is evident," says Mr. Lyell, "from the observations of Mr. Hamilton Cooper and my own, 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 new land supported forests in which the megatherium, mylodon, mastodon, elephant, and a species of horse different from the common one, and other quadrupeds lived, and were occasionally buried in the swamps †." On the western side of the Alleghanies, in Kentucky, at the spot called the Big Bone Lick, in lat. 38° 50′, entire skeletons of extinct animals and the separate bones have been found in black mud, containing recent terrestrial and freshwater shells about twelve feet below the surface. "It is supposed that the bones of mastodons found here could not have belonged to less than a hundred distinct individuals; those of the fossil elephant (*E. primigenius*) to twenty; besides which, bones of a stag, horse, megalonyx and bison are stated to have been obtained. It is impossible to view this plain," Mr. Lyell adds, "without at once concluding that it has remained unchanged in all its principal features from the period when the extinct quadrupeds inhabited the banks of the Ohio and its tributaries ‡."

Dr. Daubeny read last year before the Ashmolean Society of Oxford a paper which contains an account of the extinct volcano of Rocca Monfina near Naples. It is very remarkable that a volcanic mountain of such magnitude as to be nearly 3300 feet in height, having a circular crater more than two miles and a half in diameter, with a conical hill rising from the centre high above the outer edge of the crater,

* Travels in North America, vol. i. p. 55.
† Id. p. 164.
‡ Id. vol. ii. p. 65.

should hitherto have been so little an object of attention, in a country so frequented, on the very borders of the Phlegræan Fields, visited and described by so many geologists. Breislak, in his 'Voyages Physiques et Lithologiques dans la Campanie,' published in 1801, refers to it cursorily, but does not appear to have examined it with any care; Dr. Daubeny himself, in his general work on volcanos, published in 1826, gives only a general outline of its structure in half a page; Mr. Lyell in his account of the volcanic district of Naples makes no mention of it*; neither does Friedrich Hoffman in 1832†, nor M. Dufrenoy in his 'Mémoire sur les Terrains Volcaniques des environs de Naples,' published in 1838. M. Abich appears to have been the first geologist who had examined Rocca Monfina with care; he spent three weeks in the investigation of it in 1838, and has given an account of it in his work published in the autumn of 1841, 'Ueber die Natur und den Zusammenhang der vulkanischen Bildungen,' which, though brief, is accompanied by two excellent maps. He tells us that M. Pilla of Naples, having seen his map, subsequently examined the mountain; and there is in the eighteenth volume of the 'Annales des Mines,' which appeared in the spring of 1841, an account of Rocca Monfina by M. Pilla; without however any mention of the labours of M. Abich, who had preceded him.

This mountain lies about 30 miles N.W. of Naples, immediately above the towns of Teano and Sessa, the river Garigliano washing its base. The summit of the conical hill that rises from the centre of the crater, called the *Monte de Santa-Croce*, was the stronghold of the Aurunci, who successfully resisted the power of Rome until A.U.C. 410. As vestiges of the ruined city are still to be seen, and as the Aurunci are mentioned at a very early period in Roman history, it is clear that there has been no eruption for at least 2500 years. The interior of the crater is covered with a fertile soil and clothed with vegetation, as is the central cone; and Dr. Daubeny tells us that the late Sir W. Gell observed to him, that "a nation like the Aurunci, to whom it was of essential importance to have near their city good pasturage for the flocks and herds, on which they depended for support, would never have selected Rocca Monfina for their capital, not only if the volcano itself had been in activity, but had not the stone which constitutes the interior of the crater been already in such a state of decomposition as to be covered with herbage, and to yield abundant crops." We have no means of estimating the period when the volcano was in activity, but this we know, that the mountain must have been formed by a sub-aërial eruption, that it has never since been submerged, and therefore that its age is posterior to that very modern period in geological chronology when the species of mollusca now found in the neighbouring sea were in existence, and when the country was inhabited by the elephants whose remains are met with in the superficial soil.

This volcanic group is continuous with, or rather included in, an offset of the Apennines, the celebrated *Mons Massicus*, composed of

* Principles of Geology, ii. ch. 11, 12.

† Geognostische Beobachtungen, published in 1839.

Apennine limestone. The external truncated cone is composed, according to Dr. Daubeny, who visited the locality, of an earthy volcanic tuff mixed with mica and occasionally pumice; a red ferruginous variety is sometimes seen in beds, alternating with the more common kind, and in one instance forming a kind of vein running vertically through the strata.

The external cone rises with a gentle slope from the base, attaining near the summit an inclination of 18°. The brim is more than 2000 feet high, and is complete throughout half the circumference, this portion of the original crater remaining perfectly intact. This part of the mountain is called Monte Cortinella, and by the map it appears to be continuous for more than three-fourths of the circumference, and Dr. Daubeny says that it may be traced in other parts throughout its entire circumference, except in one place. The outer brim is covered over with loose or compacted aggregates of volcanic sand, and of stones promiscuously heaped one upon the other. Blocks of a kind of porphyry, composed of a decomposing felspar, including large crystals of leucite and minute crystals of augite, are often imbedded in the tuff, and a little below the external margin there is a bed of this leucitic porphyry continuous for some distance. The external cone has a steep inner escarpment, forming the crater, enclosing a great plain, from the centre of which rises the conical mount of Santa-Croce, about three-quarters of a mile in diameter at its base, and rising to a height of 1082 feet above the inner plain, towering considerably above the brim of the crater at its highest point, in the Monte Cortinella. The plain is thus about three-quarters of a mile broad between the base of Santa-Croce and the escarpment. These measurements are not all contained in the memoir of Dr. Daubeny, they are partly taken from that of M. Pilla. The summit of the conical hill is exactly equidistant from all parts of the crest of Monte Cortinella. It is composed of a fine-grained compact rock, a trachyte containing much mica, and Dr. Daubeny assumes that the whole hill is composed of this rock; but as he tells us that, abrupt as it is, it is everywhere covered with vegetation, it is possible that it may not be of so simple a composition; a doubt I may be permitted to express, as he lays so much stress on the structure of this interior mount, in his theory of the formation of the group.

M. Abich, M. Pilla, and Dr. Daubeny agree in considering Rocca Monfina as a very perfect example of a crater of elevation. Dr. Daubeny thus expresses himself:—"The circumstance which, in a geological sense, attaches the highest interest to the structure of this mountain, is the support which it appears to afford to the *theory of elevation*."—"A conical mass of rock so considerable, and yet so completely circumscribed within the area of the crater, could only, as it would seem, have been brought into the position which it is seen to occupy, by being upheaved *all at once* from the interior of the globe, whilst in a semi-fluid or pasty state, but not in a condition of actual liquidity."—"Alternating strata of tuff and lava may indeed be imagined to build up in the course of time a mountain of considerable elevation, but a hill consisting of tuff alone, as appears to be the case with a large part at least of Rocca Monfina, could only have attained its present height in consequence of some elevatory movement subsequent to its ejection; and if this be admitted, we have before us, in the central trachytic rock of Monte della Croce, an agent calculated to cause such an upheavement, and itself hardly to be accounted for without such a supposition."

To this theory of the formation of Rocca Monfina, it appears to me that the following objections may fairly be urged. In the first place, the advocates of the theory of elevation have never yet been able to give a satisfactory answer to the general objection, so frequently urged, that if, by the application of a force from beneath, a series of horizontal sedimentary deposits were suddenly elevated, so as to form a conical mountain with a central cavity or crater, the brim of that crater could not be continuous; it must necessarily be rent by numerous fissures, that would be widest at the brim, become gradually narrower towards the base, and finally disappear. Now Dr. Daubeny and M. Pilla both describe the brim of the original crater, for a large part of the circumference, as unbroken—as "*absolutely intact*." In the second place, if the trachytic cone raised up the horizontal beds of tuff, although it is very possible that it might be in a pasty state and might protrude, still the beds of tuff it raised up would lie upon its sides all round. Now we are told, that not only is there no tuff on the Monte de Santa-Croce, but that it stands isolated in the centre of an area, with its base more than three-quarters of a mile from the inner escarpment of the crater. The height of the escarpment above the interior plain from which the Monte de Santa-Croce rises is not given; but whatever it is, the removal of the whole mass of materials from the space between the conical hill and that escarpment, has to be accounted for by the elevation theory; and it is not easy to conceive by what agency this could have been effected.

It would not be at all contrary to what has been seen in other volcanic mountains, if we suppose that the external cone was formed, in great part, by materials erupted from a central vent; that after a repose of some duration, there should be a subsidence in the interior, leaving Rocca Monfina in the same state as Vesuvius is represented to have been in the time of Strabo, as shown in the figure that accompanies Dr. Daubeny's memoir; that subsequent volcanic action, that had been long dormant, should again burst through the old vent, the weak part of the incumbent mass; and that lava in a pasty state should be protruded, which would settle into a conical form, if the whole of Monte de Santa-Croce be so composed.

Dr. Daubeny, in arguing in favour of the elevation theory, adverts to the marine fossil shells found on the sides of Somma, as a proof that that mountain was formed by the upheaval of sedimentary deposits. If such remains had been found in a continuous bed, the evidence would not have been conclusive, for Somma may have been a cone formed by submarine eruptions, since raised in mass; but it is admitted that the shells are found in loose blocks in the tuff, and also in the tuff itself. As the sand and comminuted matter ejected from existing volcanos are frequently found to contain infusorial remains, it is clear that the volcanic force has acted upon aqueous deposits lying above it in the interior of the mountain, which it has reduced to powder. It is not therefore an improbable supposition that the blocks on the sides of Somma are fragments of sedimentary strata broken up by the volcanic action and thrown up through the vent.

In conformity with the plan I have followed in this Address, were there not a sufficient reason in the length to which it has already extended, I ought not to enter upon the consideration of any of the works published in the last year that treat of the older formations; but I cannot deny myself the satisfaction of calling your attention to the memoir of Sir Henry de la Beche, which I have already alluded to, on the formation of the rocks of South Wales and South-western England, for I consider it the most comprehensive and most important work relating to this period in the Geology of England which has appeared since the publication of the 'Silurian System' of Sir Roderick Murchison. It is the first of the series of essays in the first volume of the 'Memoirs of the Geological Survey of Great Britain,' and occupies 300 closely printed large octavo pages, so that the mass of information it conveys is immense. Four-fifths of it refer to the palæozoic rocks, and the igneous rocks associated with them; in the remainder of the essay there are many valuable details respecting the New Red Sandstone, for which the author retains the name given by the Rev. Wm. Conybeare of the *Poicilitic* series, and also respecting the lower parts of the Oolitic series, that occur westward of a line drawn from Lyme Regis to the borders of Shropshire. Even a brief analysis of the most important parts of this essay would extend far beyond the space to which I must limit myself. As a topographical guide and companion to the geological map of the Survey, the memoir is invaluable; and it abounds in proofs how eminently fitted the author is to teach others "how to observe in geology." I know no portion of any country the geology of which has now been more thoroughly examined and described than the west of England; and I cannot conceive a more instructive or more agreeable occupation for a geologist, whether he be already well-versed in the science, or be a student acquainted only with the elements of it, than to travel through these western counties and South Wales, with the geological maps and sections of the Survey, this volume of memoirs, Sir Henry de la Beche's former report, the joint memoir of Sir R. Murchison and Professor Sedgwick on the Physical Structure of Devonshire, and the 'Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and West Somerset,' by Mr. Phillips. When he arrives at the places of which they treat, he will also find most valuable assistance from the papers of Austen, Lonsdale, Buckland and Conybeare, that treat of this country.

Although I am unable to lay before you even an outline of that which may be learned from the study of the memoir of Sir H. De la Beche, I will call your attention to some parts of it which appear to me of special interest.

The first I shall advert to are the proofs he brings forward of extensive volcanic action throughout the whole series of the palæozoic rocks. There is evidence, he tells us, "that during the period when the Llandeilo flags and their equivalents in the Silurian system were accumulated over the area extending from Malvern to Pembrokeshire, volcanic points existed from whence molten matter and often ashes were ejected, and were intermingled with the detrital accumulations of the period;" that "trappean ash, the volcanic ash of the period, was mingled with the gravels and sands now forming conglomerates and sandstones, that it was accumulated in beds, interstratified with mud and sand, and that the remains of the crustaceans of the day are found in it." This ash, moreover, he is of opinion points to *sub-aërial* volcanos, and probably therefore to land from which it may have been carried within a moderate distance*. This ash often covers an area of great extent. The facts of the contemporaneous existence and interstratification of igneous rock with the fossiliferous and inferior slates had been before pointed out by Professor Sedgwick and Sir R. Murchison, and the latter in his 'Silurian System' frequently adverts to the intermingling of volcanic ashes; but, if I am not mistaken, Sir H. De la Beche is the first who has pointed out the probable existence of *sub-aërial* volcanos at that remote period of the earth's history; that is, active volcanos on land, prior to the eruption, as I shall presently mention, of the granite of that region, which at no distant period geologists were accustomed to consider as the deep-laid foundation on which all the superincumbent slates rested; on which slates also the venerable name of primitive was conferred.

Ascending in the series, he describes Devonian strata near Tavistock, argillaceous slate and limestone intermingled with fused trap and ashes, a pumice filled with carbonate of lime, and the remains of mollusks in ashes; and much ash and vesicular igneous rocks are intermingled, he says, with the beds of the South Devon limestones†.

Treating of the carboniferous series, he describes Brent Tor as presenting a mixture of trap rocks, ash, and a conglomerate containing vesicular portions of igneous rocks, which approach the condition of pumice; and adds that "these rocks are associated in a manner such as is often seen in volcanic countries ‡."

The author is of opinion that the protrusion of the granite of Cornwall and Devon clearly took place after the deposit of the coal-measures of Devon, and anterior to that of the Newred sandstone series. "The Devon and Cornish granites," he says, "seem to have been thrust up through points of least resistance, in a line extending from the southern part of Devonshire to the Scilly Islands, part having protruded through the weakest places, and the remainder still concealed beneath, supposing this granite connected below, at moderate depths, during the whole distance §."—"From the Scilly Islands to Dartmoor inclusive, we seem to have the upthrust of one mass, which found points of less resistance amid the superincumbent accumulations more in some places than in others. As the masses rose, the edges of the detrital, trappean and

* Pages 30 to 35. † Pages 84 to 90. ‡ Page 137. § Page 228.

calcareous beds against which they pressed were frequently fractured, and into the fractures the granitic matter was forced, forming the granite veins, as they have been termed, which can often be traced terminating in somewhat fine threads; so that not only was the pressure great, but the fluidity of the igneous rock sufficient to pass into small rents and cracks." He makes the following important remarks:—"When we observe the mode in which the granites of Cornwall and Devon have been brought into their present position, it is evident that they have not been intruded in the manner so common among the trappean rocks in this region. We have nothing resembling the accumulations of ashes or cinders, nor the lines and masses affording sections like those of upturned lava streams or sheets of matter ejected from craters, and widely covering subjacent detrital or calcareous accumulations*."

The following cases of metamorphic action and the observations of the author upon them are highly interesting:—"Some of the changes of the sedimentary deposits, effected by the heated molten rock in juxtaposition, have even amounted to a melting of such rocks and their consequent incorporation, in part, with those in igneous fusion at the time. There can be little doubt that detrital rocks, chiefly composed of felspathic matter, have been so melted between two masses of greenstone, greenstone porphyry, and vesicular trap, as to form one body with them, their original bedded character appearing both on the north and south, and the change from the one condition to the other being very gradual. Great care is required, while studying this portion of country, not to confound trappean substances with true fused rocks, since organic remains are to be discovered in many beds which, at first sight, perfectly resemble those which have undergone fusion. Some colourless argillaceous accumulations have become by metamorphic action large natural beds of biscuit china, the elementary substances being the same as a potter might employ for the purpose. Rocks of this class, though not of the finer varieties, are seen to contain crystals of felspar, so as to constitute a sort of porphyritic slate; a kind of alteration showing, that the conditions attending it were such as to permit a movement of particles; so that some of the component elementary substances could adjust themselves in a definite manner, and complete the crystallization of the compound formed, while the remainder retained a coarse porcellanic character, the body of the rock keeping the lamination due to the original deposit of fine detrital matter from mechanical suspension in water†.

There are many other observations throughout the work on chemical action, exemplified in many of the phænomena described, which are very important, as leading to a more correct understanding of the true nature of the rocks. I will give as examples those that relate to the colouring matter of the greenish-blue bands and spots of the red-sandstones, and to the formation of clay-ironstones. A large extent of country, in Herefordshire, Shropshire and South Wales, is covered by the old red sandstone deposit. It is estimated that there is an unbroken surface of 2100 square miles, and taking the average thick-

* Page 232. † Page 33.

ness of the mass, as it appears from measuring the beds vertically to their outcrop, there are more than 1500 cubic miles of, chiefly, red-coloured detrital matter. These beds afford, comparatively, few animal remains, and those chiefly in the lower portion, while below them are a series of strata often teeming with organic remains. No sooner did these red-stained beds cease to be deposited than marine creatures again resorted to the waters above them, as we see by the carboniferous limestone that rests upon the old red sandstone. A great change of physical conditions therefore must have taken place from the commencement of these red beds. Peroxide of iron mechanically suspended in rivers is known to be fatal to the animals previously living in them. We can thus account for their great rarity both in the old red and new red sandstone series; but as yet nothing has been discovered to lead us even to conjecture whence this enormous quantity of iron in deposits formed out of the detritus of pre-existing rocks has been derived. Analyses show that marls of the old red sandstone have yielded 6 per cent. of peroxide of iron, and those of the new red nearly 10 of peroxide and 4½ of protoxide. But there is a well-known character common to both, that which is the origin of the term poicilitic as applied to the new red sandstone, viz. the prevalence of layers, stripes and patches of a bluish-green and grey colour; the cause of which has hitherto been a matter of great difficulty to account for. Sir H. de la Beche states that Captain James, R.E., has pointed out the probability that the clefts and joints of the rocks are changed from red to bluish-green by the percolation of water charged with vegetable matter, which, under certain conditions, changes the peroxide into a protoxide*. "With the knowledge," he says, "that under the conditions where vegetable acids are forming in contact with peroxide of iron, the latter is robbed of part of its oxygen, and converted into a protoxide, it is interesting to consider if the colours of these greenish bands (often very marked, and continuing over the same planes amid the red rocks for considerable areas, showing the operation of some common and widely-spread contemporaneous cause over them,) may not be due to a change produced upon the peroxide of iron by vegetable matter. Throughout the Silurian rocks, and above the black slates (formerly black mud), wherein carbon is found, we cannot suppose the animals whose remains are often so abundantly entombed in the mud, silt and sand of the time, to have existed without marine vegetation, though we commonly find no trace of it, the vegetation with the soft parts of the animals having been decomposed, partly into acids, and partly into different gases, which if coming into contact with peroxide of iron would convert it into protoxide," the state in which it exists in the bluish-green parts of the sandstones. Some analyses of the blue marl, conducted in the laboratory of the Museum of Economic Geology, led Dr. Lyon Playfair to remark that the carbonic acid is greater in the blue than in the red marl, because the carbonic

* Since this Address was delivered, I have been reminded that Mr. J. Dawson of Pictou, in a paper read before this Society 22nd January, 1845, suggested that the bleaching of the red-sandstone may have been caused by the decomposition of vegetable matter.—Quart. Jour. of Geol. Soc. i. 327.

acid from the decaying vegetable matter has united with protoxide of iron to form the carbonate*.

On the theory of the formation of the ironstone bands and nodules of the coal-measures, which, as you know, often contain impressions of plants and also freshwater shells, our author makes the following observations:—"The clay or argillaceous ironstones are formed of carbonate of iron, mingled mechanically with earthy matter, commonly corresponding with that constituting the shales with which they are associated. In many of the underclays of the coal the ore occurs in nodules irregularly distributed. Mr. Hunt, of the Museum of Economic Geology, instituted a series of experiments to illustrate the production of these clay ironstones, and he found that decomposing vegetable matter prevented the further oxidation of the protosalts of iron, and converted the peroxide into protoxide of iron, by taking a portion of its oxygen to form carbonic acid. Under the conditions necessary for the production of the coal distributed among the associated sand, silt and mud, the decomposition of the vegetable matter would necessarily form carbonic acid among other products. This carbonic acid mixed with water would spread with it over areas of different dimensions according to circumstances; forming salts and meeting with the protoxide of iron in solution, it would unite with the protoxide and form a carbonate of iron. The carbonate of iron in solution would mingle with any fine detritus which might be held in mechanical suspension in the same water, and hence when the conditions for its deposit arose, which would happen when the needful excess of carbonic acid was removed, the carbonate of iron would be thrown down mingled with the mud †." If not in sufficient quantity to form continuous beds, it would aggregate into nodules, and be arranged in planes amid the mud, in the same manner as is so commonly seen to be the case with argillaceous limestones and nodules of various geological ages.

PALÆONTOLOGY.

During the course of the past year several important contributions have been made to this department of our science, both at home and abroad. Through the liberality of Mr. Richard Griffith, a valuable account has been published of the Silurian fossils of Ireland, drawn up by Mr. McCoy, and illustrated by excellent figures. Numerous new species, many of them of great interest, are described, and the localities from whence the specimens had been collected are fully stated. This work throws new light on the relations of the English and Irish Silurian strata.

In the Journal of our Society for the year 1846 are many contributions to British palæontology, but to these it is unnecessary for me to refer. In the course of the year, the first number of a new periodical work appeared, 'The London Geological Journal and Record of Discoveries in British and Foreign Palæontology,' which contains some interesting communications respecting new British fossils from Eocene, Cretaceous and Permian strata. We find in it a memoir by Mr. Serles Wood, in which he has announced the discovery of an

* Pages 51, 52, 53, 255, 264.

† Page 185.

alligator and of several new mammalia in the eocene beds of Hordwell Cliff in Hampshire; of a new Bulimus from the same formation near London; of a species of Mososaurus from the chalk of Essex by Mr. Charlesworth; of a new species of Ichthyosaurus from the lower chalk in the vicinity of Cambridge; and Mr. King of Newcastle on Tyne has made known to us the existence of a Chiton in the magnesian limestone of Sunderland, a genus of very rare occurrence in the fossil state, and of which a Silurian species has been described by Mr. Salter in a paper read before us last June, and published in the number of our Journal which appeared on the 1st of this month.

On the Continent, new works on palæontology appear in rapid succession. Among the most recent, the 'Palæontographia' of Durker and Von Meyer, and the 'Petrefactenkunde Deutschlands' of Professor Quenstedt may especially be mentioned, on account of the beauty of their illustrations. The latter work contains excellent figures and careful and fully-detailed descriptions of fossil Cephalopoda. The researches of Beyrich on Trilobites and of Volborth on Cystidea may also be noticed on account of their interest to the student of British palæozoic fossils. Numerous new Trilobites have been described in a little work on the Silurian strata of Bohemia by M. Barrande, well-worthy of the attention of the geologists of this country; but it is very desirable that figures of the new forms therein announced, and too briefly described, should be speedily published.

One of the most valuable contributions to palæontology from the Continent, during 1846, is the admirable account of the fossils of Petschora by Count von Keyserling, illustrated by excellent drawings, forming a worthy supplement to M. de Verneuil's researches in Russian palæontology.

It now only remains for me, before quitting this Chair, to express to you my deep sense of the obligation I am under to you, for the pleasure I have had during the last two years in the discharge of the duties of your President. I became a member of this Society a few months after its foundation, now nearly forty years ago, and the active part I have lately had to take in the management of your affairs has renewed the pleasures I enjoyed as one of the secretaries, in my younger days, for nearly six years. To the Geological Society I am directly and indirectly indebted for some of the chief sources of my happiness throughout the greater part of my life; and gratitude alone will prompt me to lose no opportunity of advancing its honour and usefulness, were I ever to cease to take an interest in the progress of our science; an abandonment of an old attachment which I shall not contemplate as possible. It gives me much satisfaction, that, by the choice you have just made, I am to be succeeded by my distinguished friend Sir Henry De la Beche; one so able, and so determined, I am convinced, to show during his presidency, that this Society continues to be a powerful instrument for the advancement of geological science, a centre of good fellowship, and a band of independent scientific men, who will steadily and fearlessly promote the cause of truth.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

June 3, 1846.

W. Salter, Esq., W. Chambers, Esq., C. Buchanan, Esq., and J. C. Cunningham, Esq., were elected Fellows of the Society.

The following communication was read:—

On the Silurian and Associated Rocks in Dalecarlia, *and on the Succession from Lower to Upper Silurian in* Smoland, Öland, *and* Gothland, *and in* Scania. By Sir Roderick I. Murchison, G.C.S., V.P.G.S. &c.

Plate I.

Having already communicated the additional knowledge I obtained last year (1845), concerning the drift and erratic blocks of Sweden*, I propose in this memoir to give the results of the examination of those palæozoic and associated rocks in several parts of that country which fell under the joint observation of my friend M. de Verneuil and myself during the same period.

Two of the districts under review have not been critically examined since they were described by Hisinger; and his memoirs being in the Swedish language, with which few persons are familiar, and having been written before the palæozoic classification

* See Quarterly Journal of the Geological Society, vol. ii. p. 349.

was established, no apology is required for the present attempt to group correctly all the ancient sedimentary deposits in those tracts, and to show what additions have been made to our knowledge of them by recent researches*.

In a memoir communicated to this Society in the year 1844, and in the first chapter of the work on Russia, I endeavoured, partly by personal exploration, and partly by the inspection of fossils in the Museums of Stockholm and Christiania, to group the palæozoic masses with Lower and Upper Silurian strata. But as an additional survey could not fail materially to improve my acquaintance with these deposits (particularly as I was on the last occasion accompanied by my able associate, M. de Verneuil), I now place the main results of our last tour before British geologists. These results coincide with the general view of the Scandinavian succession which was before propounded, and which is clearly developed near Christiania in Norway. But I have still to describe peculiar features which exhibit, on the one hand, the rupture and isolation of the strata in Dalecarlia and Scania, and on the other, the unbroken and symmetrical succession of the *whole Silurian system* which Scandinavia affords, and which is exhibited in sections proceeding from Småland on the main land of Sweden, through the great islands of Öland and Gothland.

The sedimentary strata to be described occupy three tracts topographically distinct and distant from each other :—1. Dalecarlia and the adjacent districts in the north ; 2. a part of Smoland and the adjacent islands of Öland and Gothland ; and 3. Scania, the southernmost part of Sweden.

In all these tracts Silurian rocks abound, and in the northernmost of them (as in Norway) there are also vast thicknesses of Old red sandstone. These deposits (like others which I have previously described in Norway and the western and central parts of Sweden†) are separated from each other by great regions of crystalline rocks, the chief masses of which, as before demonstrated, are of *azoic* characters and of age anterior to the lowest fossiliferous strata.

Not pretending to be able to describe in detail, the various characters of the crystalline rocks in the vast intermediate spaces, I have not attempted to give a coloured map of the districts under

* Professor Eichwald of St. Petersburg visited Gothland about three years ago, but although he has alluded to its organic remains, he has given no sections of the island. In the last summer, and two months before M. de Verneuil and myself went thither, the island was examined in some detail by Col. Helmersen, whose account of it has been communicated to the Imperial Academy of Sciences of St. Petersburg. Whilst this author, the chief fossils of whose collection we examined at St. Petersburg, entertains ideas resembling those we have adopted, in believing the beds to be on the whole equivalents of the Upper Silurian, there is a point of some importance as to the details of succession which will be discussed in the sequel, on which I differ from my distinguished friend and fellow Academician.

† See Quart. Geol. Journ., vol. i. p. 468, and Russia in Europe, vol. i. p. 15.

consideration; and as my sole object at present is correct classification and not topographical accuracy, the precise limits of such deposits are left to be subsequently defined by Swedish observers. At the same time, whilst it is hoped that the accompanying diagrams (see Plate I.) will sufficiently illustrate the chief phænomena and the order of the strata, the reader will do well to refer to Forsell's map of Sweden*.

1. *Dalecarlia and the surrounding country.*

The portion of Dalecarlia in which transition rocks are known to occur (from the descriptions of Hisinger accompanied by a detailed map), includes the extensive parishes of Rättvik, Ore, Orsa, Mora and Sollerön; or in other words, it is the country circumscribed by and in parts extending beyond the Lakes Siljan, Orsa-sjön, Skatunge, Oresjön and Garsjön. These lakes, fed by streams from the higher country, are nothing more than expanded and gently meandering tributaries of the great river Dal-Elv, which flowing from west to east to the south of Fahlun, finds its way, through other and smaller lakes, to the Baltic Sea south of Gefle.

Bounded on the south, the east and the north by regions of gneiss and other slaty crystalline rocks, as well as intercalated granites and greenstones of different dates, the chief palæozoic rocks of this tract of Dalecarlia form merely a ragged belt surrounding a dome of porphyry. Surrounded by the lakes in question, this dome is a nearly circular mass of about twenty English miles in diameter, the inner portion of which has been left blank upon the geological map of Hisinger. From all that we could ascertain by examining its edges, or by information from persons who have penetrated further than ourselves (there being no roads in the greater part of these woodlands), this district is occupied by granitic as well as porphyritic rocks, which, to judge from the evidences that fell under our notice, must all have been erupted, or at all events were thrown up posterior to the deposit of the Silurian strata, and probably after that of the Old red sandstone.

The crystalline central dome-shaped mass rises to about a thousand feet above the sea, and contains some small upland lakes or tarns. On the whole, this tract is geologically analogous to the central masses of the Christiania district already described, wherein porphyritic, hypersthenic and younger granitic rocks have burst through, and dislocated the Silurian strata.

In the Table attached to his Map, Hisinger has correctly represented

* I must here express my great obligations and those of my friend to Baron Berzelius, who not only furnished us with Hisinger's district maps, but also gave us every facility for examining the collections under the superintendence of Professor Mosander and Professor Lovèn, and further made us known to M. Sefström and M. Weggelin. The latter gentleman, who has examined the rocks of Dalecarlia in some detail, gave us some useful notes respecting them.

the presence of three members of the sedimentary deposit, viz. sandstone, lerskiffer (black schist) and limestone, but does not state whether they were accumulated in that ascending order. Indeed, without the knowledge that has since been obtained concerning the true order of these formations in Britain, Russia and other countries, and its application to less disturbed districts of Scandinavia, no one could venture to form even a well-founded conjecture of the Dalecarlian succession. Thus, although the chief members of the lower sedimentary strata are clearly referable by their fossils to portions of the Lower Silurian group, they are here more insulated than in any part of Europe I have examined; no example having yet been detected of more than two contiguous sub-groups whose relations are determinable. After this preliminary notice, I will now briefly describe a few natural sections which indicate these dislocations.

The low country adjacent to the eastern shore of the Lake Siljan is covered with debris (in parts a perfect Os); but a little above the hamlet and post-house of Uitby, and thence ranging along to the farms of Alsarby (see Plate I. fig. 1), courses of limestone and shale (*c*) are exposed on the lane sides and in the farm-yards, the beds being nearly vertical as you ascend the hill, but less highly inclined at a lower level. These strata consist in parts of thin-bedded, earthy limestone with shelly way-boards, in some parts of red and in others of grey colour, in which the large *Orthoceratites duplex* (*O. communis*, His.) and the *O. trochlearis* occur, together with the gigantic *Asaphus tyrannus* (nob.), (*A. Heros*, Dalm.), *A. expansus*, *Orthis calligramma* and other forms. These fossils leave not the slightest doubt that the strata in question are identical with those of the chief limestone at Kinnekulle, which there, as in numerous other tracts, form the central or principal mass of the Lower Silurian group of Sweden. But the relation of this limestone to inferior or superior deposits is invisible; the slope towards the lake being entirely covered up with detritus, whilst between the calcareous ledge of the higher hill of granite (*q*) there is also a rough talus of angular fragments of that rock.

Seeing, however, the vertical and dislocated position of the beds, which here range from N.N.E. to S.S.W., in conformity with the general outline of the shoulders of granitic rock on the east, and further observing that this latter (*q*) is a red unstratified younger granite or granitello, the masses of which *in situ* are visible at a few paces from the limestone, little doubt was entertained, on our very first inspection, that the granite (*q*) had been protruded posterior to the limestone (*c*)—a conclusion to which we were led by all the other sections we made.

In the lower country, extending from Uitby to Rättvik and in the valley to the north, the shale inferior to the limestone is visible, whilst at Rättvik the limestone again crops out. Following the outline of the lake and passing another promontory of granite which cuts off the limestone and here advances nearly to the water, the ground beyond it on the west subsides into the low fertile holm of

Skärberga. The strata on the shore are there seen to consist of the same limestone as that which occurs at Uitby and Rättvik, but the dip is entirely changed. The beds being inclined only 22° to 25° to the N.W., expose in successive ledges a thickness of 40 or 50 feet of limestone; the uppermost being of red and green mottled colours with marlstone, and the central or thicker beds (1 to 2 feet each) of deep red tint. These beds are loaded with gigantic Orthoceratites (*O. duplex*), some of which are more than 3 or 4 feet in length, and with these are associated other fossils, including *Lituites convolvens*, a form well-known in the Lower Silurian rocks of St. Petersburg.

At the adjacent hamlet of Vickarby and between that place and Oya, shale and limestone are to be observed, but not in juxtaposition; the former a black schist (lerskiffer) on the banks of a rivulet north of the road, the latter on the high road to Mora, and about three-quarters of an English mile beyond Vickarby, where a rock similar to that before described, but containing a few fossils, is seen in highly inclined strata, striking east and west, and at only ten paces from the granite from which it dips away rapidly to the S. and S.W.

In all the hilly and rugged tract which intervenes between this spot and Mora nothing is observable save the detritus of granitic and other crystalline rocks; and though faint traces of the Lower Silurian beds are visible near Mora and Vika on the western side of the Lake Siljan, I will at once refer to the natural sections exposed in the isle of Soller, near the western extremity of the lake of that name, as they are among the best which can be observed in this region, for the purpose of developing the relations of the different beds of the Lower Silurian rocks to intrusive granite.

This isle, about a Swedish mile or nearly six English miles in length from S.E. to N.W., consists in its south-eastern part of that variety of granite (composed of greenish-white and pink felspar, mica, quartz and hornblende) which is called "granitello" by the Swedish mineralogist Erdmann. This mass, rising to about 200 feet above the lake, is flanked at lower levels towards the N.W., first by a band of limestone and next by one of sandstone.

The church and chief portion of the village stands on the northwestern edge of the granite, and a very little below them, limestone, identical with that of Vickarby and chiefly of a reddish colour, is seen in a sloping plateau inclined to the N.W., W.N.W. and N.N.W. at angles varying from 5° to 14°. This red rock affords the usual Orthoceratites (*O. duplex*); whilst a grey and greenish variety, found at a somewhat lower level, is charged not only with *Orthis regularis* and *O. moneta*, but also with the *Sphæronites aurantium*, a species of Von Buch's family of Cystidea, which at Kinnekulle and elsewhere in Sweden, as at Petersburg, is typical of the Lower Silurian formation.

A single traverse of these strata on one parallel might lead to the belief that the granite was the fundamental rock of the isle, and that next to it in ascending order of age came the great Orthoceratite limestone and Sphæronite beds, and lastly the sandstone, which lies in the low promontory to the N.W. By passing, however, along the granitic escarpment and by tracing the junction of that rock with the sedimentary strata, we saw that such an interpretation was fallacious.

The dip is there found to vary according to the form of the masses of granite against which the beds of limestone abut; and by following these beds to the N.E. it is at length clearly seen, that the granite has been irregularly thrown up against the edges of different beds of limestone which have been folded and contorted around the intrusive rock in different directions. We also observed, that instead of passing under the sandstone, the limestone was cut off by a line of fault parallel to the granitic scarp, which so ranges athwart the isle as to come up to the limestone on the N.E. shore of the isle. This fault probably ranges downwards into those bituminous schists (lerskiffer) which in so many parts of Sweden lie beneath the Orthoceratite and Sphæronite limestone, and surmount a sandstone which is the fundamental Silurian rock in all other tracts of Sweden where the strata lie undisturbed (the Slepsten or whetstone of Dalecarlia). One or two small quarries of this whetstone are visible in the low grounds, and it is, as elsewhere, a fine-grained whitish and yellowish sandstone with a few flakes and patches of green marl. Though much traversed by diagonal joints, the strata present no other appearance of inclination or disturbance; for the quarries lie at some distance from the granite.

The transverse section (Pl. I. fig. 2) sufficiently explains the relations of the rocks in the isle of Soller. 1st, the sandstone (*a*) is the same which almost invariably underlies the bituminous schists in other provinces of the kingdom; 2nd, the place of the bituminous schists is occupied by a fault, indicated by a line of morass, peat, bog and water; 3rd, the red Orthoceratite limestone and the grey Sphæronite rock (*c* and *c**) really form the uppermost strata of this isle, the granite having been irregularly upheaved through them.

In following the Lower Silurian limestone northwards to Orsa, the red Orthoceratite beds are seen at Watnäs in a vertical and highly elevated position, striking N.E. or N.N.E. and S.S.W. This calcareous ledge, rising out from beneath a gradual slope of detritus towards the lake of Orsa on the west, is succeeded on the east by many rolled fragments of conglomerate and porphyry. On ascending however to the hill top or ridge of the Degeberga, we observed in a rugged mountain road (and for more than an English mile) a succession of peculiar strata whose strike was conformable to that of the Orthoceratite limestone, and also highly inclined (see Plate I. fig. 3).

Some of these beds (*x*) are undistinguishable from quartz rocks; others resemble highly crystalline hard red sandstone; others, again, might be mistaken for what would usually have been called grauwacke grits and fine conglomerates, the whole being more or less thin-bedded and containing some strata passing into cherty and flinty masses, and others into hornstone, &c. These highly inclined and altered beds are thrown off by syenitic granite (*q*), which seems to pass on the north into a porphyry. The natural inference from this section (if it occurred in an undisturbed region) would be that the beds of sandstone and conglomerate were of older date than the fossiliferous Lower Silurian rocks; but subsequent observation rendered this point very doubtful. By following the Orthoceratite Silurian limestone upon its strike to the N.E., it was evident, that upon the shoulder of the Degeberga above Wängsgårde, the porphyry of that mountain (a red felspathic rock) was in absolute contact with the limestone, which is there a thin-bedded rock, having somewhat the aspect of marble, but still offering no very distinct evidence of having been altered. That the strike and inclination of these beds had been deranged and changed by the invasion of the eruptive rock was made more evident, by trending the flank of the headland of porphyry which sweeps eastwards from the valley above the vale of Orsa, where we found that the limestone also changed its direction and wheeled round to the E.N.E., the strata dipping from 50° to 75° to the N.N.W. In one spot, indeed, we observed the edges of the calcareous strata expanded over a width of not less than 250 paces on the slopes of the hill or between the porphyry and the lake; both the red Orthoceratite rock, the gray and green limestone with Lituites and other fossils being exposed. Again, between this spot and the valley of the Ore we saw (near the village of Enon) portions of a black schist charged with Graptolites and a very minute Orthis, which seemed to overlie the limestone, a small advanced promontory of which we detected in a highly inclined position striking across the brook above the bridge from N.N.E. to S.S.W. But on ascending the banks of this stream (which is not marked either in the maps of Forsell or of Hisinger), we looked in vain for any connection of those masses with the great body of Orthoceratite limestone higher up the hill to the south. The stream is seen to run through a gorge of porphyry, the protrusion of which has evidently dismembered the strata. Here, as elsewhere then, we had to decipher the probable original relations of mere detached fragments of the Silurian rocks, and all that we could determine from their character and fossils was, that as a whole they clearly belonged to the Lower Silurian group. We next proceeded along the central dome of eruptive rocks (porphyry in one part and granite or granitello in another) on its northern and eastern faces, first by ascending the Ore Alf from Orsa to Skatunge, and thence by following the road from the latter place to Ore, Osmundsberg, Böda and the waterfall called Styggfors, in order to connect if possible the whetstone and shale of the valley with the well-known horizon of the Orthoceratite limestone*.

Judging from the deep incoherent sands, devoid of nearly all other detritus, which occupy the lower part of the valley, and have the appearance of being nothing more than the disintegration of the whetstone or "Slepsten," that rock may be presumed to form the basis of the lower and undisturbed portion of this tract. For, on

* From the mouth of the river Ore this whetstone is largly exported, being conveyed by the Orsa and Siljan lakes to different parts of Sweden.

proceeding a few miles and ascending to Skatunge, we reached quarries of the whetstone, in one of which the reddish or pinkish variety is obtained, and in the other the usual fine white sandstone. This rock is very irregularly bedded, traversed by innumerable devious joints and affected by slickensides. Though of pinkish and reddish colours, the fine-grained, soft, non-micaceous character of the rock was quite the same as that which characterizes the Lower Silurian sandstone in many parts of Sweden where that rock (as previously shown *) forms the base of the fossiliferous series, like which it is here charged with flakes and spots of whitish and greenish clay, and is occasionally irregularly laminated with white and greenish-white lines.

At Skatunge, or a mile only in advance of those quarries, but at a higher level, the " Slepsten " or fine sandstone is no longer visible, and its place is apparently occupied (see Pl. I. fig. 4) by a red felspathic porphyry (*p*), regularly bedded and jointed, striking east and west (in conformity with the outline of this portion of the porphyritic dome), and dipping 60° to the north. The succession on the dip is obscured for a short distance; but on the grassy slopes and fields below the village calcareous and sandy beds with Orthoceratites and other fossils (*c*) are overlaid by black shale, the whole dipping north and being conformable to the porphyry (*p*), by which they have unquestionably been thrown off.

As if to add to the confusion within the area of dislocation, we observed on the road hard micaceous flagstones, perfectly unlike the soft whetstones described, which the peasants had extracted from the adjacent low hills, where, as in Norway, they are associated with porphyry; and as these rocks were wholly unlike anything seen in the Silurian series of other parts of Scandinavia where the relations are clear, and were undistinguishable from well-known specimens of Old red sandstone in Norway where its position is distinct, we began to infer that these as well as the highly inclined beds of red sandstone and conglomerate seen near Wattnäs (Pl. I. fig. 3) might belong to that formation, to the abundant presence of which in another part of this country I shall presently allude.

But although most of the porphyry of this tract, like the " rhombic porphyry " of Norway, has evidently been protruded after the deposit of the Old red sandstone, it must be observed that near Mora we found a very large rolled block of a hard coarse red conglomerate containing fragments of porphyry, thus showing that there must also have existed a rock of that character which had been consolidated anterior to the accumulation of the Old red sandstone. Some of these porphyries, as in Pl. I. fig. 4, may, therefore, have been formed contemporaneously with the Lower Silurian or protozoic strata †.

* See Quarterly Journal of the Geological Society, vol. i. p. 15; and Russia and the Ural Mountains, vol. i. p. 15 *et seq.*

† According to M. Erdmann of Stockholm, who kindly explained his views to me, there are three chief varieties of porphyry only in Sweden; viz. felspar, hornstone, and jasper porphyry, each of which has been erupted posterior to the primary or azoic rocks.

In travelling from Skatunge to Ore we crossed a tract marked as limestone by Hisinger, but that rock is no way visible from beneath coarse detritus (as far as we could observe), except in the bed of the stream, which at about three English miles east of Skatunge flows from the porphyry dome or plateau into the lake of Skatunge. The bridge by which the road crosses this stream at a spot called Lada-Oken, is arched over upon ledges of red Orthoceratite limestone, which there dip to the N.N.W. at 15°, but on ascending the bed of the rivulet amongst a chaos of fallen trees and rank vegetation, the same beds were found to be completely wrenched round even in a hundred paces, dipping first to the east and afterwards to the E.S.E.

These strata doubtless owe their contortion to the influence of the contiguous porphyry, which a little further east (in the tract called Ruttberge) rises and occupies the surface of the higher grounds in a multitude of small spherical domes. No sooner were we on these hard knolls than we observed their surface to be striated in the manner described in my last communication, and here most unquestionably the direction of the striæ was from N.N.W. to S.S.E., the direction which the great mass of the drift has taken in this part of Sweden.

These rounded porphyry knolls are miniature representations of the entire dome, around which the fragmentary masses of the Lower Silurian rocks can be traced. In one spot we observed (almost in contact with the porphyry) a compact, finely-laminated ironstone, which the peasants had begun to break into, in hopes that it might prove of value; and this rock, in almost horizontal strata, graduated into a hard, flag-like, red, micaceous sandstone*, evidently a portion of the same rock to which I have previously adverted, and which here (as in Norway) seems to be intimately associated with the porphyry, the elevation and outburst of which have also broken up the symmetry of the Silurian deposits.

Leaving the porphyritic dome or plateau with its red sandstone and passing southwards, we found ourselves in an undulating tract, which, extending along the western shores of the lake of Ore (Ore-Sjon) from Furadal by Ore to Dalby, and thence by Osmundsberg to Böda and Rättvik, is usually void of crystalline rocks *in situ*. Wherever the fundamental rock can be discovered beneath the detritus, it consists of Lower Silurian strata, similar, or nearly so, to those on the other sides of the crystalline dome. In these fragmentary masses, however, other links in the chain of a Lower Silurian group are detected, which we had not yet observed in this tract. Thus, at Furadal, at the northern end of the Ore Sjon,

* In the wild forests north of Skatunge inhabited only in summer by shepherds &c., and into which we did not penetrate, we were informed that there was much sandstone as well as limestone. Having cross-questioned the peasants, we clearly ascertained that they perfectly distinguished what they called sandstone (undistinguishable from our Old red) from the "Slepsten" or whetstone which is a Lower Silurian rock; and it is therefore probable that the Old red occupies a large tract to the N.E. of the great porphyry region of Elf Dal, as I shall presently show it does to the west thereof.

which we reached by passing through deep sands (similar to those of the Ore Elf, and probably like them derived from the decomposition of the bottom sandstone or "Slepsten"), we obtained from M. Classen* some specimens of Trinucleus in black schist (one approaching very near to *Trinucleus Caractaci*), as well as other Lower Silurian fossils; but here as elsewhere no connexion between the beds could be detected; the limestones and black schists with Trinucleus being only discernible in fragments which have either been rent asunder by eruptions or buried under superficial detritus.

Further southward, Osmundsberg is an insulated, tabular-crowned hill, rising to the height of 498 feet above the adjacent lake of Ore, or 1272 Swedish feet above the sea, and lies about two or three English miles to the north of Böda†.

When I first cast my eye over this hill (the summit of which is about an English mile in its longest diameter) I thought it must afford some explanation of the relation of the limestone, of which its upper part is composed, to the surrounding lower tract; but even here no clear sections could be obtained, owing to the slopes being covered with detritus. To the west, as well as on the eastern and southern sides of the hill, the limestone presents bold cliffs in which no clear stratification is visible; the hard and crystalline rock conveying the idea that it had been partially affected by heat.

But to whatever extent it has been altered, the limestone is here and there charged with fossils, which when examined left no doubt of its age. Without such search, and judging from its grey colour and resemblance to some of our English mountain limestone, as well as from its profusion of imbedded Encrinites, a field geologist, if brought suddenly to the spot, might well have pronounced it to be of carboniferous age.

The fossils however that we collected at Osmundsberg were all Lower Silurian forms, viz. *Illænus crassicauda*, *Asaphus expansus*, *Orthis parva*, *O. moneta*, *O.* n. sp., *Leptæna sericea* and *L. imbrex*, with some undescribed species, a few corals, and many Encrinites. As the rock in which these fossils occur occupies the summit of a nearly horizontal plateau (see Pl. I. fig. 5), and as the sandstone or whetstone (*a*) is seen, though in fragments only, in the surrounding low country, the inference would clearly be, that if the rolled debris on the slopes of the hill did not obscure a junction, the limestone (*c*) would be seen to repose, as in other parts of Sweden, on black schist with some limestone, and the latter on the light-coloured sandy rock as a base.

That this is the true succession in this region was sustained by the evidences which are afforded in the picturesque gorge of Styggfors near Böda, two or three English miles to the south of Osmundsberg (Pl. I. fig. 6). There, one of the branches of a stream which works several small mills, issues from the edge of the plateau

* The director of the iron-works at Furadal.

† The slight descent of the waters from this rocky region of Dalecarlia to the Baltic has been noticed in the memoir previously read upon the superficial accumulations of Sweden (see Quart. Geol. Journ., vol. ii. p. 374).

or dome of eruptive rock (which here has a granitic character) (*q*), and falls over ledges of sandstone (*a*), which although highly altered and quartzose when in contact with the granitic rock, becomes at the distance of a few paces a hard quartzose representative of the light-coloured whetstone, and is overlaid by finely laminated dark gray shale (*b*)*. The shale, which is considerably expanded in this locality and is present in highly inclined strata, contains nodules of argillaceous limestone, and resembles the strata which overlie the Lower Silurian sandstone along the Omberg on the Wettern Lake, formerly described by me†. It may be fairly inferred that these rocks constitute the base of the Lower Silurian group in this tract, because the strata plunging to the south and east are followed in these directions by a considerable breadth of Orthoceratite limestone, which is confluent with the strata before alluded to in the environs of Rättvik, beneath which lie the shale and sandstone, as seen in the bed of the Dragsjon.

On reviewing, then, all the natural evidences which can be collected from this confused and broken district, the geologist who has made himself familiar with the mineral characters, fossils, and order of the strata in other parts of Sweden, necessarily concludes that all the fossiliferous beds which are visible in detached and insulated localities around the dome of erupted rocks above mentioned, or which come out from beneath much crystalline and transported detritus in this part of Dalecarlia, belong to the Lower Silurian group, and are referable in ascending order to the sandstone, bituminous schist, Orthoceratite limestone and Graptolite schist of other parts of the country; the only exceptions being certain sandstones and flagstones, which from evidence, to be given in the sequel, are supposed to belong to the Old red sandstone.

Tract of Porphyry and Old Red Sandstone in Elf Dal and on the lake Wenjan.

If doubts might exist in the tract above described whether the conglomerates, quartzose bands and flagstones which there occur at intervals, may represent the Old red formation, there can be little hesitation in considering the sandstone of the Lake Wenjan, which is intercalated in the adjacent porphyritic country on the west, to be of that age.

But even there misgivings might be entertained (so hidden are the relations), if it were not, that in the adjacent tracts of Norway rocks of precisely the same character overlie true Upper Silurian rocks. Now, throughout Dalecarlia, as in other parts of the main-

* The chief stream at this spot, which issues from the crystalline plateau, is precipitated over a hard siliceo-felspathic rock, of which I did not bring away specimens, and concerning which I have no notes, but my impression is that the mass is an altered sandstone. Rushing through rents in the rock the water cascades into a deep abyss, excavated in black schist with calcareous nodules. We detected no fossils in our visit to this picturesque scene.

† Quarterly Geological Journal, vol. i. p. 477; see also 'Russia,' &c., vol. i. p. 17.

land of Sweden, in which these rocks occur (with the exception of Scania), Lower Silurian rocks only are visible, and the strata which I refer to the Old red sandstone seem, in all these tracts, to have been deposited next in succession without the intervention of the Upper Silurian strata.

The red sandstone in question is separated from the Silurian rocks by a rugged range of porphyry covered with dense woods, whose sides are so loaded with debris, that in a few situations only is the solid rock visible. Of the forty to fifty varieties of porphyries and crystalline rocks (including syenite, syenitic granite, serpentine, &c.) which are worked into ornaments and polished at the works of Elf Dal which we visited, but three or four are taken from rocks *in situ*. These quarries afford the dark and purple porphyries which are so well known over Europe, and of which beautiful monuments occur in the Royal Gardens and public places of Stockholm. We ascended from the valley of the Elf river through heaps of porphyritic detritus, to visit the quarries of Bliberg, which are opened on the southern face of the summit of hills, whose outlines are formed of domes, rising to 700 or 800 feet above the sea. At Bliberg, the porphyry, which is cut down vertically to a depth of about thirty feet, and horizontally for about 100, has a dark purple base filled with small crystals of white felspar, and is traversed by vertical joints, the faces of which strike 10° east of north: these joints are cut by rectangular planes (the beds of the quarrymen) which incline very slightly (5°) to the north. Though the rock is of exceedingly uniform composition at this spot, the very same range of hills a little to the west contains a light red and different porphyry, whilst to the east, at only a very short distance from Bliberg, it passes into the syenite or granitello of Gärberg*.

Thus, in the ridges of the Elf Dal, as in the great dome-shaped mass between the Siljan, Orsa and Skatunge lakes before described, one portion of the same rocks (all erupted posterior to the palæozoic age) is a porphyry, and another a granite. This fact is, indeed, completely in harmony with what was specially alluded to in my memoir on the environs of Christiania, where various kinds of porphyry†, syenite, granite and greenstone, all integral parts of the same

* It is from this rock that the Swedes are now cutting the monument to be erected at Stockholm to the memory of Charles XIV.

† By a letter recently received from my distinguished friend Leopold von Buch, I learn that after a careful analysis, M. Gustaf Rose has determined the peculiar rock of Ringerigge near Christiania, with large rhombic crystals of glassy felspar (the rhomb-porphyr of Von Buch), to be an augite rock. The analyses of this skilful mineralogist, when added to those of Berzelius and others, may doubtless ultimately define the true composition and characters of crystalline rocks, and enable us to group them more precisely than has hitherto been possible in their respective families; but can such nomenclature be shown to have reference to geological relations, by marking distinct eruptive rocks as peculiar to particular æras of disturbance? If certain granites, porphyries and greenstones were (as I believe) erupted at the very same time, and if in the very same ridge all these rocks are so collocated in reference to bedded strata that they must have been erupted simultaneously or nearly so, this distinction of M. Rose, as far as I now understand it, would seem to be rather mineralogical, than historical or geological.

range of hills, have perforated, and in some cases overflowed, both the Silurian rocks and the Old red sandstone of that territory.

In addition to an excursion into Elf Dal, we threaded the porphyry range which separates the Siljan from the Wenjan Lake, passing by the iron forge called Siljan-fors to the glass works of Johannisholm, situated at the south end of the last-mentioned sheet of water.

The sides of this lake, whose length is about seven miles from N.N.W. to S.S.E. and its mean width about a mile and a half, are of no great altitude. The outline on the western shore is however much more pronounced and elevated, and consists either of porphyry, which, as seen in the buttresses near Johannisholm, has a grey felspathic base enclosing small crystals of black hornblende, or else of a red porphyry with greenish and grey crystals. This latter rock, like the red porphyry alluded to near Skatunge, is as regularly stratified and jointed as any sedimentary rock, its strike being nearly north and south, and the beds either vertical or dipping at 70° to the west.

Enclosed between these porphyry ridges on the west side of the lake and those of Siljan-fors, which range up to Elf Dal, is a considerable breadth of sandstone, which, from its characters and intimate association with the porphyry, is, I have no doubt, of the same age as the rocks at Ringerigge near Christiania, and the equivalent of the Old red sandstone of Britain*. This sandstone, which constitutes in fact the western bank of the lake, is there dislocated and piled up in the remarkable manner described in a previous memoir. The rock is with difficulty observed as a solid mass *in situ*; but from the points at which we detected it, as well as from information we received from the Magister Westrom, that the rock is extensively quarried at Wenjan, it would appear that throughout a great space it is nearly horizontal.

That such is the position of the fundamental rock might, indeed, also be inferred from the fact, that throughout the space of the few miles which we travelled amid its numerous and colossal angular fragments the sandstone exhibited no varieties, all the specimens being referable to the same stratum; whereas, if the beds had been inclined, we ought to have met with conglomerates, flagstones and thick-bedded hard sandstones, &c., similar to the succession which the formation presents in Norway, portions of which rocks I have already adverted to as occurring in the district east of Mora†. Here the sandstone is uniformly a finely laminated, slightly micaceous hard rock, and is for the most part of mottled light red and grey, red, green and yellow colours. In short, it is undistinguishable from some well-known forms of the British Old red sandstone, like which,

* These relations having been incorrectly expressed in a woodcut published in the first volume of the Quarterly Journal of the Geological Society, the reader is referred to the second volume of that work, Part ii. p. 71, and to 'Russia in Europe and the Ural Mountains,' vol. i. p 13.

† See a further account of these angular blocks, Quart. Journ. Geol. Soc., vol. ii. p. 374.

the fine lamination of its alternating laminæ of different colours is a striking character, when exposed in the vertical edges of the joints or backs of the stone, whilst a transverse blow sometimes gives a conchoidal fracture, in which no lamination is visible. Besides these more compact beds, others which are more micaceous split into flagstones and expose ripple-marked surfaces. Now, whilst this rock cannot be distinguished from the Old red sandstone of Great Britain and Norway, and is here, as in the latter country, encased between masses of porphyry, it is wholly unlike any member of the Silurian rocks of Scandinavia, and is in every respect dissimilar, since the latter consist of soft non-micaceous fucoid sandstone and arkose, which form, as I have shown, the fundamental deposit of the protozoic series of Scandinavia. My belief is, that whenever the north of Sweden shall be correctly explored, this Old red sandstone will be found to have a very considerable extension; for I was informed that the rock extended for many miles (forty to fifty miles English) northwards from Wenjan into tracts where there are no roads, and where, in fact, owing to impassable forests, the country can only be examined by ascending the streams and lakes.

How far the sandstones which exist in large expanses in the region immediately to the north of Dalecarlia may be of this age I am not prepared to say, but the Lower Silurian rocks, including vast sheets of red Orthoceratite limestone, are largely expanded around Ostersund*, and as these are surrounded by vast breadths of red sandstone, also associated with porphyry, I am disposed to believe that the relations must there be the same as those in Dalecarlia; a suggestion, it is right to state, which could not have been ventured upon if I had not previously made myself acquainted with the precise relations of the Silurian and Old red formations of Norway in their normal positions.

Before dismissing the consideration of the Old red sandstone of the north of Sweden, I may allude to the red sandstone and conglomerate of Gefle, which we examined on our return from Dalecarlia to Stockholm. Occurring on the south bank of the river at Gefle, in a width of about one and a half English mile, this rock ranges from the sea on the N.E. to the lake called Storsjon on the S.W., or along a space of about twenty English miles. In that low country, no part of which rises much above the sea, and which is to a great extent either covered by detritus of rocks or by rich clay

* A knowledge of this fact I owe to M. Henry Gahn, a young Swedish geologist, with whom we fell in on his return from Ostersund, as we were proceeding from Furadal by Dalfors and Alfta to Gefle. In respect to the region which lies to the W. and N.W. of Dalecarlia, I learnt from M. Erdmann, that red sandstone, associated with porphyries, ranges along the mountains which form the banks of the Western Dal Elf to Hormundsjon, and which in the hills between Tisjon and Arefors trend from N.N.W. to S.S.E., and are consequently parallel to the band of Wenjan. Red sandstone occurs also largely in the mountain of Stadjan, and much higher up this drainage and 3904 feet above the sea, where it is said to alternate with schist or slaty clay, and is highly indurated near its contact with the greenstone of Idresjon. The northern boundaries of this sandstone are unknown.

and loam, this sandstone is nowhere (as far as we could ascertain) exposed as a solid rock *in situ*; but being found at intervals, and exclusively along the zone defined, in large untravelled, angular slabs and broken fragments, the rock is extensively quarried both for millstones and building-stone, and was largely used for the latter purpose in constructing the base of the royal palace at Stockholm.

Whether this slightly micaceous reddish and pinkish sandstone be referable to the Old red (Devonian) system or to the Lower Silurian, I am not prepared to decide. If time had permitted, the question indeed might possibly have been determined by a visit to the islands off Gefle, where there are limestones with Lower Silurian fossils, and where it is possible that the relation of the sandstone to such fossiliferous strata may be determined. In the meantime, knowing that all this country is very little elevated above the sea, and that ancient gneiss or azoic rock appears in numerous promontories all around, and further, seeing that several varieties of this sandstone had much more the characters of an arkose, or rock regenerated from the gneiss, than any portion of the Old red sandstone properly so called, I am at present rather disposed to believe that it will be found to be of Lower Silurian age.

Mines.—In taking leave of Dalecarlia and Helsingland, it may be expected that I should allude to the several mining points which we visited, viz. Fahlun, Bisberg and Danemora, and which lie between those northern tracts and the country of Upsala and Stockholm.

As however the first and last of these mines, the one famous for its copper ores, the other for its magnetic ores, have been described in detail by other authors, I can scarcely pretend to offer much that is new respecting places at which we only remained a very short time. Still I may state that both these mines appeared to me to occur in crystalline rocks more ancient than the Silurian system.

At Fahlun, the gneiss, or rather mica schist, and its associated quartzose and felspathic rocks, are so traversed by veins, the surface is so strewed over with loose blocks (adverted to in my last communication), and the mounds of refuse materials are so large, that, independent of mining statistics and details, and the occurrence of some beautiful minerals, there is little to interest the geologist.

At Danemora (though surrounded by ancient granitic gneiss) the prevailing rock in which the magnetic iron occurs is a quartzose felspathic rock, which the Swedes term Helle-flinte. M. Erdmann's analysis has proved that it contains at least 10 per cent. more silica than compact felspar rock, being composed of 70 per cent. of silica, the remainder consisting of alumina, with some soda, and about ½ per cent. of lime. That author, who is disposed to think that some of the Swedish iron ore lies in beds, admits that it here occurs as a sort of vein of irregular form, but contends that as it occupies troughs, and has always been found to be based on schists, it cannot (like the magnetic iron of the Ural Mountains, described in the work on Russia) be considered as pertaining to the class of eruptive rocks.

In these splendid open mines or quarries, which have been worked for 400 years, and into which the workmen are seen descending in buckets to depths of 80 and 100 fathoms, nothing is to be observed that can authorize the separation of the rocks in which they occur from the primary or azoic class. At the same time it must be stated, that crystalline white limestone, partially used as a flux, folds over here and there in the irregular contortions of the mass, and seemed to me *to be cut by the veins* of magnetic iron, some of which are ninety feet wide. These iron masses vary, containing from 40 to 80 per cent. of the metal. The chief vein has a devious direction from N.N.E. to S.S.W., and hades 70° to the W.N.W.*

The mines of Bisberg near Säter occur in what M. Erdmann terms a mica schist composed chiefly of quartz and mica, though much felspar rock also appears. Judging from the splendid open cuttings or chasms from whence the magnetic iron has been extracted, and also from the appearance of laminæ of deposit in the ore, my first impression was that the ore laid in beds which strike with the strata from N.E. to S.W., and dip to the S.S.E. at 80°. But after all it seemed impracticable by slight observation to determine that these are true beds of ore; for in following the mass underground (which we did not), it may, I apprehend, be found to traverse the strata in a slightly oblique direction. At all events, judging from the ancient walls of the rock alone from whence the ore has been extracted, I came to the conclusion that, although more or less parallel to the highly inclined strata of mica schist, it must be considered a true vein. In fact, besides crystals of calc spar, hornblende, quartz and other minerals, films of earthy serpentine and finely polished slickensides occur upon the walls of the parent rock from whence the iron ore has been extracted (some of these masses being charged with magnetic iron), thus leaving little doubt that here, at all events, the metalliferous matter has resulted from an action of an eruptive nature, which had penetrated the body of the rock, chiefly indeed between its laminæ of deposit, but long after its original formation. In short, I completely agree with Baron Berzelius, that however much some of the Swedish metalliferous products may at first sight appear to lie in beds, they all belong to true veins.

2. *Coast of Smoland, and Isles of Öland and Gothland.*

The large and fertile islands of Öland and Gothland, which lie to the east of the province of Sweden, called Smoland, have long been known to consist chiefly of ancient or transition limestones. In a former memoir, as well as in the work on Russia, I have endeavoured to show, that whilst Öland, lying near to the mainland, is composed of sandstone, schist and Orthoceratite limestone (*i. e.* of the same Lower Silurian strata known in other portions of Sweden), Gothland, situated nearly in the middle of the Baltic Sea, is a true Upper Silurian deposit. This conclusion was indeed arrived at solely by the inspection of the fossils and the evidences given in the

* So powerful is the magnetic attraction, that my compass was here carried round 35° to the west.

works of Hisinger, as the localities had not yet been visited by English, French or German geologists. The first addition we were enabled to make to our previous knowledge of these tracts was by discovering along a large portion of the coast of Smoland, extending from the north of Monsteras to the south of Calmar, a light-coloured, whitish sandstone, precisely similar to that which I have previously described in the contiguous provinces of the mainland (Kiunekulle, Lügnos, &c.), and this sandstone, lying upon azoic and granitic rocks, is surmounted by black aluminous schist and Orthoceratite limestone. The tract of Smoland occupied by this lowest bed of the Silurian system of Sweden, is so low, and has so few natural features which can expose the subsoil, that the sandstone itself is not, I believe, to be seen *in situ* at more than one locality.

The inhabitants of the district have, indeed, no reason to go to the expense of excavating quarries; for, with the exception of a few *osar* containing water-worn northern detritus, nearly the whole surface of the country, along a distance of many miles, is strewed over by large angular fragments of the sandstone, affording ample materials for working into millstones, building-stone, &c. As this sandstone is identical with that which partly occupies the western shores of the Isle of Öland, and as the mainland, extending to the west, the north and the south, consists of gneiss and ancient granitic rocks, there can be no doubt that all this sandstone of the low seaward promontories of Smoland is merely dislocated and broken up *in situ*, and was formerly in connection with a similar rock in Öland; the narrow channel between that island and the mainland having since been excavated in this deposit. (See Pl. I. fig. 7, *a*).

On reaching the port of Calmar, we were prevented by a violent storm from reaching Öland, where it had been our intention to inspect the exact relations of the sandstone and the overlying schist, which is largely used for the extraction of alum, as well as the Orthoceratite limestone, which is extensively quarried and exported both for lime and as an ornamental marble. These rocks (all slightly inclined to the E.S.E.) having however been correctly laid down by Hisinger in a geological map, accompanied by an account of the order of superposition, and the fossils having been examined by us in numerous collections, we felt less regret in not having been able to accomplish our object. In fact, the succession in Öland is so symmetrical and unbroken, and its limestone is so clearly of Lower Silurian age, that no doubts can be entertained concerning it. This rock contains the *Orthis calligramma* and *Illænus crassicauda*, both of which typify the Lower Silurian rocks of Scandinavia, Russia and England, together with *Orthis moneta*, *Asaphus expansus*, the well-known *Orthoceratites duplex* or *communis*, *O. trochlearis*, with the Cystidea, *Echino-sphærites pomum*, *E. aurantium* and the *Sycocystites granatum* (V. Buch); all these species characterize rocks of the same Lower Silurian age in various parts of Sweden and the Baltic provinces of Russia, and have nowhere yet been found in Upper Silurian strata.

Öland exhibits, in fact, the same normal ascending succession of

Lower Silurian strata (viz. sandstone, alum slate (largely worked) and Orthoceratite limestone) which has been pointed out at Kinnekulle and many other places on the mainland of Sweden.

Upper Silurian Rocks of Gothland.

A wide channel of the sea separates Öland from Gothland. The latter island, having a length of upwards of eighty English miles and an average breadth of twenty to thirty miles, differs from the former in being chiefly composed of shale and coralline limestone, with some peculiar sandy and oolitic rocks towards its southern end; whilst all its strata contain fossils of Upper Silurian age. This general inference was indeed long ago drawn from the description of its fossils, and I was enabled, when the 'Silurian System' was published, to identify the chief limestones of Gothland with the well-known British types of Dudley and Wenlock. Independently of a wish to collect many of these fossils on the spot and to determine the nature of the drift and the surface-phænomena of its rocks (as described in a former memoir), I had a special interest in visiting Gothland, in order to satisfy myself if the view suggested in the second chapter of the work on Russia was correct; viz. whether the southern portion of the island was of more recent age than its main mass, and could be paralleled with the Ludlow formation of England.

Rising in no part to heights exceeding 250 to 300 feet above the sea, Gothland, though well-watered, contains no stream of any note. Extensively covered with northern drift, its depressions are occupied by morasses, woodlands and lakes, but its structure is nevertheless well-exposed in numerous bold coast-cliffs. The great mass of the island is a coralline limestone, so slightly deviating from horizontality, that it is only by following the strata from N.N.W. to S.S.E. throughout the whole length of the island, that any attempt at subdivision can be made in them.

On the west and north-west, or to the north and south of the chief town, Wisby, a light grey coralline limestone is everywhere at the surface, and in the sea-ward cliffs is seen to repose on dark grey shale with nodules of earthy limestone. This succession occurs at numerous points along the northern and north-western coast, whether at Cappelhamn and Lummelund to the north, or at Hög Klint to the south of Wisby. Thus at Nygard's jog (paper-mill), near Lummelund, the shale beneath the limestone is beautifully exposed at a cascade, where the waters gathered from the interior of the island and the adjacent lakes and marshes of Martebo, and passing through subterranean courses in the limestone, gush out in a fine broad torrent from the face of the abrupt cliff (brutt-klint), and fall over the nodular shale, about fifty or sixty feet above the sea. The slight undulation of the northern limestone is proved by the reappearance of the rock at intervals in the interior, from beneath the incumbent mass of northern detritus, and by its forming the cliffs at Slite and other places on the eastern as well as on the western coast, in the parallel of Wisby. The numerous gates, churches and monasteries of the once-flourishing Hanseatic city of Wisby, stand upon different ledges of the rock. They there constitute an undercliff, the site having evidently been chosen on account of numerous springs of pure water which flow out upon the subjacent shale. The Wisby limestone is, for the most part, a grey subcrystalline mass passing in numerous points into marble†, in which abundance of Upper Silurian corals are visible; but with the exception of corals and encrinite stems, which occur profusely, other fossils in good preservation are less frequently obtained in the limestone than in the argillaceous way-boards and underlying nodular shale.

In order to convey a just idea of the structure of the northern division of Gothland, I have prepared two diagrams. The first of these (Pl. I. fig. 8) is a sectional view of the coast extending from Hög Klint to Lummelund, as seen from the cliff, which is vertical and higher than in any other part of the island. The second (fig. 9) is the detailed section of the same High Cliff, or Hög Klint. The lowest beds (*e*, fig. 9), extending to the water's edge, consist of dark grey shales, from thirty to forty feet in thickness, with nodules of limestone, and perfectly resemble the Wenlock shale of Britain. In these the *Terebratula plicatella* and *T. prisca* are very abundant, together with *Leptæna depressa*, *Spirifer cardiospermiformis*, *Orthis elegantula*, Dalm., a *Leptæna* approaching to *L. sericea*, and many well-known Wenlock species, both of shells and corals, including in the latter a multitude of Cyclolites.

The next strata (*f*), forming a projecting ledge midway in the cliffs, are reddish encrinital limestones, in beds three or four feet thick, very much resembling certain red and pink varieties, worked for marble along the Wenlock edge; these beds graduate upwards into the uppermost mass (*f**), a hard grey limestone containing large irregular concretions, like the ball-stones of Wenlock and Dudley, which, as in England, descend into and apparently cut out the bedded rock.

From the angular masses of limestone which had fallen on the beach below, we collected, in addition to the fossils above-named, the following corals: *Catenipora escharoides*, *Favosites Gothlandica* (most abundant), *Stromatopora concentrica*, *Cystiphyllum helianthoides*, *Porites pyriformis*, &c., together with *Euomphalus funatus*, *E. alatus*, and two or three species of Crinoidea, &c. These fossils (the same group occur at Cappelhamn and at Lummelund on the

† The limestones of Gothland have served in ancient time for the construction of the numerous beautiful Gothic churches with which the island abounds, and many of the porticos of these churches exhibit varieties of marble which have been formed into slender pillars and highly wrought and elaborate capitals. An archæologist would indeed reap a rich harvest in spending a summer month or two in Gothland, where not only amid the magnificent monastic ruins of its capital, Wisby, but also in many of its striking parish churches, he would find some fine types of early Norman and mediæval architecture, all easily accessible, and for the examination of which the kind and hospitable Governor, General von Hohenhausen, the Baron Fock, the intelligent English Vice Consul, M. Enequist, the Magister Söderberg, the Countess Schærer, and others I could gratefully refer to, would afford him every facility.

north) would be quite enough to fix the age of these rocks as being the same as the limestones of Wenlock and Dudley. The collection in the town of Wisby is indeed so amply supplied with fossils from the surrounding localities as to render quite certain the identification of the limestone and shale of the north of Gothland with the Wenlock limestone and shale of England. In short, I doubt if in any other quarter of the globe two synchronous deposits can be found, which, 900 miles apart in a straight line, are so closely assimilated as the Wenlock and Wisby limestones, both by mineral characters and fossil contents.

Thus, among the Wisby Encrinites is the remarkable *Hypanthocrinites decorus*; among the Trilobites, the *Calymene Blumenbachii*; among the Orthoceratites, the *Orthoceratites annulatus* and *O. ibex*; and among the Euomphali, the *E. rugosus* (*E. catenulatus*, Dalm.), together with the *Pentamerus galeatus*, *Atrypa tumida*, and numerous other shells, whereof a list is annexed, which are typical Wenlock forms.

On the east coast of the northern part of Gothland we visited the bay and port of Slite with its promontories and islands, where the same rock is burnt for lime, and whence it is largely exported. This rock, nearly as white as chalk when viewed at a distance, exhibits in its interior very much the same general appearance as certain varieties of the Wenlock limestone of England, wherein concretions or "ball-stones" of greenish, greyish and pinkish colours, and loaded with corals, encrinites, &c., are irregularly wrapped round by partings or way-boards of greenish or ash-coloured shale.

It is on the western shore of the fine land-locked bay of Slite, that portions of this rock stand out in those grotesque masses of limestone which were rudely figured by Linnæus in the description of his tour in Gothland. These rocks of Länna are in fact dismantled portions of former hard coralline reefs, the earthy and softer portions of which have been worn and washed away. The highest of these masses may be from thirty to forty feet high, and they consist of the small concretionary, coralline, marble-like limestone of pinkish and grey colours, each great mass being, in fact, a huge ball-stone traversed by irregular lines of fracture, and presenting in one point of view the appearance given in the drawing (Pl. I. fig. 10).

Whilst however not a shadow of doubt could exist (even before our visit) respecting the age of the great mass of limestone and shale of the north of Gothland, the interesting point before alluded to remained to be determined, namely whether the southern and south-eastern portions of the island that terminate in the rocky promontory of Hoburg might not (as I had supposed) be referred to a still higher member of the Silurian system, and be in fact the equivalent of the Ludlow formation of Britain. To answer this question, M. de Verneuil and myself, escorted by Baron Fock, travelled from Wisby to Mount Hoburg and the adjacent tracts.

The general results of our survey are explained in the diagram (Pl. I. fig. 11); though it must be understood that this section, extending over a distance of about fifty miles in a very flat region, is clear at certain points only, the most remarkable of these being at Hög Klint, Klinte Berg, and from Grötlingbo to Mount Hoburg.

To the south of Hög Klint and along its inland continuation, called Tofta, the surface of the ground, *i.e.* the limestone (*f*) (much obscured by northern drift and local calcareous detritus), declines gradually to the south into the depressions of Sandviken or Vestergärn and the bay of Klinte. At the latter place, the low country extends for some distance eastwards and E.N.E. into the island, and by numerous wells sunk for water, as well as by the heavy surface-soil, the substratum of this valley is known to be a greenish grey shale, very similar to the shale both above and below the Wenlock limestone in England.

This central Gothland shale (*g* of section) more resembles the Lower Ludlow rock than the Wenlock shale; since by certain sinkings it has been found to contain argillaceous flagstones. These shale-beds are distinctly overlaid by a bold ledge of limestone, Klinte Berg, which presents an escarpment sixty or seventy feet high above the plain, and trending from W.S.W. to E.N.E. At Djupviken on the coast, where the shale crops out from beneath the limestone, it is found to contain the *Calymene Blumenbachii* and several very minute Trilobites, with *Terebratula prisca*, *Leptæna depressa*, *Delthyris cardiospermiformis*, *Delthyris* or *Spirifer crispus*, *Atrypa tumida*, and Orthoceratites.

The overlying limestone (*h* of section, fig. 11) (and we examined its summit and sides transversely for two or three English miles) is at least sixty feet thick, and contains in its central and massive parts abundance of Pentameri (the *Gypidia conchidium* of Hisinger), associated with *Terebratula Wilsoni*, *Terebratula prisca* or *affinis*, and numerous corals, including *Catenipora escharoides* and others, of which the *Favosites Gothlandica* and the *Porites pyriformis* constitute entire reefs. The uppermost stage of this limestone is a perfect congeries of Encrinites, the large stems of which are occasionally very striking. This succession presents, then, a decided distinction between the beds of Klinte and those of Wisby and Hög Klint, where the encrinite band specially occupies the lower part of the limestone (see fig. 9).

As a local distinction between the limestones of Wisby and Klinteberg it may be noted, that the uppermost ledge of the latter is made up of Encrinites in flagstones, whilst in the sections near Wisby (fig. 9) these fossils abound in the lowest strata of the limestone.

Although the strata are here what would be called horizontal, they appeared to me to hang slightly to the S.S.E., and the form of the escarpment, which runs E.N.E., transversely to the longitudinal axis of the island, together with the gentle slope of the land southwards from the summit of this escarpment, favour this view.

We had not time at our disposal to visit the adjacent islands of the Great and Little Charles (Stora and Lilla Karlsö), which lie off this western shore of Gothland; but we saw their bluff escarpments sufficiently well in a bright autumnal day, to perceive that each of their summits consisted of tabular limestone reposing on shale like the rocks of Klinteberg on the main island.

Now, if it be asked, whether the limestone of Klinteberg can be separated, as in the general section, fig. 11, from that of Wisby and Hög Klint, I reply, that in the absence of positive proof of superposition in this flat region, I have only ventured to do so from the preceding and following balance of evidence.

Whilst, as already stated, the surface of the limestone of Wisby and Hög Klint declines gradually to the south, and apparently passes under the shale and limestone of Klinteberg, distinct proofs will presently be given of a positive succession to younger strata in the southern and south-eastern parts of the island. My belief therefore, as drawn from this analogy, is, that the limestone of Klinteberg (*g*) and its underlying shale (*h*) stand in the place of the Aymestry limestone and its underlying British stratum, the Lower Ludlow rock.

This suggestion is sustained by the collocation in the Klinteberg of abundant Pentameri, very closely allied to ***P. Knightii***, with *Terebratula Wilsoni*, fossils which have not been observed in the northern masses of limestone. Moreover, we found in the shale at Klinte (or at Djupviken near it) the *Orthoceras Ludense* and *O. annulatum*, both of which species in England are chiefly found in the shale beneath the Aymestry limestone. These, with other Orthoceratites peculiarly characteristic of the Lower Ludlow rock of England, occur also at Grogarn and Kathamarsvik on the eastern or opposite side of the island in this parallel. These zoological facts, combined with the lithological changes above-stated, induce me therefore to repose confidence in the belief that the strata are arranged in an ascending series from N.W. to S.E.

But besides these fossils, so typical of the Aymestry and Lower Ludlow rocks, there are, it must be admitted, other shells, such as the *Leptæna depressa*, *Terebratula plicatella*, and numerous corals, which are identical with those of the northern or Wisby limestone. Such however is the case in England also, there being very few Aymestry or Lower Ludlow fossils which have not been detected in the Wenlock formation of Siluria.

On the whole therefore I think that the Klinteberg strata are on the parallel of the central and lower parts of the Ludlow rocks.

Passing from the environs of Klinte southwards to Burge, we next travelled over a flat tract covered with detritus and osar; but having reached Grötlingbo, we found solid strata at the surface of a plateau about seventy feet above the sea. Here, at all events, it was at once evident, from the lithological aspect of the rocks alone, that we had reached a formation essentially different from any which we had seen in the northern and central parts of the island. (See Pl. I. fig. 11, *i.*) In the common to the south of the church of Grötlingbo, quarries have been pretty extensively opened in the rock, which unlike the crystalline limestone of the north is a peculiar sandy calcareous grit, with beds and inosculating courses of a white pisolite, in parts a perfect oolite, and these beds graduate downwards into strata of very fine-grained, finely laminated and slightly calcareous earthy sandstone, having a yellowish exterior and a bluish nucleus, the beds of which thicken downwards.

In these strata, particularly in the sandy limestone and oolite, we speedily procured numerous specimens of the shell figured by Hisinger as the *Avicula retroflexa*, and repeated by me in the 'Silurian System.' It was the occurrence of this fossil which formerly led me to suppose that the southern end of Gothland would be found to differ from the mass of the island, and would eventually be placed in the parallel of the Ludlow rock, in which that striking shell occurs in England. When we fairly determined on the spot, that this species of Avicula was undistinguishable from that of Britain, and further saw that it was here, as in England, associated with the spinose *Leptæna lata* or *Chonetes sarcinulata*, a fossil never found in any inferior Silurian strata, whether in Northern Gothland or in England, and also that these shells were mixed with other forms of Avicula, Cypricardia and Turritella equally unknown in the northern limestones of Gothland, but strikingly representing the collocation of shells of the Upper Ludlow of England, there was no longer any doubt that we had pursued an ascending section from the north, and were now fairly amid the equivalents of the Ludlow rocks of England. Among the other Ludlow rock fossils, Mr. Sowerby has since my return to England identified the *Terebratula pulchra*, *Cypricardia retusa*, *Pleurotomaria articulata* and *Turbo corallii* of Grötlingbo with species of the Upper Ludlow rock. We here also found fragments of Trilobites and a small Battus or Agnostus, identical with the *A. tuberculatus* published in the 'Silurian System' from the Downton Castle building-stone of the Ludlow rock*.

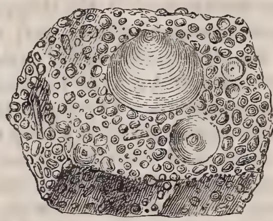
In this district we soon indeed obtained positive proof, that the beds dip to the south, though the inclination is so slight that no indication of it can be detected in a single locality.

The quarries of Grötlingbo, where the peculiar shelly oolite and sandstone occur, are, as before said, about seventy feet above the sea; but on descending from them and passing southwards for four English miles along the marine bay called Bursvik, the same beds of calc grit, oolite, pisolite and sandstone (containing the very same shells) are next detected, close to the little port of Bursvik, at a height of not more than twenty feet above the sea; whilst near the promontory of Hoburg, a few miles further south, they are actually on a level with the water. The diagram (fig. 11) explains therefore, by stratigraphical evidence, that the Upper Silurian oolite and sandstone (*i*) dip away from the great masses of limestone and shale (*e*, *f*, *g*, *h*), of which the central and northern portions of the island are composed, and distinctly pass under the limestone of Hoburg (*k*).

These quarries at Bursvik and Mount Hoburg have been long opened, and they are the only valuable sources in the island for the extraction of free-stone, which is available for building and roofing purposes and for whetstones. This fine and slightly calcareous psammite is as greedy of water as portions of the Ludlow rock, like which it increases astonishingly in weight upon exposure to

* This crustacean, I would here observe, is distinct from the *A. pisiformis* of the Lower Silurian rocks.

moisture, as formerly pointed out by Linnæus, when he spoke of the *Conchistriati* and *Entrochi* of this locality. In the quarries of Bursvik the best sandstones are separated from each other by thin courses of shale, and though they here and there present casts of shells, it is chiefly in the overlying or pisolitic bed that these occur; viz. *Cypricardia retroflexa*, *C. reticulata*, *Leptæna lata*, with a beautiful *Lucina*, which seems to have escaped the vigilance of Hisinger, and which we willingly dedicate to that persevering Swedish geologist, who is entitled to much commendation for his various works, geological and palæontological (*Lucina Hisingeri*, Murch. and De Vern.).



Lucina Hisingeri.

LUCINA? HISINGERI: *a smooth lenticular shell, with the apex inclined rather forward and slightly curved.* It is a matter of regret that neither the inner surface nor the hinge has been seen, consequently the genus is doubtful.

Between Grötlingbo and Bursvik the sandstone and oolite are not overlaid by any rock, and with the exception of a few large northern blocks and some blown sand, which partially obscure the surface, this barren and treeless district is characterized by its stone walls of sandstone and its pisolitic oolite.

This external aspect might well indeed have led to a geological mistake; for anyone who did not examine the fossils and had not learnt their position in the palæozoic series by comparison with the structure of other countries, might naturally have referred these strata to the oolitic series. The coarser oolite or pisolite of South Gothland is, in fact, scarcely distinguishable from the pea-grit of the inferior oolite of Cheltenham, and the finer-grained rock is mineralogically the same as numerous specimens of the middle and upper oolites of Britain, or of the tertiary oolites of Styria.

This error was committed by Hisinger, in his general map of Sweden*, and the same author having published a true Jurassic or Lias Ammonite as pertaining to this district, the erroneous view was for a time entertained by other European authors.

With respect to this Ammonite, we were informed by the best authorities in Stockholm that it was not found in any stratum of

* Hisinger's petrographical map of Gothland, on the contrary, conveys an opposite view, viz. that the limestone is the same from north to south, and directly overlies the sandstone of Bursvik and Grötlingbo. The latter was therefore considered by that author to be the fundamental rock of the island, instead of being the uppermost as here represented.

Gothland; but whether transported thither, or simply misplaced and mislabelled in a museum, it must, after the preceding description, be obvious to every geologist that no such fossil can have had a place in the rocks charged with the true Upper Silurian forms which are found throughout the southern mass of Gothland, extending from Bursvik on the north to Hoburg Point on the south.

Hoburg Head, though not the *mountain* spoken of by Linnæus (for it seemed to us at no point to exceed 200 feet in height), is still a bluff bold headland, particularly when viewed on its southern and western faces, which are washed by the sea †.

Its lower strata, as represented in the diagram (Pl. I. fig. 12, *i*), consist of the sandstone above-described, only visible at low tides in the form of flag and tile-stones; the lower beds of sandstone rising to the north being only apparent a little to the north of the Hoburg Head, where they are quarried. The next stratum (*i**) is a small concretionary limestone, representing in a very coarse form the pisolite and oolite of Bursvik and Grötlingbo, and containing some of the same fossils. The rock marked (*k*) is a mass of coralline limestone, a perfect breccia or plexus of corals with earthy partings forty feet thick: among other shells we found in it the *Avicula retroflexa* of the inferior pisolite also in this band. The next stratum (*k**) is an encrinite limestone forty feet thick, with few or no corals. This uppermost stratum is a hard marble of red, greenish or greyish and white colours.

The limestone of Hoburg, which unquestionably overlies the sandstone and pisolite of Grötlingbo and Bursvik (fig. 11) as seen in various hills of this southern peninsula in the parishes of Vamlingbo and Sundre, certainly contains two or three species of shells and numerous corals identical with those of the north of Gothland. But the great mass of the Wenlock shells are no longer found in it, their place being taken by other species; whilst the corals *Catenipora escharoides* and *C. labyrinthica*, so characteristic of the inferior strata, no longer appear. It is also to be observed, that in addition to the Ludlow fossils ‡ above-mentioned, we here find the *Leptæna Fischeri* (nob.), a species belonging to the unquestionably Devonian system of Russia.

Considering then the order of succession and the fossiliferous contents of this southern promontory of Sweden, I must beg to differ from those who have previously visited it, including my distinguished associate in the Imperial Academy of Sciences of St. Petersburg, Colonel Helmersen, who preceded us in our last summer's survey. Seeing that the limestone of Hoburg Head was very full of certain species of Upper Silurian corals, and even contained two or three species of shells similar to those of the central and northern parts of this island, he, in common with previous authors, concluded,—1st, that the chief calcareous mass of the island is everywhere identical;

† It has a fine cavern on one of its northern faces.

‡ A specimen of *Homalonotus* has also been found in the Hoburg promontory, and is to be seen at Copenhagen.

and 2ndly, that the sandstone of South Gothland underlying such limestone, was necessarily the oldest rock in the island. When however the limestones of North and South Gothland are closely compared, the essential distinctions both in fossils and superposition above-described, fortify me in the belief, that Hoburg is unquestionably of younger age than the north-western and central masses of the island.

In every section in the northern part of the island, whether on the coast or in the interior, the great limestone, as already explained, rests on shale charged with Wenlock shale fossils, whilst the limestone of Hoburg stands at once upon pisolite, oolite and sandstone, containing a group of Ludlow rock fossils which have nowhere been found beneath the Wenlock limestone. Thus stratigraphical, lithological and zoological evidences combine to support my view. Again, if the sandstone and oolite were so low in the series as Hisinger and Helmersen suppose, why should we have no traces of such rocks and fossils in that part of the series in other parts of Scandinavia?

At Kinnekulle and all other places, whether in Sweden or in Norway, where an ascending series can be continuously observed, the Lower Silurian limestones, wherever I have seen them, are covered by great thicknesses of Graptolite shale; but nowhere is there a trace in that horizon of oolites and peculiar calc grits and sandstones similar, either in lithological or zoological aspect, to those of the south of Gothland. The truth then seems to be, that this being the only tract in the Swedish kingdom where an ascending series is traceable so far upwards as to pass gradually from rocks loaded with Wenlock fossils into others in which Ludlow forms predominate, we might reasonably look for a peculiar *facies* of the rocks. An oolitic structure having long been known in some of the carboniferous limestones of England*, and having since been shown to exist in the Devonian rocks of Russia, we now simply extend the demonstration downwards, and indicate that similar arrangements of calcareous particles took place in the Upper Silurian strata as in succeeding periods; the fact is however interesting as indicating the most ancient oolites hitherto known, and may eventually be of value in leading to the establishment of just theories respecting the origin of certain inorganic phænomena.

Should the preceding view of the succession in Gothland be sustained, it would appear that in the northern and central parts of the island, where the limestone and shale have the same characters and the same relations to each other as in the typical districts of the Wenlock limestone of England, a striking identity or similarity of fossils is coexistent in the two countries; whilst in the southern extremity, where the higher strata assume in part a different lithological structure and are terminated upwards by much purer calcareous masses than at Ludlow, we are presented both with some remarkable species hitherto only found in that formation in England, and with

* See 'Silurian System,' p. 120, for a description of the oolite of the Clee Hills.

a few species common to other limestone tracts of the island, associated with a few forms undistinguishable from Devonian types.

Thus Colonel Helmersen discovered two specimens of the *Calceola sandalina*, a shell hitherto exclusively found in the Eifel and Devonian limestones. This fossil was found on the south-eastern shore in the limestones of Lansberg, which though somewhat to the N.E. of Grötlingbo, probably belong to the same overlying group as the remaining portion of the south of the island. At that point the higher plateau extending from the shore towards the interior (across which we walked), resembles a shingle beach chiefly made up of loose corallines, but beneath these loose fossils lies a blue-hearted, sandy, thin-bedded limestone, which considerably resembles the forest marble of the British oolite; whilst the inland cliff overhanging taluses of gravel and detritus, to which I have alluded in a previous memoir, is a hard breccia-like agglomerate with few traces of bedding.

In a region so flat and so obscured in many parts by drift and local detritus, it is truly no easy matter either physically to connect or to dissociate the portions of the island in the manner attempted in the ideal general section (fig. 11); for corals reappear everywhere in the limestones; and the coast cliffs, which are so bold and striking from the south of Lummelund to the Hög Klint (see figs. 8 and 9), there subside into broken taluses which slope down into bogs, morasses and lakes, it being at certain points only—those especially to which I have alluded—that any clear order of superposition can be traced. I trust, however, that the evidences elicited along the east coast are sufficient to demonstrate, that the lowest stratum in the island is the Wenlock shale, and that the highest is a sandy and calcareous equivalent of the Upper Ludlow rock, with indications of a passage into the Devonian group.

I subjoin to this description a list of the Upper Silurian fossils of Gothland. The list however includes only the shells, Encrinites and Trilobites; the corals, which are very numerous, being under examination by Mr. Lonsdale. These it is intended to publish in a separate memoir; and the argument will be found greatly strengthened when their additional evidence is produced. The species in this list marked with an asterisk (*) have been determined by Mr. Sowerby from specimens brought away: the others were identified on the island by M. de Verneuil.

It is necessary to observe that the localities Hög Klint, Paper Mill and Wisby, may all be considered synonymous with North Gothland; Klinte and Djupviken are in Central Gothland; and Grötlingbo, Bursvik and Hoburg in South Gothland.

List of Upper Silurian Shells, Crustacea and Encrinites of Gothland.

Name and author.	Place. This refers to the Specimens in the Table only.	Situation in the series given in the 'Silurian System.' Upper Ludlow.	Aymestry.	Lower Ludlow.	Wenlock limestone.	Wenlock shale.	Lower Silurian.	Russia.	
*Actinocrinites moniliformis, *Miller*	Hoburg ... Bursvik ...	...	...	...	+				
Hypanthocrinites decorus	N. Gothland	...	...	...	+				
Terebratula semisulcata, *Dalm.*	N. Gothland.								
*—— pulchra, *Sil. Syst.*	Grötlingbo ...	+							
*—— plicatella, *Dalm.* (lacunosa, *Sil. Syst.*)	Hoburg ... Hög Klint.	+	...	+	+	...	...	+	
*—— reticularis, *Linn.*, T. affinis, M. C.	Grötlingbo. Klinte	+	+	+	+	+	+	+	
*—— cuneata, *Dalm.*	N. Gothland	...	...	...	+				
*—— Wilsoni, M. C. ...	Klinte ...... N. Gothland	...	+	+	+	...	...	+	
*—— marginalis, *Dalm.* (imbricata, *Sil. Syst.*)	N. Gothland	...	...	...	+	+			
*—— canaliculata, *Dalm.*	N. Gothland.								
*Pentamerus conchidium *Dalm.*	Klinte	...	+ ?	+ ?	+ ?	...	...	+	P. Knightii? Sil. Syst.
*—— galeatus, *Dalm.*	N. Gothland	...	...	+	+	+	...	+	
*—— ? (Atrypa) didyma (*Dalm.* Ter.)	N. Gothland	+	+	+	+	...	...	+	
Cyrtæna baltica, *Dalm.*	S. Gothland.								
Spirifer? ptychodes	S. Gothland?	+							
—— ? trapezoidalis		...	+	+	+	+	...	+ ?	
*—— ? Pisum	N. Gothland	...	...	...	...	+			
*—— crispus ?	Grötlingbo ...	+	+	...	+	+			
—— caudatus	N. Gothland.								
—— cardiospermiformis *Dalm.*, Ter. biloba., *Lin.*	N. & S. Gothland	...	...	...	+	+			
*—— radiatus (lineatus, *Martin*)	N. Gothland	...	...	+	+	+	+	+	
*—— sulcatus, *His.*	N. Gothland.								
*—— octoplicatus	N. Gothland	...	...	...	+				
*Atrypa ? tumida, *Dalm.*, tenuistriata, *Sil. Syst.*	Klinte ...... N. Gothland	...	...	...	+	+	...	+	
*—— prunum, *Wahlenb.*	N. Gothland								
*Orthis pecten, *His.* non *Linn.* nec *Sil. Syst.*	Grötlingbo.								
Carried forward		6	6	8	16	9	2	9	

Upper Silurian Shells, Crustacea, &c. of Gothland (continued).

Name and author.	Place. This refers to the Specimens in the Table only.	Situation in the series given in the 'Silurian System.' Upper Ludlow.	Aymestry.	Lower Ludlow.	Wenlock limestone.	Wenlock shale.	Lower Silurian.	Russia.	
Brought forward......		6	6	8	16	9	2	9	
*Orthis demissa? *His.*? ...	Hoburg.								
*—— elegantula (canalis, *Sil. Syst.*)	Grötlingbo . Hög Klint .	...	...	...	+	+	+	+	Very rare in Gothland.
*—— calligramma (callactis, β. *Sil. Syst.*) ...	Paper Mill . N. Gothland	...	...	...	...	...	+	+	
*—— sp. nov.?	Grötlingbo.								
*Leptæna euglypha	Grötlingbo? N. Gothland	...	...	+	+	+	+	+	
*—— depressa............	Hoburg ... N. Gothland	...	...	+	+	+	+	+	
*—— sericea	Hög Klint ...	...	...	...	...	...	+	+	
*—— Lepisma...............	N. Gothland...	...	...	+	...	+			
*—— Fischeri	Grötlingbo ...	...	...	...	...	...	...	+	Devonian of Russia.
*—— lata (Chonetes sarcinulata, *De Kon.*) ...	Grötlingbo ...	+	+	...	...	...	...	+	
Calceola sandalina (Devonian)	Lansberg ... S. Gothland	...	...	...	...	...	...	+	Devonian, Eifel, N.E. Russia, and Devonshire.
*Cypricardia retusa?	Grötlingbo ...	+	+?	+					
—— carpomorphus, *Dal.* cymbæformis, *Sil. Syst.*	Grötlingbo ...	+							
*Tellina prisca (Lucina?)..	N. Gothland.								
*Lucina Hisingeri, n. s. ...	Bursvik.								
*—— sinuata, n. s.	Hoburg.								
*Avicula retroflexa	Hoburg ... Grötlingbo .	+	...	+					
—— reticulata...............		...	+	+	+	...	...	+	
*—— small do.?............	Grötlingbo.								
—— aptera, n. s.?	Grötlingbo.								
Euomphalus discors.........	N. Gothland...	...	...	...	+				
—— rugosus	N. Gothland...	...	...	...	+				
*—— funatus	Hög Klint . N. Gothland	...	+	+	+	+	+		
*—— sculptus?	N. Gothland...	...	+	+	+				
—— carinatus	N. Gothland...	...	+	...	+	+			
*—— alatus, *Sil. Syst.* ...	Hög Klint ...	...	...	...	...	+			
*Turritella obsoleta?	Grötlingbo ...	+							
*Murchisonia corallii	Grötlingbo ...	+	+						
*Turbo corallii	Grötlingbo ...	+	+						
*Orthoceras ludense (communis, *Wahl.*) ...	N. and Cent. Gothland ...	...	...	+	...	...	...	+	
*—— regulare............	N. and Cent. Gothland ...	...	...	...	...	...	...	+	
Carried forward......		13	14	17	25	16	8	20	

Upper Silurian Shells, Crustacea, &c. of Gothland (continued).

Name and author.	Place. This refers to the Specimens in the Table only.	Situation in the series given in the 'Silurian System.' Upper Ludlow.	Aymestry.	Lower Ludlow.	Wenlock limestone.	Wenlock shale.	Lower Silurian.	Russia.	
Brought forward......		13	14	17	25	16	8	20	
*Orthoceras imbricatum, *Wahl.*	N. and Cent. Gothland ...	...	...	...	...	...	...	+	
*—— angulatum, *His.* (virgatum, *Sil. Syst.*) .	N. and Cent. Gothland ...	+	+	+	...	+	...	+	
*—— undulatum, *His.* (annulatum, M. C.) ...	N. and Cent. Gothland ...	...	...	+	+	+	+	+	
—— trochleare, *His.* ...	N. and Cent. Gothland ...	...	...	...	+	...			
—— Ibex.................	N. and Cent. Gothland ...	+	...	+	...	...	...	+	
*Cytherina Baltica, *Dalm.*	N. Gothland.								
Agnostus ?	Grötlingbo.								
—— tuberculatus, South Gothland (*De Vern.*)									
Calymene Rowii ? *Green.* ..	Grötlingbo.								
*—— bellatula, *His.*	N. Gothland...	...	...	...	...	...	...	+	Mus. Geol. Soc. Dudley ?
*—— Blumenbachii var. pulchella, *His.*	Djupviken ...	...	+	+	+				
*—— concinna	Djupviken.								
*—— punctata, *Brong.* non *Murch.*	N. Gothland...	...	...	...	...	...	...	+	Mus. Geol. Soc. Dudley.
*Asaphus subcaudatus ? ...	Grötlingbo ...	+	+						
*—— caudatus? var. small.	Djupviken ...	...	+	+	+	+			
Homalonotus ? (of Hoburg)		+							
*Cornulites serpularius ...	N. Gothland...	...	...	...	+				
		17	18	22	30	19	9	26	

General Summary.

Upper Silurian species (British)	46	
... ... (Russian)	17	
	—	63
Lower Silurian species (British)............		9
		—
Total Silurian......		72
Devonian species		2
		—
Total number of species......		74

In concluding this sketch of the islands of Gothland and Öland I may be permitted to say, that in a region where the strata deviate so very slightly from horizontality, there can be no surer indications of the general strike or direction, than the geographical outlines of the rock-masses and the successive outcrops on a great scale of their different beds. Thus, we see that the major axes of both islands* are nearly parallel and trend from N.N.E. to S.S.W.; a direction which coincides with the prevalent strike of rocks of similar age in Norway and Sweden, and is to a great extent that which prevails in the Silurian and older strata of Britain.

In Öland the low sandstone or base rock is only visible in the cliffs on the shore of the N.W. face of the island; it then disappears under the alum shale near Borgholm, and is no longer traceable along the western shore between that point and its southern extremity; whilst according to Hisinger the alum shale vanishes in its turn near the southern extremity; the extreme headland being exclusively occupied by the Orthoceratite limestone. These facts show, that whilst the island extends from N.N.E. and S.S.W., its strata subside obliquely to its general outline, and hence that their true strike is probably somewhat nearer to N.E. and S.W. and their inclination on the whole to the S.E. or S.S.E.†

Assuming that the Orthoceratite limestone of Öland was succeeded by schists with Graptolites (as it is in many parts of the mainland of Sweden), there are fair grounds for supposing, that the channel of the Baltic which separates Öland from Gothland has been excavated in that soft deposit which would be represented by the letter (*d*) in the general ascending section. Extending thence our view to Gothland, we perceive that its boldest and highest cliffs (forming its north-western shores) are very nearly parallel to the axis of Öland and consist of Wenlock limestone resting upon shale; and that these rocks occupying a great area in the northern part of the island, are succeeded by younger strata representing on the whole the Ludlow formation. An ascending order from N.N.W. to S.S.E. prevails therefore in the Upper Silurian of Gothland as in the Lower Silurian of Öland, and the inferences I have drawn from the positive evidences of fossils and lithological changes in Gothland, are sustained by the analogy of the physical arrangements of the inferior strata in Öland which contain well-known Lower Silurian types.

This view is, indeed, quite in accordance with an opinion I have for some time entertained‡, that the Baltic Sea may be considered a great Silurian trough, the lower rocks of which occupy both the Russian and Swedish mainlands, whilst the true Upper Silurian strata

* See any geographical map; or the general geological map in the work, 'Russia and the Ural Mountains.'

† In referring to Forsell's map of Sweden, it will be seen that it is precisely along the bluff cliff coast, *i. e.* the N.N.W. part of the island, that the sea is deepest, and the shore most swept of detritus, and that where the coast is lower and shelves away into sandy and gravelly bays (as around most of the remainder of the island), detrital accumulations are greater and the soundings shallower. This fact seems to strengthen the view of a geological succession from older and more elevated strata on the north and N.N.W., to younger on the south and S.S.E.

‡ See Russia and the Ural Mountains, vol. i. pp. 18*, 35*.

are only to be found in islands nearer the centre of such trough, as in Gothland on the one hand and in Oesel on the other.

Whether these Ludlow or uppermost Silurian strata ever extended upwards into others which fully represented the Devonian system, in that space now occupied by the wide sea between the Swedish island of Gothland and the Russian island of Oesel, can of course be only conjectured; but the indication of the presence of two or three Devonian species of shells and a profusion of corals common to Upper Silurian and Devonian in the southern and S.E. parts of Gothland seem to favour this hypothesis, which becomes more probable when we know that vast territories of Russia are composed of true Devonian rocks.

3. *Palæozoic Rocks of Scania.*

In the appendix to the work on Russia and the Ural Mountains (p. 646) geologists were informed, that although researches had led me to believe that the chief masses of the palæozoic strata of the continent of Sweden (certainly all those which at that time had fallen under my survey), were of Lower Silurian age, there were strong reasons to suppose, particularly from the researches of Professor Forchhammer, that patches of Upper Silurian also existed both at Aalleberg in West Gothland and in Scania. It was then stated, that this point would, if possible, be cleared up by personal observations in the course of last summer. In reference to Scania, M. de Verneuil and myself travelled from Carlscrona to Christianstad; and thence passing to Andrarum, well-known for its alum slates and their fossils, we made a transverse section across the country by Öfved's Kloster to Lund.

Owing to the flat and very slightly undulating nature of the country, the highest points of which are not 300 feet above the sea, and to wide-spreading masses of superficial clay covered with erratic blocks, &c., the succession of the strata is obscurely seen. But, whilst the relations of the different masses of any one system, such as the Silurian, are difficultly traceable, there is no tract in Sweden in which such a variety of sedimentary deposits occur. Besides the ancient granitic and slaty rocks, Scania contains both Lower and Upper Silurian strata; there are also lignite or coal deposits with many plants (which have been referred to the oolitic series as well as to the Wealden and the greensand); numerous patches of chalk occur charged with beautifully preserved fossils; and lastly, besides northern drift and erratic blocks, this district is of deep geological interest as exhibiting in its terrestrial and modern strata abundant remains of extinct animals commingled with some which now exist. In short, just as Scania first presents the aspect of Denmark, to the traveller proceeding from the north, in its people, architecture, flat surface and deep soil, so by its overlying secondary and recent deposits, it is naturally linked on to the great continent to the south of it, with which, as stated in a preceding memoir, it must have been united, when Sweden and Northern Scandinavia were to a great extent submarine and subjected to very different conditions.

4. *Silurian Rocks of Scania.*

The lowest Silurian rock of Scania, as in other parts of Sweden, is a sandstone. In parts north of Andrarum, referred to by Professor Forchhammer, it is seen in contact with the granitic and gneissose rocks, on which it rests; an order which is also exposed in the adjacent isle of Bornholm, described by that author. In our traverse from Andrarum to Lund, we could only detect this sandstone appearing at one or two spots, without visible relations to any other rock. At Andrarum, however, we were abundantly satisfied with the fine exposure of the next overlying band or alum slate*, which is there a jet-black, finely laminated schist, wholly devoid of slaty cleavage and disposed in horizontal beds. Being largely charged with sulphuret of iron, these schists are broken up for the extraction of alum. Some of the beds are slightly calcareous, and contain at intervals concretions both large and small of an earthy dark limestone, which are occasionally not less than three feet in diameter and of flattened cheese-like forms. Where this concretionary action has taken place, the pyrites is often collected into groups of crystals.

The most abundant fossils are the *Olenus paradoxides* and the *Battus pisiformis*; the latter being the same species which occurs in the British Lower Silurian rocks, whilst the former occurs in the alum slates of Kinnekulle and other parts of Sweden.

The section, Pl. I. fig. 13, explains the general relations visible in passing across this tract from east to west.

Traversing the country westwards from Andrarum through Vallarum and Fremminge, over undulating plains and low plateaus covered with detritus and boulders, it was only at rare intervals, and in a ravine or two, that we could detect the outcrop of other members of Silurian rocks; but whenever they did appear it was in the form of shale and schist, occasionally with Graptolites, but without limestone. In fact, we were assured by Professor Forchhammer, and M. Marklin of Upsala, who have sedulously examined this country, that the great limestone, with remains of Asaphus and Orthoceratites, so abundant in all other parts of Sweden where Lower Silurian rocks occur, has no existence either in Scania or in the island of Bornholm; the whole of the lower group being there represented by sandstone and schists, the latter containing some traces of black limestone. These schists however, though not divided by the Orthoceratite limestone (which appears to have thinned out), are characterized in their upper part by Graptolites, and in their lower by Trilobites, Agnostus, &c. At length we emerged from the monotonous region of mud (derived from the decomposition of these Lower Silurian schists), and at Bielo-gåard we fell in with the first limestone visible. From the aspect of this rock and its imbedded fossils, it was evident that we had reached a true Upper Silurian rock, since it contained forms of Avicula, Spirifer and serpuline

* As there is no cleavage in these rocks, the term "alum schists" or "alum flags" would be a more correct term than "alum slate."

bodies, with fragments of Orthoceratites and many true Upper Silurian corals, *Favosites* (*Calamopora*) *Gothlandica*, *F. polymorpha*, *Aulopora serpens*, with many fragments of Encrinites, &c.

This rock is an earthy, flat-bedded, grey limestone, with light grey shale, and is very slightly inclined. It is, in fact, a portion of the rock which has been worked in old quarries through the drift clay of the adjacent low plateau (Kärsbye and Skärtofta). It is in some places an absolute coral reef, loaded with many characteristic Wenlock species. In descending along the course of a little streamlet which runs from the western side of this plateau into the lake of Vomb (Vombsjon), we found the above-mentioned limestone surmounted by grey and greenish shale and hard flag-like limestone, with fragments of Trilobites, an elongated Avicula, Orthoceratites, Tentaculites, and a small Battus, (*Agnostus*) the very same species as that which occurs in the uppermost Silurian rocks of England and Gothland (see (*i*, *j*.) of Gothland, Pl. I. fig. 11 and 12). These earthy, flag-like limestones, of compact character and flat conchoidal fracture, and which are not burnt for lime, are called "Ahlsten" by the peasants, and are clearly distinguished by them from the true limestone, or "Kalksten."

The succeeding and apparently overlying rock (though no absolute junction was detected by us) is a reddish, earthy, finely micaceous sandstone, laminated with purple streaks, small quarries of which have been opened on the left bank of the little brook which works the Skärtofta mill. Though at a low level where we examined it, this rock rises into woodlands from 100 to 200 feet above the level of the adjacent lake, where it affords a fine building-stone, and in the village of Öfved Kloster it is penetrated by a red, earthy porphyry. (See Pl. I. fig. 13. p. *.)

From its red colour and association with porphyry, Professor Forchhammer was at first disposed to consider it as a representative of the Old red sandstone. After an inspection, however, of the casts of fossils which it contains in several localities, particularly to the north of our line of section, and which were submitted to us by Professor Forchhammer, I have little doubt that this sandstone must be classed as an Upper Silurian rock, of about the same age as the Upper Ludlow rocks of England; since it contains forms of Cypricardia and Avicula, with Turritellæ and the *Leptæna lata*, which cannot be distinguished from English species of that age (see also *i*, *j* in the Gothland section, Pl. I. fig. 11).

In the neighbourhood of the Ring Lake to the north of our line of section (Ringsjon), these uppermost Silurian strata further contain the *Avicula retroflexa* and the *Cytherina Baltica* of Gothland; and as in that latitude there are also black shale and limestone with Lower Silurian fossils, there can be no doubt, that there also both Upper and Lower Silurian strata exist, though I cannot define their boundaries. It is also worthy of remark, that although the true lower Orthoceratite limestone has not been detected in Scania, the *Asaphus expansus*, one of the most characteristic species of that age, is found whenever small bands of limestone of black colour are prevalent, and thus, however the lower calcareous zone may be attenuated in reference to other districts, and however visible in patches only on the surface of this low country, the Silurian series of Scania maintains, through certain typical shells, its continental and general divisions of Upper and Lower.

To the west of Öfved Kloster the Upper Silurian rocks above-described are bounded by a depression occupied by the Vombsjon and other sheets of water, with intermediate tracts of loose sand, which depression is flanked on the west by a low ridge of granitic rocks that ranges from N.N.W. to S.S.E., *i.e.* from Hardeberga on the N.N.W. by Romele Klinte to near Skärby. This granitic ridge thus forms an axis which separates the depression with its lakes, and all the low Silurian tracts on the east, from the country of Malmoe and Lund on the west. To whatever extent covered by clay, sand, detrital matter and boulders, this latter district is presumed from certain outcrops to belong essentially to the Cretaceous series.

Though it formed no part of our object to examine in detail the secondary rocks of Scania, we should certainly (had the season not been so far advanced) have visited the coast sections to the north of Lund, where lignite coal with many fossil plants occur (notably at Höganaes), as also the patch of sandstone at Hör, or Hoer, which is loaded with fossil plants, and which, as described by Professor Nilsson, is considered by most geologists, including Professor Forchhammer, to belong to the Jurassic series, and to be possibly of the same age as the coaly strata of the eastern moorlands of Yorkshire. Nilsson is indeed of opinion that some of these plants (the most abundant of which are the *Nilssonia elongata* and *N. brevifolia* with several species of Pterophyllus) are identical with species from the Yorkshire Oolite.

But this point requires further examination, since M. Ad. Brongniart and Dr. Mantell have suggested, that the plants of Scania may belong to the Wealden formation*, and the presence of animal remains will doubtless be required before the question can be satisfactorily settled. However this may be, true chalk and cretaceous rocks are visible as detached masses in many parts of Scania, and many of their fossils have been described by Nilsson.

I may here observe that at Christianstadt we were delighted to inspect some very rich collections of fossils obtained by M. Malm from various patches of chalk adherent to the crystalline rocks around that place. This ardent young collector asserts that he has found about 300 distinct species, and nearly 200 more than have been published by Professor Nilsson.

* In his work, the 'Medals of Creation,' p. 125, Dr. Mantell, referring to the plants of Hoer, states that their general analogy to those of the Wealden led M. Ad. Brongniart to suppose that the plants in question may belong to that formation, and that M. Nilsson himself, when in England, identified some of his species with undescribed forms collected by Dr. Mantell at Tilgate.

It seems indeed to be the prevalent opinion, that the terrestrial flora which prevailed during the Jurassic series is pretty nearly the same as that which occurs in the Wealden and lower greensand deposits. Hence no safe inference can be drawn concerning the age of Hoer from an examination of the plants alone.

If among these we recognised several of our characteristic British species, we were indeed much struck with the profusion of new forms. This fact is the more remarkable considering the very small areas occupied by the chalk in Scania in reference to its enormous development in Britain, Russia, and other countries.

To the overlying erratic and modern deposits of Scania I have adverted in a former communication.

Conclusion.

In terminating this memoir, I have to remark, that the examination of certain districts of Scandinavia, made during last summer in company with M. de Verneuil, has substantiated the conclusions at which I had previously arrived by visits to other tracts of that region, and by an inspection of many collections, that the Silurian system is there most clearly separated into Upper and Lower groups, and cannot usually be further subdivided.

In Norway the Lower Silurian rocks are chiefly schists and black limestones; in large tracts of Sweden they are more expanded, and with a sandstone base containing no fossils except fucoids, and with the same alum-bearing schists as in Norway, the overlying calcareous matter expands into masses of considerable thickness, laden with Orthoceratites and Trilobites, and surmounted by black Graptolite schists.

In Russia the lower member of these strata consists of soft shales with a few fucoids only (a mere unconsolidated mudstone), which is overlaid by a sandstone and grit, sometimes a conglomerate, containing the peculiar shells Ungulites or Oboli with a few Orbiculæ. These beds, the lowest containing fucoids only, as in Sweden, and the next having small horny bivalves, are surmounted by thick beds of earthy limestone not harder than our most slightly coherent secondary strata, in which a great mass of fossils are distributed, many of them, particularly the Orthidæ with simple plaits, being typical of Lower Silurian strata in different parts of the world.

Now, with this variation in mineral characters, or in other words, with this change of the original condition of the deposit, we are presented in each region with local peculiarities of zoological development. Certain genera, and even the same species of Trilobites, Orthidæ and Orthoceratites, are indeed common to the lower group of each of these northern kingdoms; but a species which is common in the one is often very rare in the other, and each district has a greater or less number of fossils peculiar to it.

If even then within the limits of the tracts around the Baltic, where no contemporaneous eruptive operations have interfered with the deposits of this age, we find that the contents of rocks (precisely on the same parallel) vary considerably in their zoological contents, we might expect that the Lower Silurian type of Great Britain and Ireland should vary according to the conditions of deposit in districts remote from each other even in our own islands, concerning which it must not be forgotten, that the thick marine sediments of those periods alternate frequently with various eruptions of igneously formed matter.

Comparing the lowest sedimentary masses of Russia and Scandinavia containing organic life, wherein no contemporaneous eruptive matter has been deposited, and those of Great Britain in which such matter abounds, and taking into consideration the great diversity of their lithological characters, it seems indeed to be truly remarkable, not that many species should be respectively peculiar to each country, but that so many highly characteristic groups of fossils of that early age should have co-existed in Russia, Scandinavia, North America and Britain.

Geologists have long ago admitted that the presence of certain Brachiopoda afford one of the surest base-lines for the identification of distant deposits; and knowing as I do that amid the numerous forms in the lower limestone of St. Petersburg there is no one more abundant than the *Orthis calligramma*, and that this form is also equally typical of the Lower Silurian simple-plaited Orthidæ, and that it is indeed this very species and its congeners which most abound in the Snowdon slates, I adhere to the opinions expressed in the anniversary discourse addressed to the Geological Society in 1843, and reiterated after much further observation in the work upon Russia, that there is no fossiliferous stratum of higher antiquity than the published Lower Silurian type, whether the appeal be made to Scandinavia, to Russia, or to America.

I have indeed in a former memoir given the chief results of a comparison of the most ancient fossils in these different countries, and have shown to the Society, that over tracts much larger than the British Isles, there is a strong and positive coincidence in all these strata (however different in mineral sturcture), which, reposing on crystalline rocks void of organic remains, constitute, in my opinion, the first recognizable chapter in the history of primæval life;—that period, in short, in which the strata are traceable downwards into beds charged with fucoids only, and which followed upwards abound in these former, which characterize the typical Lower Silurian rocks of Britain and other regions.

And here I would observe, that every year of additional researches, even in our own country, has led to the confirmation of this view. In the Lower Silurian rocks of Scandinavia and Russia, for example, in which calcareous matter abounds, those earliest crinoids, the Cystidea, occur in myriads; and if a geologist, arguing on negative evidence, had been disposed to consider the Lower Northern group as distinct from the Lower British group, he might have dwelt on these and other apparent zoological exceptions; and in addition to Lower Silurian he might have instituted a "Petropolitan system." But the researches of our Government geologists under Sir H. De la Beche have found these very Cystidea in a mass of rock in Pembrokeshire, formerly described by myself as Lower Silurian *. By the labours of other officers of the same corps, I am informed that these fossils have been

* Whilst this memoir is going through the press, Professor E. Forbes has shown to me specimens of Cystidea and Illænus in the limestones of Bala, associated with typical forms of Orthis, Trinucleus, &c. of the Lower Silurian rocks.

also found in the S.E. of Ireland, in strata which by their place in the series, and by other associated fossils, are also considered to be true Lower Silurian.

Now, whilst the Cystidea occur in thick clusters in the north of Europe, where peculiar calcareous conditions abound, they are comparatively rare in our schistose, muddy deposits of the same age. So is it with the genus *Illænus*, of which *I. crassicauda* is the type, which swarms in the Lower Silurian of the Baltic provinces of Russia, but which is not so abundant in Scandinavia where the conditions change, and which only occurs as a rare fossil in British rocks of the same age.

If indeed the presence of a few peculiar fossils in certain tracts were to be admitted as the test of the individuality or isolation of the stratum in which they occur, then truly may many new names be proposed for the protozoic group. On this principle, the lower black schist and limestone of Scandinavia, containing some organic remains specifically unknown in England, might be termed the Odinian group, in honour of the mythic deity of the early inhabitants; whilst in the new continent, the strata which (as Mr. Lyell believes) occupy the same horizon, might from their geological outcrop be named Canadian. But these local appellations, whether Petropolitan, Odinian or Canadian, are, after all, nothing but the already typified Lower Silurian strata, which in several regions have been seen to repose on masses in which no signs of animal life have been discovered.

For the above reasons, and others cited in my previous works, particularly in the first chapter on Russia, I am of opinion that Professor Sedgwick's recent proposal to establish a Cambrian group*, as distinguished from the Lower Silurian, cannot be sustained, and that the attempt to introduce such a group, as founded on observations in tracts often replete with igneous rocks both contemporaneous and posterior, and which has been subjected to so many dislocations, will, if intended for general use, necessarily lead to much confusion, particularly among foreign geologists. Such a question must, I apprehend, be definitively settled by appealing to countries like Scandinavia, Russia and America, where the very rocks in question are spread over enormous horizontal areas, or in slightly inclined and undisturbed positions, without the trace of contemporaneous disturbances of the sea in which their remains were entombed, and where the strata, the lowest in position which contain organic remains, can be actually seen to repose on pre-existing mineral masses void of such remains.

It is not by finding, after several years of elaborate research, a few undescribed and rare British palæozoic forms, that the age of rocks can be determined. The true tests are order of superposition and the common or prevalent fossil types; for if amid forms peculiar to one or two localities, the prevailing typical shells of a previously named group should occur in lower or thicker strata; or if the band in question can be followed into other tracts where the usual types abound, the point is determined.

Objecting therefore entirely to this proposal, because I now know

* See Quart. Geol. Journ. Vol. ii. p. 130.

that some of the lowest fossiliferous strata of North Wales are charged with shells which are well-known types of the Lower Silurian strata in Britain, Scandinavia and Russia, I object quite as strongly to another suggestion of Professor Sedgwick, that the Wenlock formation may perhaps be merged into the Lower Silurian. This suggestion however is only sustained on the ground that a few species of fossils are found to pass relatively upwards or downwards between the Wenlock shale and the upper beds of the Lower Silurian group as hitherto defined. This fact was to a certain extent known to me when I published the 'Silurian System.' I then knew (as may be seen in my tables) that certain species ran from the lower group even high into the upper *; and subsequent researches of others have, I admit, extended the phænomenon. Without an acquaintance with this fact, I should, indeed, have been most unfortunate in the selection of the name "Silurian," as embracing the lower and upper groups in one system of deposit. The question then really is, whether after types have been recognized, and after they have been applied and found to hold good over large regions of the globe, it is permissible to make changes of geological demarcation founded on the observation of certain slaty districts of Britain, where I venture to say the palæozoic order could never have been worked out had not the clear Silurian types been previously established;—tracts, also, in which little or no continuous limestone occurs, and where the whole of the Silurian series assumes to a great extent a common impress.

Looking to his native hills as he may well do with pride, because he has so well unravelled their intricate relations, Professor Sedgwick would seem to suggest, that the Upper Silurian group should be exclusively confined to the equivalents of the Ludlow rocks as developed in the coarse slates of Westmoreland, &c. But although this may be a good local division in the Lake country, it would, I must say, be utterly valueless if tested in the region of Siluria (where the rocks are unaltered and not in a slaty condition), and if possible, still more so when applied to the Upper Silurian strata of Norway and Sweden.

The Wenlock limestone is, I assert, the true and only definable centre of that which I have designated "Upper Silurian," and extensive European researches, and comparisons with America made by native authors as well as by Mr. Lyell, have confirmed me in this view, to which I hold as an essential and fundamental point in sustaining the Silurian classification. If we deprive the Upper Silurian group of the Wenlock division, and reduce it to the Ludlow rocks, it becomes in many tracts of the globe a mere shred or way-board, though it be a rock of great thickness in Westmoreland †.

* About 5 per cent. of the Silurian species were then shown to be common to Lower and Upper Silurian rocks.

† I may here state, that I have twice traversed Westmoreland and the adjacent country since the publication of the 'Silurian System.' The first visit was made before the memoirs of Mr. James Marshall, Mr. Sharpe and Professor Sedgwick brought the strata there into accordance with different members of the Silurian

If on the contrary, we continue to unite the Ludlow and Wenlock as originally proposed, by calling it Upper Silurian, we have a group, which, however the fossils of its lowest part or the Wenlock shale occasionally graduate into the subjacent strata, is, on the whole, as clearly separated from that beneath it (whether in the Siluria of the British Isles, the continent of Northern Europe, or in North America) as any two groups belonging to the same series which geologists have attempted to define in rocks of secondary or tertiary age.

It has been stated by Professor Sedgwick, that " beautiful as the sequence of Siluria is, it is not the true mineral type, either for England, Wales or Ireland." Let me here say that I never proposed it as a general mineral type, but simply as a good fossiliferous type of rocks of that age. Few persons, on the contrary, could I think have laboured harder than I myself did to afford evidence of the great lithological differences which are observable even within the Silurian region, by the comparisons I then instituted between the slaty Silurian groups of West Shropshire, Montgomery, Brecon, Caermarthen and Pembroke, and their calcareous equivalents in other parts of Shropshire, and in Radnorshire, Herefordshire, &c. But what I did contend for, and what I think European and American researches have confirmed, was, that in selecting as types those tracts, which, void of contemporaneous igneous rocks and slaty cleavage, were full of calcareous matter, and consequently of fossils, and in running them out into countries where such calcareous matter thinned out, and with it many of the fossils, and where strata precisely of the same age assumed a slaty cleavage, and were associated with igneous rocks, I enabled others who might follow me to estimate mineral conditions at their true value.

Whilst I thus indicated to geologists who might explore those tracts in which strata of like age occurred, that they must not expect to find elsewhere Aymestry, Wenlock, Woolhope and Llandeilo limestones exactly in the order in which they occurred in my typical districts, I stated emphatically, that what I expected to result from extended inquiries in Europe, would be the confirmation of the existence of *two* united natural groups ; the quantity, variety and identity of species in each being regulated by the varied mineral character or conditions of the deposits in the different countries appealed to. This appeal having now been made, my surprise is, first, that notwithstanding numerous diversities in lithological structure, so many typical forms should appear in synchronous palæozoic strata in very distant kingdoms ; and secondly, that there should even be, as far as Europe is concerned, such occasional striking coincidences of mineral succession ;—in a word, that flaggy and thin-bedded limestones should appear at great distances from England on the horizon of the Ludlow rocks,—that

system, and I then observed to Mr. Marshall, who accompanied me from Coniston to Ulverstone, that there could be no sort of doubt that the Coniston limestone represented a part of the Lower Silurian, whilst on the whole the Kendal and overlying schistose series represented the Upper Silurian group. In fact, I urged Mr. James Marshall to publish a memoir on his Coniston band.

great coral reefs and masses of limestone should be found on the parallel of Wenlock and Dudley—that a band of limestone with *Pentamerus lævis* should turn up in Scandinavia, Russia, and even in America, at precisely the same horizon as the little band of Horderly and Woolhope in England—and that copious lower limestones should represent those courses which at Llandeilo and other parts of England and Wales are interpolated in the schists, sandstones and slaty rocks of Britain.

In speaking of the lithological characters of these lower rocks, Professor Sedgwick further expresses his belief, that "as a general rule, 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 limestone, and all Silurian limestone both upper and lower *." But this observation is surely as applicable to the limestones *above* the carboniferous. There are essential distinctions between the strata of the Permian age in Russia and those of Western Europe. The dark lias shale of our countries is a solid, light-coloured limestone in the Alps and Carpathians. The middle and lower oolites of the south of England are represented by sandstones and shales in Yorkshire. Even the white chalk, which is the most persistent perhaps of all the secondary deposits of Western Europe, assumes an arenaceous and quartzose type in Eastern Germany, and is unknown in the cretaceous strata of America and Hindostan.

Again, if we ascend into the tertiary series, we find the dense clay of London represented by a white shelly limestone at Paris, and the blue marls and sands of the sub-Apennines, the north of Italy, and the basin of the Danube, become fine oolitic limestones in Lower Styria. Having examined a very large portion of Europe, I contend, that there are no secondary, and certainly no tertiary limestones which exhibit a greater persistency when followed to distant tracts, than the limestone of Wenlock and Dudley as developed in the islands of the Baltic, at a distance of near 1000 miles from the typical English formation. Hence I maintain that the original grouping of the strata by reference to such typical limestones, is a better principle of classification than one founded on the slaty and argillaceous constitution of strata of the same age in other British districts since referred to.

In the same memoir in which the changes or modifications are suggested which have thus led me to express my opinion on the subject, Professor Sedgwick states, that near Builth the lower flagstones there visible, which contain the *Asaphus Buchii*, lie a very little below the Wenlock shale.

If from mentioning this circumstance (which is indicated in my original sections) the object be to infer that the Caradoc sandstone is not a constant stratum between the Wenlock shale and the Llandeilo flags, it is merely the re-announcement of a fact which I have not only long ago admitted, but which I wish to be generally understood. I have indeed specially shown, at first in the year

* Quart. Geol. Journ. Vol. ii. p. 127.

1835*, and afterwards in the 'Silurian System' itself, that the so-called "Llandeilo flags" (those in the very environs of Llandeilo) consist of various bands of limestone interstratified with sands and shales, which in reference to the upper strata exhibit in that tract only a very thin course of sandstone, representing the great Caradoc band of Shropshire. That which is thick in one place thins out in another. In one tract, shale, flagstone and calcareous courses prevail; in another, sandstone and sandy limestone; in a third, shale and slaty rocks; but all these, I contend, are characterized by the same group of fossils, viz. *Asaphus tyrannus*, *A. Buchii*, *Trinuclei* of various species, *Illænus crassicauda*?, and above all by the simple-plaited Orthidæ, *Orthis Actoniæ*, *O. flabellulum*, *O. lata*, &c., of which *O.* (*callactis*) *calligramma* is the type†. In short, the protozoic group, as subsequently worked out, has now been proved to be nothing more than Lower Silurian‡.

The list given by Professor Sedgwick of fossils common to the Wenlock and Llandeilo rocks in those tracts where no intervening sandstone occurs, may perhaps lead inexperienced observers to think that there is no longer a true distinction between these formations; but in the localities to which he appeals, few of the Lower Silurian fossils, except such as are common to great portions of the Silurian system, and have a very wide geographical distribution (such as *Calymene Blumenbachii*, *Leptæna depressa* and *L. euglypha*, &c.), run up into the Wenlock limestone, whilst the presence in that rock of a single species of those simple-plaited Orthidæ which appear in such millions of individuals in the Lower Silurian, is, when it does occur, a very rare phænomenon, either in the British Isles or Scandinavia§.

If we confine our reasoning to Britain alone, and take the common and characteristic typical shells, there can I think be no better proof that the Lower Silurian is well separated from the Upper,

* Phil. Mag. June, 1835.

† As other explorers will doubtless visit the very instructive tract of Corndon and Shelve to the south of Shrewsbury, which I have described in some detail (with all its igneous rocks, both contemporaneous and intrusive), they will there see a very instructive epitome of what I consider to be a group analogous to many tracts in Cambria, or North Wales. The great mass of the Lower Silurian rocks, as shown by my sections (Sil. Syst. pl. 32. figs. 1 and 2), terminate downwards in the copious sandstones and quartz rocks of the Stiper stones, and upwards in flagstones containing *Asaphus Buchii*, which in their turn are surmounted by Wenlock shale; thus presenting, though on a much clearer and grander scale, the same succession as at Builth. Here therefore if "Llandeilo flags" are to be alone recognised by their containing *Asaphus Buchii*, they may, according to my own published sections, be said to overlie Caradoc sandstone. But as mineral constants are unknown, so at Llandeilo the alternating lower fossiliferous series of sandstones and limestones is separated from the upper group by quartz or sandstone. It is to the "Lower Silurian" fossil types only that I appeal.

‡ We have yet to be made acquainted with those forms announced by Professor Sedgwick to distinguish his Protozoic Cambrian from my Protozoic Lower Silurian (as published).

§ Amidst a profusion of Upper Silurian shells, one simple-plaited Orthis (a variety of *Orthis calligramma*) was found by myself in the lowest shale (Wenlock) of Gothland, and of this species one or two individuals only were detected.

than that which was afforded in the work which established the Silurian system. We there find, that out of the twenty-five species of Orthidæ (including in that number four forms doubtfully referred to Spirifers) one species only, the *Orthis canalis*, had been then observed by myself to pass up into the Wenlock formation; whilst after years of assiduous labour, Professor Sedgwick and Mr. Salter add but one other species, the *Orthis lata*, which also rises from the one group into the other. The occurrence of *Trinucleus Caractaci* in the Wenlock shale, and of *Calymene Blumenbachii* in the Caradoc sandstone, does not invalidate the fact, that the one crustacean occurs in myriads in the Lower and most rarely in the inferior part only of the Upper, and the other abundantly in the Upper group and very seldom in the higher part of the Lower; whilst among the thirty-eight species of Trilobites published in the 'Silurian System,' nineteen are still recognised as exclusively Upper Silurian, and fifteen or sixteen as Lower Silurian forms.

I must also dissent from the plan whereby Professor Sedgwick strengthens his conclusions, by excluding corals from his calculations, "as being too widely spread," for by the valuable labours of my friend Mr. Lonsdale, I have shown (and the demonstration has never been invalidated) that by far the greater number of the Silurian zoophytes are confined to the Upper Silurian, and that whilst eight or nine species only descend into the Lower stage, the latter contains some species which have never yet been detected in the Upper. Nor can Crinoidea be considered too imperfect to be of value in establishing a classification. The beautiful forms of *Actinocrinites moniliformis*, *Hypanthocrinites decorus*, the five species of *Cyathocrinites*, and other species of the Dudley limestone both published and unpublished (all generally recognised as true Upper Silurian types), have nowhere been found in the Lower Silurian strata, whilst on the contrary in Russia, Scandinavia and Britain, the Cystidea form a typical Lower Silurian group representing the Crinoidea, and not met with in the Upper group.

But if by such striking evidence, as well as by the absence of vertebrata, the Lower Silurian may generally be well separated from the Upper, I am far from denying that among the 500 Silurian species alluded to by Professor Sedgwick, a few (more even than he has mentioned) may not pass from the one group to the other. Since Mr. W. Smith established his succession of the Oolitic series of England, a number of fossils ten times greater, I will venture to say, has been found to be common to his widely-honoured groups, than by the incessant researches of a number of the best geologists in England, in Siluria, and Wales, have been shown to be common to my Upper and Lower groups; but such a reason has not been deemed sufficient to induce us to change the classification established by the Father of English secondary geology. So far from regretting that multiplied observations subsequent to my own have brought out the fact (which will be rendered more striking when the results of the Geological Survey of Great Britain are published), that a few more species are common to the Lower and Upper Silurian than

I could make myself acquainted with, I rejoice in such discoveries, because they still better *link the two groups together in one indissoluble natural system.* At the same time, referring my readers to the introductory chapters of the work on Russia, and requesting them also to consult the tabular lists of the Upper and Lower Silurian fossils of Scandinavia, I beg them to remark, that whilst some typical species of those regions are omitted, or have not yet been detected in England, they have been found on the same geological horizon in North America. It is from a combination of all these facts, that although when I published the 'Silurian System' I thought and hoped that there might be found a different group of animal life in the western and northern regions of Wales and in those tracts occupied by the so-called "Cambrian rocks," which, without critical examination on my own part, I left to be decided by the researches of Professor Sedgwick, I now repeat that an appeal both to those tracts as well as to other regions of the globe since I addressed the Society to that effect from the Chair, has sustained the conclusion, that the fossiliferous portion of the system alluded to in my work as Cambrian, is at length shown to be inseparable from the Lower Silurian type; and that whilst this group passes stratigraphically and zoologically into the Upper Silurian, the latter is characterized by many typical and peculiar fossils.

Admitting that "organic changes are the surest guides in making out the history of successive changes on the surface of the globe," Professor Sedgwick says that "they form a part only of our evidence, and that the great physical groups of deposits, however rude or mechanical, are historical monuments of perhaps equal importance in obtaining any true and intelligible record of past events*." Now, if by this it is meant, that without duly noting all the synchronous and posterior eruptions by which the surface of the earth has been modified, as well as the density of marine sediments in one region and their tenuity in another, no geological description of a given region can be complete, every one must subscribe to the position. But, on the other hand, I maintain, that if thick accumulations replete with igneous rocks and dislocations, do not contain as many relics of former inhabitants as strata of much less vertical dimensions (occupying the same geological horizon), the latter ought to be appealed to in preference to the former, as superior evidence for compiling the history of the earth.

Professor Edward Forbes has clearly shown, that what he has laid open in existing nature cannot but have been true in the remotest antiquity, and that in former as well as in the present seas, animal life can only have existed down through a given thickness. Now, assuming that the Lower Silurian is the oldest type of animal life, we might expect that at that period there would be a diminution in the numbers of the animals in proportion as the strata were accumulated at greater and greater depths, and that in those protozoic days there might have been depths of the sea

* Quart. Geol. Journ. Vol. ii. p. 129.

in which no fauna existed. It must, indeed, be evident that we gain no additional knowledge concerning the true chronology of the earth, by dwelling upon great local expansions of sediment, if no new groups of animals are discoverable in them. For example, a coal-field of thin vertical dimensions, whose relations are clear, is quite as instructive historically, if charged with fishes, shells and plants, as the enormously thick coal basin of Glamorganshire recently measured by Sir H. De la Beche.

Mineral masses of very great thickness and importance doubtless occur in North Wales and in the North Cumberland Mountains, but no new group of fossils has been found in those tracts. This, it appears to me, is the only question at issue between my friend Professor Sedgwick and myself; and although in the memoir already referred to he speaks of his Cambrian group, as the most remarkable physical group of England, he admits that he cannot say it is characterized by peculiar fossils* distinct from those published as Lower Silurian, nor that it is physically separated from what I defined as Lower Silurian by any line of general dislocation as formerly supposed (see Phil. Mag. June, 1845). Under these circumstances, and believing that there was no clearly-defined base-line in England for these palæozoic rocks, I have appealed to those countries in which, though the mineral masses be not of such great vertical dimensions, the earliest visible fossil types have been accumulated in tranquil seas, and have been so raised up for our inspection as to show a decrement of animal life in descending order, until all traces of organic existence are lost, and the whole series is seen to repose on slaty and crystalline azoic rocks. The geologist therefore ought I think to prefer this simple and unbroken legend of primæval life, to that which, however voluminous it may be, is interleaved with numerous blank, torn and ruffled pages, and whose earlier leaves are so nearly illegible, that they have not yet been deciphered.

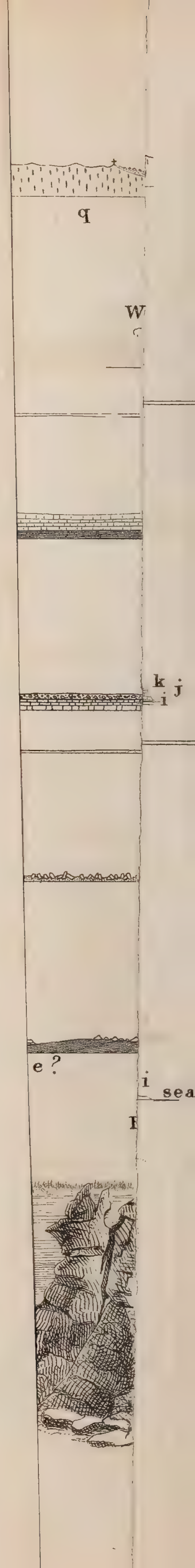
In conclusion I beg to say, that if the alterations proposed in the Silurian classification by Professor Sedgwick, instead of being the result of researches in slaty, broken, contorted and igneous districts of the British Isles only, had been arrived at in consequence of a general appeal to nature's clear and normal types—or again, if even now, any sufficient data should be produced (of which I am as yet

* One of the few zoological reasons given by Professor Sedgwick for the belief on his part that his Cambrian rocks may be distinguished from the Lower Silurian, is that he has not found the *Asaphus Buchii* in the former. At the same time he admits that the *Asaphus tyrannus* is abundant in his Cambrian. Now the latter of these Trilobites is quite as characteristic, if not more characteristic, as a Lower Silurian species than the other; and surely no one who is acquainted with the habits of crustaceans and their frequent isolation in special localities can attach importance to this negative fact. The *Asaphus Buchii* occurs abundantly in the Lower Silurian rocks of Norway together with other common Lower Silurian Trilobites of Sweden, and at least 30 or 40 species which have never been found in the latter country, whilst in Sweden the *Asaphus Buchii* is so exceedingly rare, that tracts larger than those alluded to by Professor Sedgwick exhibit no appearance of it; and so by parity of reasoning I might speak of the "Odinian" or lowest group of Sweden as distinguished from the lowest group of Norway, though they are in fact absolutely synonymous.

ignorant), and that rocks with peculiar fossils should be pointed out in lower positions than any of those charged with Lower Silurian forms, and reposing on still lower strata—or lastly, if Sir Henry De la Beche and his coadjutors, who are now subjecting North Wales to a rigorous survey, shall assure me that there is a distinct fossiliferous system beneath that which they have honoured me by terming "Lower Silurian," then I hope I have sufficient candour to modify my views according to such evidence and render them subservient to the advancement of Geological science. But supported by the fossil proofs and the order of superposition derived from investigations in Europe and America, and by the opinions of all those palæontologists with whom I have acted (including Mr. James Sowerby and M. de Verneuil), I adhere at present firmly to my classification, founded on original researches in Siluria.

The additional matter supplied in this memoir will, I trust, at all events be taken as affording the clearest evidence, that in Scandinavia the Lower and Upper groups are well-defined by the same divisional lines as those originally proposed by me for the classification of these deposits; for he who would attempt to rob the Wenlock formation of Gothland of one of its members, in order to include it in the Lower Silurian group of those countries, would most certainly be opposed by every geologist who had ever seen either the country or the fossils.

Again referring my readers to the first three chapters in the work on Russia and to my former Memoir on Scandinavia, as well as to the comparative tables then and now published, I leave this subject to the consideration and decision of geologists, merely expressing my hope, that the classification of Lower and Upper Silurian may not be put aside or obscured, so long as the order of succession and zoological evidence sustain it. My aim during the last few years has been, not to dwell upon the peculiar development and details of the sections in North Wales; for that ground is in the course of survey by several Government geologists, who will accurately determine the dimensions of such strata and all their physical and zoological features. My chief objects, on the contrary, have been, to ascertain on a great scale, whether the lowest stage containing vestiges of life in other parts of Europe was or was not zoologically the same as the Lower Silurian of my own country, and whether it was there, as in England, succeeded in ascending order by another member of the same natural system of deposits which I had termed Upper Silurian. The Silurian system, so defined, has been shown to be successively surmounted, over wide tracts, by the Devonian, Carboniferous and Permian systems, thus completing the history of palæozoic succession in Northern Europe.



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DESCRIPTION OF PLATE I.

1. Dalecarlian Sections.

Fig. 1. Section near the eastern end of the Lake Siljan in Dalecarlia, between Leksand and Rättvik, showing how the Lower Silurian limestone (*c*) is thrown off by the "granitello" (*q*) at Alsarby. The slope below the limestone is covered by detritus.

2. Relations in the Isle of Soller of the Lower Silurian rocks.—(*a*) inferior sandstone, (*b*) schist obscured by morass, and (*c* & *c**) beds of limestone with Orthoceratites and Cystidea in irregular contact with the granitello (*q*). The limestones are broken by transverse faults, and in one part (not represented in this drawing), mantle in an altered condition around bosses of granite.

3. Section at Watnaes near Möra.—The same Lower Silurian limestone (*c*) as that of the preceding diagrams, appears at intervals in highly-inclined strata, but is here separated from the eruptive rocks (*p**), which form the western part of a great porphyritic dome, by quartzose rocks, siliceous sandstone and fine conglomerate (*x*), which seem to have been altered by igneous agency.

4. Section at Skatunge on the north side of the great dome of porphyry and granitello, exhibiting regularly stratified and jointed, earthy, red porphyry (*p*).—A slope obscured and the Lower Silurian limestone and shale (*c**) with Cystidea in highly-inclined positions.

5. Section across the insulated hill called Osmundsberg, which is composed of Lower Silurian limestone (*c*), the inferior schist (lerskiffer) (*b*) and sandstone (*a*), being for the most part covered by detritus.

6. Relations at the waterfall of Styg-fors near Böda on the eastern flank of the eruptive dome. The subjacent or eruptive rock is here a granitello (*q*), and the sandstone (*a**) in contact with it is a highly-indurated quartz rock, which is surmounted by peculiar nodular shale (*b**).

2. Sections and Drawings in Oland and Gothland.

7. A general transverse section showing how the Lower Silurian sandstone (*a*) reposes (though chiefly in dismembered lumps) on the azoic or antecedent crystalline rocks of the province of Smoland (*az*); and also, how the same sandstone (fucoid grit of my former memoir) is seen on the western shore of Oland to be surmounted first by the alum schist (*b*), and finally by the Lower Silurian limestone (*c*), which occupies the great surface of the island of Oland in very slightly-inclined strata. The surface of the mainland is obscured by erratic blocks (*bl*).

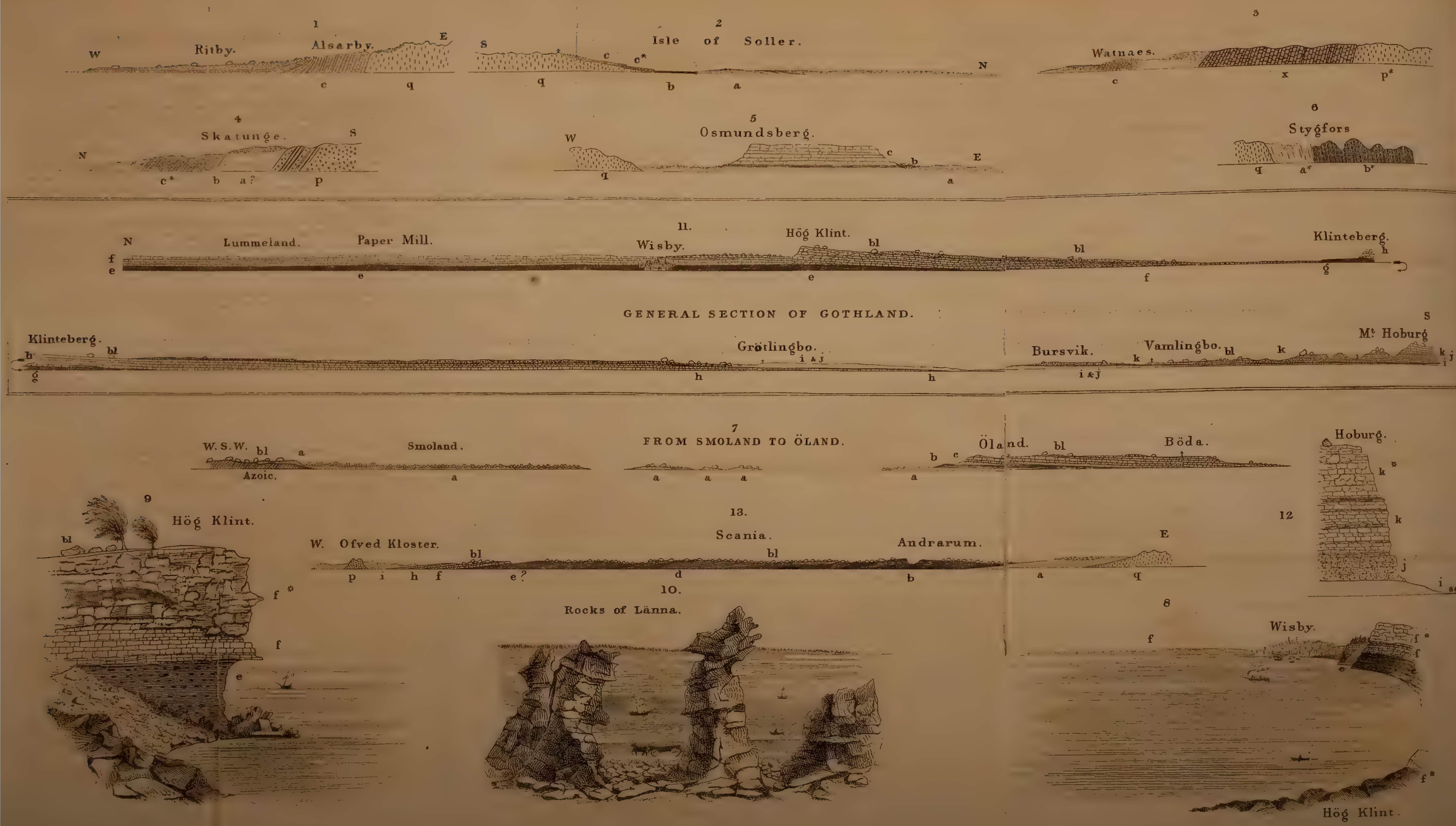
8. Geological view, looking from Hög Klint, the highest point of the cliffs of Gothland, and representing Upper Silurian rocks, consisting of the nodular Wenlock shale (*e*) surmounted by the Wenlock limestone (*f*), both to the S. and N. of the city of Wisby.

9. View of "Hög Klint," or High Cliff, as seen from its northern base, and showing the detailed order of the Wenlock limestone (*f* & *f**), in relation to the subjacent nodular shale (*e*). Two or three erratic blocks (*bl*) are seen on the summit.

10. Grotesque forms of the Upper Silurian coralline limestone (Wenlock) at Länna, in the fine bay and anchoring-ground of Slite on the east coast of Gothland.

11. General Section from N. by W. to S. by E., showing an ascending order in the Upper Silurian strata of Gothland from the Wenlock shale and limestone of the environs of Wisby, through other strata near Klinte, which represent the Lower Ludlow rock and Aymestry limestone (*g*, *h*) into overlying oolite, calc grit, and sandstone at Grötlingbo, which are true equivalents of the Upper Ludlow rocks (*i*, *j*). The coralline limestone of Mount Hoburg (*k*) may represent a passage into strata of the Devonian age (see memoir).

12. Detailed order of the strata at Mount Hoburg, the southernmost promon-



R. I. Murchison. del.t

C. F. Wallis. Sculp.t

tory of Gothland, where the preceding section terminates; showing how the same sandstone (*i*) which occupies the surface of the plateau at Grötlingbo on the N., is here brought down to the sea level; thus proving a general southerly inclination. The overlying calcareous strata (*j*, *k*, and *k**) are described in the memoir.

Fig. 13. General section from E. to W. across Scania. This is merely given to indicate, as far as possible, the successive outcrops of Lower and Upper Silurian rocks in a low obscure tract much covered with mud, rolled blocks and gravel (*bl*). The Lower Silurian sandstone (*a*) is partially seen, the alum schist (*b*) with its fine trilobites is copiously exposed, but the prevailing Swedish and Russian Orthoceratite limestone with Cystidea is no where seen, its place being taken by an occasional thin course of black limestone subordinate to graptolite schists (*d*). The Upper Silurian rocks are recognizable in grey limestones and shales (*f*, &c.) which are surmounted by purple sandstones containing casts of Cypricardiæ and other fossils apparently belonging to the uppermost zone of the Ludlow rocks. The porphyry of Ofved Kloster is marked (*p*).

June 17, 1846.

George Aug. M. Dermott, Esq., and Thomas Macdougall Smith, Esq., were elected Fellows of this Society.

The following communications were read:—

1. *Description of a Fossil* Chiton *from the Silurian Rocks, with remarks on the fossil species of the genus.* By J. W. Salter, Esq., F.G.S., of the Geological Survey of Great Britain.

The discovery of a species of Chiton in beds of undoubted Silurian age appears to be a fact sufficiently important to be brought under the notice of the Geological Society, not only from the rarity of the genus in a fossil state, but because it carries back to an earlier date another of the many families we are in the habit of considering as characteristic of later epochs. The shell I have now to describe presents peculiarities distinguishing it both from recent species, and also from those found in the carboniferous rocks. In introducing the subject I propose to glance at the ordinary characters of the family, for so this group must be considered, in order to show the relation of the fossil with the living species.

The Chiton is one of the lowest forms of Gasteropodous Mollusca, and is considered by naturalists as closely allied to the genera *Patella* and *Lottia*, and as forming with them a distinct order of Mollusca under the name of *Cyclobranchia* (Cuvier), distinguished by the arrangement of the branchiæ. The Chitons have a double generative system, terminating (according to Blainville and Rang) on either side of the body. This is a very marked character, and one indicating strongly the low position the group holds in the order to which it belongs. The shell is of course the only part with which we have to do (in treating of fossil species), and its variations are fortunately accompanied by differences in the structure of the mantle and the thickness or expansion of the entire form.

Lamarck had long ago described a tertiary species, *C. grignonensis*, figured by Deshayes; and Cantraine, in his 'Malacologie Mediterr. et littorale,' added another, *C. subapenninus*, from Italy. As both these belong to the common form of Chiton, no more need be said of them. Count Münster in his 'Beiträge' first described a species from the carboniferous strata of Tournay, under the name of *Chiton priscus*, and from detached valves, which are very numerous there, he reconstructed the shell (fig. 2). Dr. Sandberger added two species from the Devonian rocks of Vilmar, *C. fasciatus* and *C. subgranosus*, and subsequently De Koninck figured two more new ones, *C. gemmatus* and *C. concentricus*, adding a third, *C. cordifer*, which however by his own consent is now admitted to be an Encrinital plate. These eight species were all that were known fossil, until very lately the Baron de Ryckholt described ten additional ones from the carboniferous and Devonian rocks of Tournay and Visè. The notice of these appears in an elaborate paper on the external structure of the shell, in which rules are given for reconstructing the entire shell, when only one or part of one cerame or plate is discovered*.

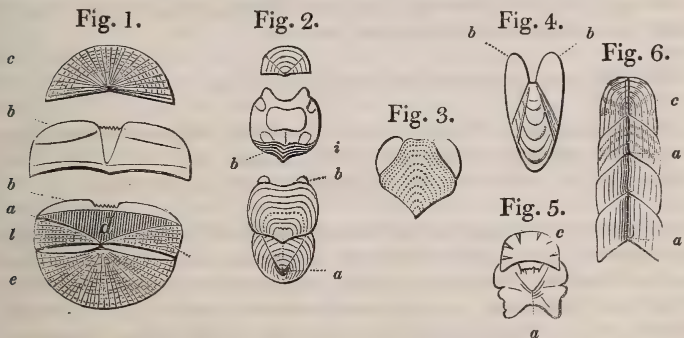


Fig. 1. Chiton Cumingii.
2. Helminthochiton priscus.
3. H. eburonicus.
Fig. 4. Chitonellus.
5. Chiton amiculatus.
6. Helminthochiton Griffithii.

With two exceptions, all the Devonian and carboniferous species (figs. 2, 3) much resemble each other, and their relations to living forms seem only to be with such as *C. incisus* and *C. alatus* of the Philippines, in which the plates are lengthened, and their contour square instead of transversely oblong. The ordinary form of Chiton is seen in fig. 1, *C. Cumingii*, a species from Valparaiso, and may be recognised in the common *C. cinereus* of our own shores; the plates are transverse, and the sides are marked by a diagonal line, fig. 1 *a*, the ornaments behind which are of a different character to those in front of it. The two areas (*d* and *e*) are called respectively the dorsal and lateral areas. The under surface is marked for the attachment of muscles, and is imbedded in the surface chiefly by an ex-

* Bulletin de l'Acad. Royale de Bruxelles, tom. xii. 2nde partie, 1845, p. 36.

pansion of the forward edge, divided into two rounded lobes (*b*, *b*) and separated by a toothed central portion. These sharp edges or sustentacula (termed by De Ryckholt *apophyses*) are important to notice, and are very large and remarkable in some of the fossils before us (fig. 3) and in Chitonellus (fig. 4). The extent to which the mantle covers the upper surface varies in different groups of the genus: in fig. 1 it extends but just over the edge, in many common species much further, and so as to leave only a rhomboidal surface free, the covered part being smooth, and always at a lower level than the free portion. In *C. incisus*, which has a great general resemblance to fig. 1, it does not extend very far over, but has a great expansion beyond the shell; in *C. amiculatus*, fig. 5, the shell is wholly concealed by it; in *C. porosus* and *C. monticularis* a narrow ridge alone is free, and the mantle is so thin, that the rugosities of the shell are seen beneath it.

There is one more peculiarity in the formation of the shell that is worth notice, viz. the inflected portion beneath the apex of each plate (fig. 2 *i i*), which diminishes in size according as the plates are more closely pressed against each other. Now the difference between the cephalic plate (fig. 1 *c*) and those on the back, consists in the former wanting the distinction of lateral and dorsal areas, for this reason, that the dorsal area is the space covered by each preceding plate from its earliest size, and the anal plate (*e*) differs from the dorsal ones only in having the area behind the apex turned out instead of inflected, being then ornamented in the same way as the lateral area of the other plates, which are in fact portions of a similar surface.

In the elongated form of Chiton, of which *C. incisus* may be taken as a type, we have the plates as long as or longer than they are wide, the apex of each plate a little produced behind, and that of the anal plate (fig. 2 *a*) carried back considerably, not, as in fig. 1, brought up close to the penultimate plate. The mantle too is widely expanded, smooth, and covering only the anterior corners of each plate. The sustentacula (*b*, *b*) are of moderate size and widely separated in this group. That the smooth plates of our palæozoic fossils were not covered by the mantle, I have reasons for believing certain, and therefore we have a tolerable approximation to a rare modern form. But in such species as *C. gemmatus*, De Kon., and *C. eburonicus* (fig. 3) we have a departure from this type so considerable, that I am inclined to believe it a distinct subgenus, connecting those last mentioned with *Chitonellus*, Lam. (fig. 4), in which the plates are inserted at a distance from each other, their form being that of an elongated rhomb, and the sustentacula occupying the larger part of the plate. The fossils of this section however (fig. 3), though decidedly approaching Chitonellus, the lateral area being undistinguishable from the dorsal, have the sustentacula widely separated and the surface granulated equally all over. In *C. tornacicola* and *C. Scaldianus*, De Ryckh. (minute carboniferous species), the form is much more nearly that of ordinary Chitons, and the lateral area is marked by a faint row of granules.

The Silurian fossil however (fig. 6) differs essentially from those above mentioned in having the plates deeply emarginate behind, and as it were bent backwards, a character very rare in living species, and never occurring to this extent. The shell described, of which only the four front plates are preserved, was not so much elongated as in the group containing *C. incisus* (fig. 2), the plates being wider than long, carinated, but not with a separate ridge along the back, and evidently of a very thin texture, as may be seen by the broken edges on the cast. In the former respect it resembles *C. amiculatus* (fig. 5), but there is an essential difference between the smooth external shell (as I believe it to be) of the fossil and the internal one of that species; for, as if to show in what light we are to regard the inflected portion, in *C. amiculatus* it is turned outwards in all the plate (fig. *5, i i*), just as in other species occurs in the anal plate, and the apex therefore (*5 a*) is within the margin.

In our fossil the apex (6 *a*) is *on* the posterior edge, and there is no expansion behind it, not even the broad double lobe that occurs in *C. porosus* before mentioned.

Notwithstanding the thin texture and deep emargination of the plates, I have no doubt this is one of the *Chitonidæ*. It is not quite anomalous, the *C. alatus*, Sow., a member evidently of the *incisus* group, having an approach to the emarginate form. This latter is a tolerably thin shell, though the lateral areas are marked by being slightly ornamented, and by a diagonal fold; nevertheless it more closely resembles our species than any other, and has a smooth thin expanded mantle.

Mr. Gray has (I believe in MSS. only) separated the species with tufted thin spines or with hairs by the name of *Acanthochætes*, but I am not aware that the elongate group has been recognised, and I venture to propose for this genus or subgenus, and rather for the fossils than the recent shells, the name *Helminthochiton*, from its vermiform character.

The twenty-three fossil species will then stand as follows*:—

Genus Helminthochiton.

Elongate; plates as long as wide, subquadrate, thin; apex of the anal plate remote from its front edge; sustentacula widely separated; shell but very little covered by the mantle [mantle expanded, smooth, thin]. Tropical?

1st Section, allied to *C. alatus*, Sow.

H. Griffithii, Salter (in Griff. Sil. Fossils of Ireland, pl. 5. fig. 5).

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* Not having access to Sandberger's paper, I cannot refer his species *C. fasciatus* and *C. subgranosus* to their proper sections.

I had overlooked Mr. W. King's interesting discovery of a Chiton in the magnesian limestone. His description of the anal plate in the 'Annals of Natural History' (afterwards republished with a figure in Charlesworth's Geological Journal) would induce one to believe his shell to be a species of *Helminthochiton*, and the figure given with it of the somewhat keeled dorsal plates, emarginate behind, would probably refer it to my first section. The Irish fossil however has no sinus in the cephalic plate, and we do not possess the anal one for comparison.

2nd Section, allied to *C. incisus.*

H. nervicanus, *De Ryckh.*
H. turnacianus, *De Ryckh.*
H. mempiscus, *De Ryckh.*
H. viseticola, *De Ryckh.*
H. priscus, *Münster.*

3rd Section, resembling *Chitonellus.*

H. gemmatus, *De Kon.*
H. legiacus, *De Ryckh.*
H. eburonicus, *De Ryckh.*
? Sluseanus, *De Kon.*
? mosensis, *De Kon.*
? concentricus, *De Kon.*

Perhaps palæozoic forms of *Chiton* proper.

C. tornacicola, *De Ryckh.*
C. scaldianus, *De Ryckh.*

Chiton proper.

C. grignonensis, *Lam.*
C. subapenninus, *Cantraine.*
C. fascicularis, *Sow.*
C. strigillatus, *S. Wood.*
C. tenuisculptus, *S. Wood.*
C. arcuarius, *S. Wood.*
C. angulosus, *S. Wood.*

I have one remark to offer concerning the formation in which this interesting fossil occurs. Mr. Griffiths found it a year or two back in the slaty mudstone overlying the fossiliferous conglomerates of Cong, co. Galway. It is associated with remarkable fossils, and in company too with a new Pleurorhynchus (*P. pristis*, Salt.), a genus yet undescribed from the Silurian rocks, unless Hisinger's *Cardium pygmæum* from the marine rejectamenta of Gothland be considered a Silurian fossil. I have of course nothing to do here with the remarkable conglomerates overlaid by this slate; I may however state (as Mr. Griffiths has already published the fact), that it contains fossils hitherto considered as characteristic of both Upper and Lower Silurian rocks associated in one bed of sandstone. Future researches will show whether the present is an instance of the continuance of Lower Silurian species to a later period, owing to favourable conditions, or a proof of the English tilestone fossils having been introduced from Ireland, where they had been developed at an earlier period. My own opinion is in favour of the former hypothesis.

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2. *Notice of the occurrence of the* Elephas primigenius *at* Gozo *near* Malta. By James Smith, Esq., of Jordan-hill, F.G.S.

The fragment which accompanied the specimen was given to Mr. Smith by Mr. St. John of Valetta, who stated that he found it, encrusted with stalagmite and adherent to the rock, in the island of Gozo. According to Dr. Falconer, it consists of two plates of a young grinder of the true *Elephas primigenius.*

The occurrence of so large an animal in a locality of such limited extent seems to point to a period when it was connected with a continent.

November 4, 1846.

The following communications were read:—

1. *Notice on the existence of* Purbeck Strata *with remains of Insects and other fossils, at* Swindon, Wilts. By the Rev. P. B. Brodie, M.A., F.G.S.

The indications of Purbeck deposits in this neighbourhood, although the beds are neither very extensive nor of any great thickness, are more clearly defined than has been generally supposed. There are about thirteen feet of strata decidedly freshwater, containing Cypris, Paludina, Planorbis, and remains of vegetables, chiefly Thuytes and small seed-vessels. The western end of the great quarry at Swindon presents the following section in descending order:—

	ft.	in.
1. Soil	2	0
2. White, soft rubbly stone divided by layers of clay	5	0
3. Fine white laminated slaty stone. The lower part is very soft and more sandy, and contains branches of Thuytes and the wing-cases of Coleoptera	1	6
4. Soft, white, crumbling bed with small Paludinæ	1	0
5. Blue clay about two feet thick, full of Cypris and Paludina, passing into a grey, earthy bed with Thuytes, seed-vessels, and other remains of plants	4	0
6. Hard white stone, very crystalline, with Planorbis and wood	1	6
Total	15	0

There can be no doubt therefore that these beds are the representatives on a small scale of a portion of the Purbeck formation. The surface of the Portland strata has been greatly denuded previously to the deposition of the overlying group, for in many cases the latter is deposited in hollows and cavities where the Portland sand has suffered erosion by water, on which it reposes at very irregular intervals.

The top of the Portland oolite is composed chiefly of whitish sand containing layers of Trigonia and other marine shells, and this includes harder nodules full of shells, chiefly *Trigonia incurva, Lucina Portlandica, Cytherea rugosa* and *Nerita angulata,* often retaining their shelly covering though decomposed and friable. These masses too are very unevenly dispersed.

No. 5 in the section, which in its lower part is highly carbonaceous and resembles vegetable mould, is to all appearance a kind of 'dirt bed,' and may be considered as the representative of one of the dirt beds in the islands of Portland and Purbeck. It also contains numerous small pebbles which are likewise found in it on the coast of Dorsetshire. A few detached scales of fish and small teeth of Saurians occasionally occur in some of the upper beds, but I could detect no traces of *Archæoniscus.* There were also but few and imperfect remains of insects; nevertheless it is interesting to find them at all in this detached portion of the Lower Wealden.

I am aware that Dr. Fitton has, in his able and interesting paper on the 'Strata below the Chalk,' alluded to the probable existence of the Purbeck series in North Wiltshire, but as there appeared to be some doubt upon the subject, it seemed desirable to notice its now certain occurrence, derived both from the evidence of geological position and organic remains.

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2. *Additional Remarks on the Deposit of* ŒNINGEN *in* SWITZERLAND. By Sir RODERICK IMPEY MURCHISON, G.C.S., V.P.G.S.

REFERRING to a memoir published by him in the Transactions of the Geological Society* eighteen years ago, the author explained that, with the consent of Dr. Mantell, he had requested Professor Owen to examine critically the original specimen of the so-called "Fossil Fox of Œningen," which has never been out of his possession. This request was made in consequence of a recent work of M. Hermann von Meyer, who, judging from the drawing alone of that animal, had named it *Canis palustris.* In alluding to certain criticisms of M. von Meyer, Sir Roderick admitted that he had misconstrued the ideas of M. Karg respecting the freshwater deposit in which the Œningen fossils are found, the opinion of that author having to a great degree anticipated his own. On the other hand it was shown, that M. von Meyer had misinterpreted the meaning attached to a diagram published in the paper referred to in the Transactions of the Geological Society, presuming that it was intended to represent the Molasse sandstone and the conglomerate, on which the freshwater deposit reposes, as being made up of highly inclined strata. Not having such intention, Sir Roderick stated that he merely wished to indicate that the underlying rocks were essentially different from those above them; since these inferior strata could be followed eastwards to the south side of the adjacent lake of Constance, where they are highly inclined and charged with fossils exclusively marine. They thus differ entirely from the superposed marls of Œningen, which are, it is well known, of pure lacustrine character. Now, as the name "Molasse Mergel," applied by M. von Meyer to the fossiliferous beds of Œningen, would imply that they are intercalated in the Molasse, Sir Roderick Murchison objected to a term which commingles a very peculiar, insulated, and overlying freshwater deposit with a subjacent marine stratum of the miocene age. But whilst he contends that these two deposits must be separated in classification, since they are distinct in nature, he now inclines to the belief, that the freshwater accumulation of Œningen (with its quadrupeds, birds, tortoises, lizards, insects, fishes and mollusca) may rather belong to the older pliocene age than to the still more recent tertiary epoch, to which, in consequence of the modern aspect of many of those animals, he formerly assigned it.

* 2nd Series, vol. iii. p. 275.

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3. *On the extinct Fossil* VIVERRINE FOX *of* ŒNINGEN, *showing its specific characters and affinities to the Family* VIVERRIDÆ. By Professor OWEN, F.R.S., F.G.S.

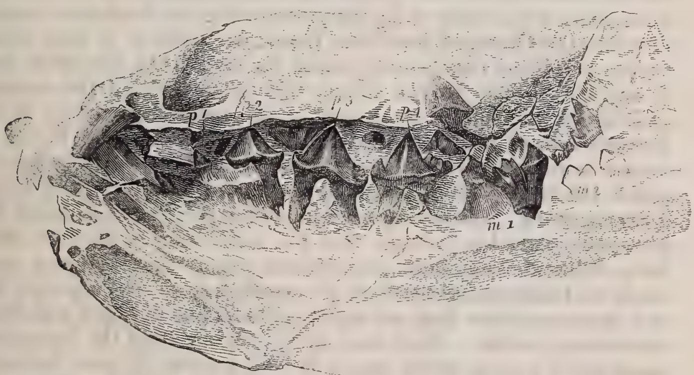
IN compliance with the request of Sir R. Murchison, I have examined the fossil Fox described and figured in Dr. Mantell's appendix to the 'Memoir on the Œningen Deposits,' in which formation was discovered that interesting and remarkably perfect specimen*.

The number and kind of teeth in the fossil are there shown (*loc. cit.* p. 291) to agree with the dental formula of the Fox and the rest of the genus *Canis* of Linnæus.

On comparing the well-preserved specimens of the teeth in the right ramus of the lower jaw, the inner surfaces of which are exposed in the right moiety of the skeleton, with the corresponding teeth of a Common Fox (*Canis Vulpes*, Linn.) of equal size with the fossil, the following well-marked differences are seen.

Fig. 1.

Jaws and teeth of *Galecynus œningensis*, nat. size.



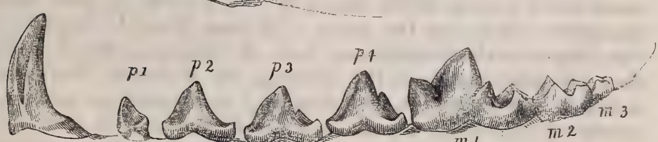


Fig. 2.

Teeth of the lower jaw of *Vulpes communis*, nat. size.

The first premolar (fig. 1. *p* 1) is relatively smaller, the third (*p* 3) and fourth (*p* 4) relatively larger than in the Fox, and all the premolars are placed closer together, and occupy, therefore, less space in the fossil than in the Common Fox, the Arctic Fox, or the

* See Trans. Geol. Soc. 2nd Series, vol. iii. p. 275.

Italian Fox (*Canis melanogaster**). The fossil *Canis* differs also from these and from every existing species of Dog, Wolf and Jackal with which I have been able to compare it, in the greater development of the anterior and posterior tubercles at the base of the crown of the third and fourth premolars.

The singular Hyænoid subgenus of *Canis*, represented by the South African species (*Lycaön pictus*), presents the above character of the fossil, with the notches of the hinder tubercle or talon, more marked even than in the fossil *Canis* of Œningen. The sectorial or carnassial tooth of the fossil (*m* 1) has a shorter antero-posterior extent of crown than in any known existing species of true *Canis*; the subgenera *Megalotis* and *Proteles* are of course excepted from this comparison, the one differing in the excess of number of true molars, the other in the deficient number, small size and simple form of those teeth†.

The second and third true molars of the lower jaw of the Œningen *Canis*, which are preserved in the left moiety of the skeleton, show as well-marked differences of form and proportion as the teeth above described: the second (*m* 2) is relatively smaller, the third (*m* 3) has a more pointed conical crown. This latter character might be modified by age; the other characters deduced from the shape and size of the teeth are not explicable on any known effects of age or range of variety hitherto observed in existing species of *Canis*. Moreover, in the shape and proportions of the premolars and of the first true molar, there may be perceived a nearer affinity in the fossil to the closely-allied genus *Viverra* than is manifested by any existing known species of *Canis*; and one might regard the single tuberculate molar of the lower jaw of *Viverra civetta* as the homologue of the two small tuberculate molars of the fossil, coalesced into one tooth.

M. de Blainville, in alluding to the fossil in question in the fasciculus of his admirably illustrated 'Ostéographie' relating to the genus *Canis*, says‡: "Il n'admet aucun doute sur son analogie avec le Renard qui existe encore dans nos contrées, comme l'a parfaitement reconnu M. Gideon Mantell dans l'examen de cette espèce de cadavre desséché et tout entier. La proportion des os du métacarpe et du tarse donnée par les figures, semble cependant indiquer une espèce plus robuste, peut-être un Chacal."

A more important character than general breadth of the feet in proportion to their length, which is greater in a marked degree in the fossil than in any Jackal or other species of *Canis*, is the different proportion of the digits amongst themselves, particularly the greater development of the pollex or innermost digit of the fore-foot (fig. 3. *m* 1).

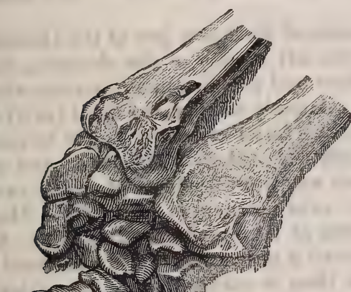
In the Jackal the metacarpal bone of the *pollex* is two-fifths the

* I am indebted to the Prince of Canino for the opportunity of making the comparison with this species, which has been accurately defined by that distinguished naturalist.

†See my 'Odontography,' p. 476, pl. 125. ‡ Page 106.

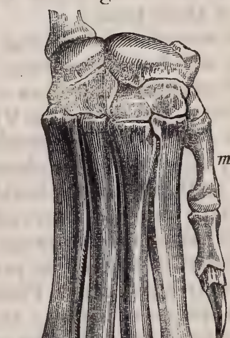
length of that of the *index* or adjoining toe ; it is not quite so long in the Common Fox (fig. 4. *m* 1) ; in the fossil *Canis* the metacarpal of the pollex equals three-fifths of that of the index, and the phalanx of the 'dew-claw,' instead of terminating short of the distal end of the next metacarpal bone, extends beyond it. This well-marked character does not arise from any dislocation of the bones of the pollex or digit of the 'dew-claw,' and it forms another instance of the affinity of the extinct Œningen *Canis* to the Viverrine group of *Feræ*, in which all the bones of both fore and hind-feet are more robust than in the Dogs, and the pollex of the fore-foot is a little more developed (in *Viverra civetta* and *V. genetta*, for example) than even in the fossil *Canis* of Œningen.

Fig. 3.



Galecynus œningensis,
Bones of fore-foot, nat. size.

Fig. 4.



Vulpes communis,
Bones of fore-foot, nat. size.

The tail of the fossil is longer in proportion than in the Dog, Wolf, or even Jackal, but it is not so long as in the known existing species of Fox ; the vertebræ are stronger also in proportion to their length ; this difference is illustrated by the figures of the two most perfect caudal vertebræ (the 8th and 9th) of the fossil (fig. 5), and of their homologues in the large Fox (fig. 6), the teeth of which were compared with the fossil. There are some other differences between the bones of the fossil and those of the Common Fox, in the relative strength of the ulna and fibula, for example; but they are of minor importance to those above detailed. The characters founded upon those differences not only establish the specific distinction of the fossil from the Common Fox, but afford as good ground for its subgeneric distinction from *Canis* or *Vulpes* as any that can be pointed out in the skeleton of *Lycaon*; the excess of development of the pollex being as remarkable in the fossil as its defective development is in the Cape Hunting Dog (*Lycaon pictus*); and the Œningen fossil tends as much to diminish the interval between *Canis* and *Viverra*, as the Lycaon does that between *Canis* and *Hyæna*.

Fig 5

Galecynus, nat. size.

Fig 6

Vulpes communis, nat. size.

The foregoing notes were written before I received the fasciculus of the 'Fauna der Vorwelt' of M. H. von Meyer (1845), in which he has copied the reduced figure of the fossil from the 'Geological Transactions' (*l. c.* pl. 33), with some criticism of Dr. Mantell's description, and some remarks on characters exhibited by the figures, which indicate the specific distinction of the fossil from the *Canis Vulpes communis*, for which name, as applied to the fossil, M. von Meyer cites Dr. Mantell as the authority, in both his present work (p. 4) and in his 'Palæologica' (8vo, 1832, p. 50*).

M. von Meyer first observes that the skull of the fossil appears to be rather short in comparison to the *Canis lagopus*, and rather high in proportion to its length as compared with the skull of the Common Fox†. Dr. Mantell however, after remarking, "The skull ap-

* *Canis Vulpes* (*communis*) *fossilis*, H. von Meyer, 'Palæologica,' 1832, p. 50. 'Vulpes des schistes d'Œningen,' De Blainville, 1843, p. 157.

† "Mir scheint der Schädel des fossiler Thiers gegen *Canis lagopus* (*Isatis*) wuniger stumpf und gegen den gemeinen Fuchs im Vergleich zur Länge etwas ez hoch," *loc. cit.* p. 4.

pears to be too deep in proportion to its length, as compared with that of a Fox," judiciously adds, "But this is owing to the displacement of the lower jaw, the right ramus of which is thrown above the left*."

M. von Meyer then says, "There is a remarkable part at the hinder angle of the lower jaw which does not exist in the Fox." In the fossil, however, the part in question presents merely the remains of the produced angle of the jaw, characteristic of both *Canidæ* and *Viverridæ*; a small portion of the matrix is left to support this process, which is not distinguished from the bony matter in the lithograph copies by M. von Meyer, and it gives the character, therefore, of a longer angular process, and one that is produced downwards; but this character does not exist in the lower jaw of the fossil.

M. von Meyer remarks, that the figures in the 'Geol. Trans.' (he alludes to figs. 1 and 2, pl. 34) exhibit an anterior basal tubercle in the third, fourth, and even the second molars, which is not found in any species of *Canis*, except in the deciduous teeth†. The character alluded to by that acute observer is, however, exaggerated in the figures cited. In fig. 1. pl. 54, of the natural size, drawn with scrupulous accuracy, the true form of the premolars may be better appreciated. In regard to the development of the anterior tubercle, the difference as compared with the Fox or other species of *Canis* is one of degree; most of the existing species having the tubercle in question, but much more rudimental, viewed from the inner side; whilst *Canis* (*Lycaon*) *pictus* has it more developed than in the fossil. The true differences manifested by the lower molar teeth of the fossil are those which I have pointed out above, in the form and development of the posterior tubercle of the premolars, and in the relative proportions of the different teeth; characters which, as before remarked, indicate a more Viverrine or tropical form of *Canis* than is now known to exist.

With regard to the rest of the skeleton, M. von Meyer merely repeats the remarks which Dr. Mantell himself has made, with the addition of M. de Blainville's notice of the more robust proportions of the feet. The characteristic Viverrine development of the pollex seems to have escaped the notice of the distinguished palæontologist of Frankfort.

* Geol. Trans. *loc. cit.* p. 291.

† "Nach diesen Abbildungen würde der dritte, vierte, und, wie es scheint, sogar der zweite Backenzahn einen Vorderansatz besitzen, der in *Canis* überhaupt nicht, oder etwa nur an den Milchzähnen wahrgenommen wird," *loc. cit.* p. 4. I have described this peculiarity of the deciduous dentition of the genus *Canis* in my 'Odontography,' vol. i. p. 477: "In the lower jaw the first deciduous molar resembles that above, but has the anterior and posterior basal tubercles better marked: the second is similar, but larger." The comparison cannot be extended beyond these two teeth in regard to the supposed character of the fossil. The milk dentition of *Canis* shows, in this respect, a closer resemblance to the Viverrine and the general carnivorous type of the premolars than does the mature dentition; and the fossil *Canis*, to the degree in which it resembles the immature dentition of the existing species, shows, like many other ancient extinct forms, the retention of a greater degree of immature characters, or of the general type, than do the recent species.

With regard to the name of the unquestionably distinct and well-marked species or subgenus of *Canis*, represented by the remarkable and well-preserved Œningen fossil, which rewarded the early geological pursuits of the distinguished author of the 'Silurian System,' the brief notice in the original memoir conveyed the idea of its specific identity with the Common Fox; it has been cited in the general catalogues of fossil mammalia, *e. g.* the 'Palæologica' of H. von Meyer, as '*Canis Vulpes* (*communis*) *fossilis*' (p. 50); and by M. Pictet in his excellent compendium, the 'Traité Elémentaire de Palæontologie,' 8vo, 1844, as the 'Œningen species of Fox,' with the expression of a doubt as to its identity with *Canis Vulpes*, chiefly founded on M. de Blainville's passing notice of the proportions of the feet.

M. de Blainville himself speaks of the fossil as "*Vulpes des schistes d'Œningen*," which, if latinized, would give the specific name "*Vulpes Œningensis*," or the 'Œningen Fox.'

M. von Meyer has the merit of having first proposed the definite binomial of *Canis palustris* (Leonhard and Bronn's 'Jahrbuch fur Mineralogie,' 1843, p. 701); but as the characters of the fossil, so far as they mark a subgenus distinct from *Canis*, equally indicate one distinct from *Vulpes*, it appears to me that the name proposed by M. von Meyer can only be retained with the understanding that the generic term *Canis* is used in the broad Linnæan sense. It is in this sense that I should myself prefer to retain it. The modern zoologists, however, who have adopted the subgeneric divisions of the Linnæan *Canis*, known under the names of *Lycaon*, *Megalotis*, *Proteles*, *Vulpes*, &c., must, in consistency, enter the present acquisition from a former world in their catalogues under a proper subgeneric name. That therefore of *Galecynus* *, as indicating the affinity of the fossil to the *Viverridæ*, may not be deemed unacceptable.

Whether the indications of the specific distinction of the 'espèce d'Œningen,' by MM. de Blainville and Pictet †, will be deemed by the systematic zoologist to give the nomen triviale *œningensis* the priority over *palustris*, may be doubted; but there is room for choice, and geologists will probably prefer to call the species which has so long been known as the Œningen Fox, *Galecynus œningensis*, or the Viverrine Fox of Œningen.

It is interesting to remark, that a more ancient species of *Canis*, from the eocene gypsum of Montmartre, apparently of the same subgenus (*Canis viverroides*, Cuv.), makes another step beyond the present *Canis palustris* in the direction towards the tropical Viverrine family of Carnivora.

* Gr. γαλῆ, *cat* or *weasel*, κύων, *dog*.

† "Il y a au moins autant de probabilité pour admettre que l'espèce d'Œningen était différente de celle qui vit de nos jours." (Traité Elémentaire de Palæontologie, tom. i. p. 162.)

4. *On the Geology of the Island of* LAFÛ, *one of the Loyalty Group, east of New Caledonia in the Southern Pacific.* By the Rev. W. B. CLARKE, M.A., F.G.S.

ON the eastern side of New Caledonia, and within sight of that island, occur two groups, known on the charts as the Loyalty and Britannia Islands. The former group has been generally represented to consist of two, but has been recently found by Mr. T. B. Simpson to consist of eight islands, of which Lafû, sometimes called Dafoo, at the eastern, and Emingina at the western extremity, are the largest. Mr. Simpson's opinion is, that the original discoverer saw but one, but that he visited part of its south-western coast where an east and west bay, seven or eight miles wide at the entrance, and from ten to twelve fathoms deep in places, but in the middle more than ninety fathoms deep, is fringed with a narrow coral reef, and has the appearance of dividing the island into two.

Of the other islands or islets, one is about eighteen miles north of Emingina, the northern end of which is in 21° 26′ S. and 167° 44′ E., and the rest are intermediate between it and Lafû.

The present purpose is to offer some remarks on the geological features of one island of the Loyalty group, viz. Lafû. It may be quoted as an example of an elevated coral island, and is selected because it exhibits more strikingly than the rest of the two groups, which are of similar construction, the distinctive proofs of that phænomenon.

The circumference of Lafû is about ninety miles; its base is surrounded by a narrow fringing reef or shelf, upon which the depth gradually increases for about a quarter of a mile, and then plunges sheer down, out of the reach of soundings. The whole island is composed of dead coral, which in patches on the summit is bare, but which is generally covered by a scanty soil of decomposed materials in which is rooted a very luxuriant vegetation.

The average height of the above ocean is about 120 feet, but on the eastern side, which is the most abrupt, there are points 250 feet high. On the western side the headlands are all remarkably similar in height and outline, each being crested with a summit higher than the neighbouring surface, and crowned with pines of similar character to the *Araucaria excelsa.*

At the lower part of the island are found blocks of recent calcareous rock, similar to those seen on various parts of the great coral reefs; consisting of recent Cardia and other shells, whole and in fragments, cemented by a paste or powder derived from triturated shells, and having the aspect of chalk and solid limestone. Stalactites and stalagmites are also frequent in the hollows below the headlands. These probably result from the action of the sea spray and atmospheric water combined with evaporation. So rapid are these agencies in certain localities, that I have seen sandstone walls in New South Wales coated by patches of calcareous matter, which is the product of moisture and evaporation acting on the fragments of sea shells employed in the cement of the buildings; and many such instances may be found in the city of Sydney, on walls but a few years old. Similar incrustations face the cliffs of the carboniferous formation, north of Bullai on the coast of the Illawarra, derived from the evaporation of the moist particles of shells and sand blown up by the wind far out of the reach of the waves.

The resemblance of the calcareous conglomerates of some of the coral islands to cretaceous rocks is so great, that it is easy to imagine by what processes some of the latter may have been produced; nor is it unlikely, that in some future geological epoch, representatives of them may be recognised in these recent formations when subjected to the transmuting influence to which the secondary chalk has been exposed.

Above these lower calcareous masses, at the height of from fifty to 100 feet above the sea, the rocks are chiefly composed of a dead coral. In the hollowed cells of this species are found calcareous mud, vegetable fibres, small decomposing shells and fragments of shells, together with attached Serpulæ, the latter proving that some of these extraneous substances have not been carried upwards by the sea or wind, but were elevated with the rock itself.

The upper part of the island consists of a dead species, apparently an *Astræa*. In this species the diverging lamellæ are connected by transverse radiating septa, which produce rectangular cellules with vertical walls and inclined floors. The stars are very irregular, some being concavely quadrilateral and others much elongated, as if from crowding or pressure of the animals in growth.

Masses of this occur full 250 feet above the sea, and at that height the hollows and cells are filled with minute fragments of shells, vegetable fibres and portions of fuci, coral sand and other marine detritus. The aspect of these upper corals is that of great age, and the more exposed are extremely crumbling, but the lowest corals have an appearance of great freshness.

Some of the appearances presented by the surface of Lafû, such as the parallelism of structure in the headlands, and the overhanging character of the cliffs, lead to the idea of a unity of action in their formation. The existence of beds of coral at the height of 250 feet above the sea, together with the adventitious circumstances of entangled marine substances, the whole island being free from cracks or fissures, prove that its present conditions are due to simple elevation; that this has been interrupted by a period of repose may be inferred from another interesting fact. At the height of from seventy to eighty feet above the sea, a ledge or shelf of the same character as that now surrounding the base of the island runs all round the cliffs; and where along the bays and hollows near the coast this water-mark is cut off by the lower level of the neighbouring shores, on pushing into the interior, the real continuation of the water-mark may be traced so soon as the country rises to a sufficient height. Nothing can be clearer than this evidence to show, that in the island of Lafû there have been two distinct elevations of the land, the latter amounting to nearly eighty feet, the former to at least 170 feet. Supposing that, in forming, coral islands must of necessity subside, the amount of elevation of the lowest visible coral rock at the level of the sea must have attained at least 500 feet from a former level.

The general surface of Lafû is that of a table land with such hollows and elevations as now mark the surface of a coral reef; and as the soil upon it is thin and much intermixed with decomposing fragments of calcareous matter, no great changes have modified its superficial condition since it attained its present elevation.

Many localities in the Pacific exhibit the occurrence of rocks of dead coral at considerable heights above the ocean, as is the case in Java, Timor, &c. In those instances the immediate connection with volcanic action points to a cause of elevation. In the case of Lafû the elevation does not appear to be connected with visible volcanic force; but it is highly probable that it is merely the result of the elevation of New Caledonia, which is composed of primary and Silurian rocks, traversed by dikes and intrusive masses of basalt and trap; and which is everywhere surrounded (for the space of 1000 miles in one direction) by fringing and barrier reefs, of which the Loyalty and Britannia groups are elevated portions.

To connect these reefs with portions of the sea to the south-westward, and with the coasts of Australia south of the great barrier reefs, by the discovery of blocks of loose coral, upon the mountains of the continent, is more perhaps than can legitimately be done; but it is worthy of mention, that fragments of coral, in all the characters of structure, colour and decomposition similar to the *Astræa* of Lafû, have been brought to me from the ranges at the head of the river Boyne in the Darling Downs west of Moreton Bay, in lat. 26° 40′ S. and long. 151° 42′ E., full 700 or 800 miles from Lafû, and at the height of not less than 2000 feet above the sea. Whether these fragments are true drift like the pumice, which I have found everywhere dispersed along the shores of Eastern Australia*, and which occurs on the high ranges of Australia Felix, far to the south; or whether they have been dropped by the aborigines, who frequently carry strange substances in their bags for many miles, there is no ground to determine; but whilst the paucity of the fragments opposes, the size of them favours the idea, that by some physical cause there have been left upon the soil blocks of this species, which in all points resemble the masses on the summit of Lafû; and upon the supposition that they were taken from the coast and carried inland, it is clear that the existence of the reef-making corals may be traced further south on the coast of New South Wales than is commonly imagined. Nay, certain Astrææ and other corals abound in Port Jackson.

In conclusion, I remark, that the occurrence of the genus *Astræa* in the harbour of Port Jackson proves, that corals of this description can thrive in shallow water of a temperature below that of the reef-studded ocean. The lower limit of sea temperature favourable to the growth of corals has not been ascertained; but the occurrence of Astræas on the shores of Port Jackson, where the average temperature of the water is between 60° and 70°, varying perhaps occa-

* See my remarks in the Tasmanian Journal, vol. i.

sionally beyond 70° from the access of the great current from the north, shows that corals do not require the amount of temperature supposed by some authors. M. Couthouy expresses this idea, that "Astræas especially seem, in exposed places washed by the coral breakers (at a temperature not over 78°), to find their most congenial climate*:" and Mr. Dana has shown that some species grow in a temperature of 66°†. As the average temperature of Port Jackson is lower than this, it is certain that some corals exist in a considerably cooler climate than others.

NOVEMBER 18, 1846.

Professor L. D. B. Gordon of Glasgow was elected a Fellow of the Society.

The following communications were read:—

1. *On the Laws of Development of Existing Vegetation and the application of these laws to certain Geological Problems.* By JOHN WALTON, Esq.

THE author's remarks are chiefly founded on the excentrical position of the pith of exogenous trees, which he states are caused by unequal heat afforded to the north and south side. He supposes that a north and south line drawn through the central axis in a transverse section of a tree will generally bisect the section, while an east and west line divides it into two unequal parts; but that at the equator and poles such section will be bisected by either line.

He then alludes to the prevailing wind as a disturbing cause, not however obliterating the action of the sun, and concludes that contemporaneous plants, whether fossil or not, being in their upright position with their roots downwards, and having lines of like development parallel to each other, have grown in the place where they are found and are in their original position. He also concludes that if the lines of development are not parallel in beds of different ages, the line of action of the cause of that development has changed. He considers that many important geological conclusions may be deduced by applying these propositions.

The author next proceeds to the subject of internal heat, and considers that since it would tend to produce an equality of development, we may determine its former extent of action by examining the trunks of exogenous trees.

Although at first he only applied this theory to exogenous vegetables, he afterwards considered that the central pith of Stigmaria and some other fossil coal plants sufficiently answered the conditions of the problem, and thence has satisfied himself, that although the data are not yet sufficient to base a definite argument upon, still

* Boston Journal of Natural History, vol. iv.

† American Journal, vol. xlvi. p. 135.

these methods being communicated may suggest to others observations from which results of great interest may be derived.

A short additional paper was afterwards read from the same author, in which he stated, that after examining many exogenous trees from Portland island, he is satisfied that the sun's heat was as much above the internal heat at the time of the deposit of the beds of Portland oolite as it is now, the stems being similarly excentrical. He also thinks that the small thickness of the rings of these trees proves that the growth of vegetation was not formerly more rapid than it is now.

In conclusion, the author directs attention to the importance of accurately observing all instances of upright stems of trees that may be discovered *in situ*.

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2. *Remarks on the Geology of the Island of Samos.*
By Lieut. Spratt, R.N., F.G.S.

Plates II. III.

The island is divided into two equal parts by a high mountain running transversely across from the north to the south shore, and attaining a height of 4000 feet. The ancient as well as modern name of this range is Ampeloni.

Besides Mount Ampeloni, there are two other conspicuous mountains rising at the two extremes of the island. The western one, Mount Kerki, is the highest point in the island and is 4000 feet above the sea. The eastern mountain is the least in elevation of the three, and does not exceed 1200 feet. Mounts Kerki and Ampeloni are composed of a mass of crystalline limestone overlying mica schists, but whether conformably I had no opportunity of observing; neither can I speak of the amount and direction of the dip of these older rocks; in Mount Kerki however the dip was considerable, whilst in Ampeloni and the eastern mountain it is not great; in the latter indeed the strata are nearly horizontal, so that the schistose rocks do not appear at all.

These mountains are connected together by a series of flat-topped hills and ridges from 400 to 800 feet in height. The deposits forming these are all of freshwater origin, and appear by their fossils to be identical with the lacustrine formations on the shores of the Gulf of Smyrna and the island of Scio, which have been described on a former occasion, and are supposed to be of eocene date.

The portion of the island of Samos described in this paper, the only part I had an opportunity of examining closely, is the district lying to the east of Ampeloni between Port Vathy on the north, and the site of the ancient city of Samos on the south side of the island.

The accompanying section is on a line between these points, where the inclined strata represent the lacustrine deposits, consisting of thick beds of a white compact limestone, not easily distinguished in mineral character from some of the secondary limestones containing Nummulites which occur in the southern part of Asia Minor.

SECTION 1. From PORT VATHY to the ancient city of SAMOS.

The lower deposits of this formation are the most compact and thick-bedded; but the upper portion of the series is more thinly stratified than the former, and occasionally interstratified with white and grey marls. The thickness of the whole deposit exceeds 1000 feet; but as the formation upon which it reposes is nowhere visible, its entire thickness is not seen.

Fossils occur in several localities, but not in any great abundance or in a very good state of preservation, the cast only of the shells remaining. Vegetable impressions are more abundant, and appear to have been made of plants which grew at the bottom of the lake. A species of reed often occurs in clusters like a number of cylindrical pipes, the cavities formed by the imbedded reeds not having been filled by calcareous matter after their decomposition. They are nearly always found in a vertical position.

The localities at which I found these reeds are (1) the western shore of Port Vathy; (2) cliffs at the ruins of the ancient city of Samos; and (3) on the summit of the ridge about two miles north-east of the large village of Mitelinious, where also, besides the casts of the reeds, there are abundant impressions of stems with leaves attached.

The longest of these stems with attached leaves was 18 inches, and the diameter of the reeds $1\frac{1}{2}$ inch. Both kinds of vegetable remains are fossilized in a vertical position, as if imbedded in the deposited sediment whilst growing at the bottom of the lake. The strata in which they are found are exceedingly hard, owing to the presence of silex. With these plants I found a single specimen of a Planorbis, which seems to be *Planorbis rotundatus*, very abundant in the freshwater deposits in the Gulf of Smyrna. The other shells are a Paludina and a Melania, both procured from the south face of the hill upon which stands the Acropolis of the ancient city of Samos. The Melania is also found on the hills bordering the west shore of Port Vathy. From the promontory on the east side of the ancient port I procured several specimens of Helix. They are associated with casts of a Lymneus, identical with that found in the lacustrine beds of the Gulf of Smyrna, and therefore identifying this formation as a portion of the bed of the great eocene lake which doubtless formerly extended over the area now occupied by the Ægean Sea.

I have now to notice another formation of a subsequent date, but whose origin is uncertain, from the absence of fossils by which to identify it. This formation reposes horizontally upon the lower beds of freshwater origin in the neighbourhood of the village of Mitelinious. A deep water-course from Mount Ampeloni cuts through these deposits, and exposes sections of the different strata, consisting of about 150 feet of brownish and grey beds of sandy marl, sandstone, grit, and gravel containing pebbles of the rocks older than the lacustrine deposits.

From the absence of fossils I can only offer a conjecture with regard to their origin, which I think to be marine. Deposits corresponding to these will however be more fully described in the next paper, on a part of Eubœa and Bœotia.

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3. *On the* Geology *of a part of* Eubœa and Bœotia.

By Lieut. Spratt, R.N., F.G.S.

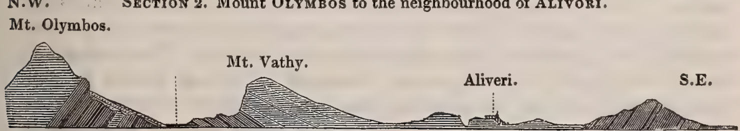
Plate IV*.

Since my examination of the freshwater deposits on the east coast of the Ægean sea and in the island of Samos, I have been enabled to pursue some geological researches on its western shores; and there, as I had expected, I found corresponding formations in several localities, establishing the fact of a great eocene lake having extended over the whole of the Grecian Archipelago, where now there is a sea which in many places is known to be more than 300 fathoms deep.

I shall first briefly notice the distribution of the older rocks in the Negropont. The southern part of the island is composed of gneiss, mica schist, chlorite and crystalline marble, elevated into very high ridges, and forming a very mountainous tract of country, the highest peak of which is Mount Elias, near its south extremity. It attains a height of 5000 feet. The formations dip in various directions and at all angles; generally the dip is either to the N.W. or S.E., and the angle not exceeding 25°.

The marble was extensively quarried by the ancients; numerous deserted quarries exist along a range of coast fifteen miles in length, in which columns and blocks of various sizes are still lying ready for transportation, and some exceed thirty feet in length. The marble is the Cipollino of the Italians, and these quarries seem to have been the chief source which supplied Rome for many of its buildings.

Section 2. Mount Olymbos to the neighbourhood of Alivori.



These older rocks terminate at Aliveri, and are succeeded by secondary rocks, composed of dark shales and limestone, containing

* The geographical map Plate 2 exhibits the relative position of Samos, Eubœa, Bœotia and Smyrna.

black flints and Hippurites; these particularly abound near Choleis, north of which spot I have had no opportunity of examining.

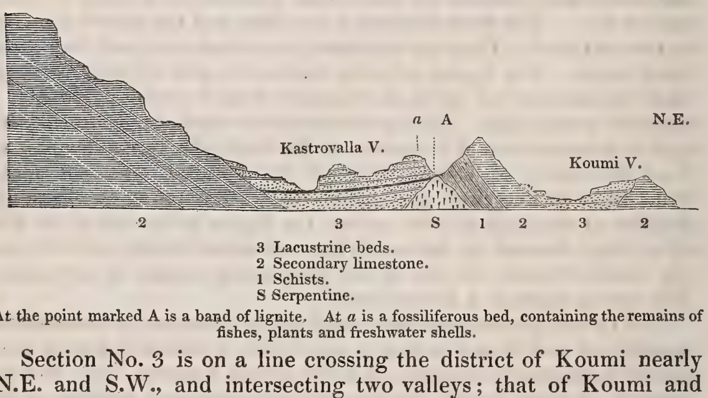
The section No. 2 shows the unconformable position of the older and secondary rocks near Aliveri, and the elevation of the latter into a great mountain chain, which runs through the island to the northward, and attains a height of nearly 8000 feet.

The locality with lacustrine deposits, which I shall first describe, is a district in the neighbourhood of Koumi, on the east shore of Eubœa, immediately opposite the Gulf of Smyrna. At this spot a similar formation has been described in a former paper read to the Society, where it is suggested that some of the sea cliffs were portions of the bottom of a freshwater lake, identical with the eocene basins in Europe*.

At Koumi also there is a continuous line of cliffs washed by the sea, about five miles in length, composed of deposits identical with those in the Gulf of Smyrna, both in mineral character and fossils.

Koumi is one of the most fertile districts in Eubœa. Its fertility is due entirely to the presence of this formation; and like the localities of contemporary origin on the Asiatic shore, it is favourable for the growth of the vine, and in repute either for the quality of its wines or raisins.

S.W. SECTION 3. Across the Valley of KASTROVALLA and KOUMI.



3 Lacustrine beds.
2 Secondary limestone.
1 Schists.
S Serpentine.

At the point marked A is a band of lignite. At *a* is a fossiliferous bed, containing the remains of fishes, plants and freshwater shells.

Section No. 3 is on a line crossing the district of Koumi nearly N.E. and S.W., and intersecting two valleys; that of Koumi and Kastrovalla, which are filled by lacustrine deposits. The deposits in these two basins lie nearly horizontally, between rocks of secondary origin. On the west side of the valley of Kastrovalla, the formation abuts against the flanks of a high mountain between 5000 and 6000 feet above the sea, composed of a mass of grey compact limestone, dipping to the east at about 25°. I found fragments of Hippurites in this limestone near the village of Konistra.

The two valleys are separated by a narrow ridge composed of semi-crystalline limestone and dark friable schists and shales, which are uplifted nearly in a vertical position by the protrusion of serpentine, which appears in several places on the west side of the ridge. These schists and limestones, I have no doubt, are a portion of a

* Quart. Geol. Journ., vol. i. part 1, p. 156.

series of similar rocks overlaid by the great mass of Hippurite limestone in other parts of the island, as may be seen in the previous section No. 2, which crosses a part of the mountain chain near Eretri.

The lacustrine deposits consist of white marls interstratified with compact calcareous beds, resembling lithographic stone, which towards the upper part of the series are thinly laminated, and easily split into slabs of any required thickness; the stone has in consequence become an article of commerce for roofing houses, and is principally used for this purpose by all the villages in the district. In some of the spots which are quarried for these slabs, freshwater shells and the leaves of land plants abound to such an extent, that it is hardly possible to split any fragment without exposing an impression of a leaf, of which there are several species. No doubt the plants grew upon the adjacent mountains when forming islands in the lake.

Besides these strata, the formation is remarkable for a bed of lignite. The coal has been tried in some of the steamers and burns well, but is objectionable from emitting a disagreeable smell, and producing a large quantity of dirt or ashes in proportion to the fuel consumed.

The lignite bed is overlaid by about 200 feet of the calcareous strata and marls, and consists of four seams included in a depth of about sixteen feet. The thickest seam is four feet, and the others from one to two feet each. They are separated by a black clay and dark indurated marls. The lignite is thinly laminated, and contains no vegetable impressions; it varies in character from a woody texture to a tolerably brittle coal. The lignite was discovered about fifteen years ago, in consequence of a landslip at the head of a ravine leading up from the valley of Koumi, through the upraised schistose rocks. From there having been a considerable wasting away of the softer deposits at the head of this ravine, the lignite crops out at the foot of a ridge, formed of the overlying calcareous strata, and within a few hundred yards of one of the protruding points of serpentine. The spot is marked A in Section 3.

The Greek government have until lately procured a considerable quantity of coal from this spot, a tunnel with a tram-way having been carried horizontally into the seam for several hundred feet; but the expense of carriage has discouraged the continued working of the mine, since the material is found not to be economical for steamers. It is principally used in factories.

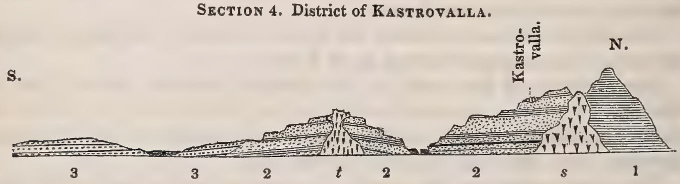
A short distance from the mouth of the mine I found, in some of the overlying strata, both vegetable impressions and freshwater shells, but in a crumbling decomposed state: they consisted of a Planorbis, Paludina, Limneus, and Cyclas. Similar fossils are more abundant at the head of the Kastrovalla valley, at the Plaka (flat slab) quarries, about two miles N.W. of the mine. The highest part of these lacustrine deposits is upwards of 1000 feet above the sea.

Fossil fish are sometimes found at these quarries, but rarely. I was however so fortunate as to find a fragment of one, and bought another perfect specimen on a former occasion, said to be from Koumi.

The deposits in the Kastrovalla valley have a dip to the south of a few degrees, so that in the lower part of the valley the lignite is again seen, but the whole of the lacustrine beds are overlaid by beds of brownish sandy marl and gravel, forming low hills and ridges from 50 to 200 feet in height, extending over a district of three or four square miles.

These gravelly beds contain no fossils, and in every respect correspond in description and position with those in the island of Samos before noticed.

SECTION 4. District of KASTROVALLA.



3. Gravel.
2. Lacustrine beds.
1. Secondary limestone.
s. Serpentine.
t. Trap.

Section No. 4 is on a line nearly north and south through this district, showing the position of the gravelly beds, and also of trap ejected through the lacustrine deposits.

I next examined the two shores of the south channel between Eubœa and Greece, on both sides of which I found evidences of the ancient freshwater lake having existed there also, viz. at the Bay of Stura in Eubœa, where the freshwater deposits and gravel repose upon mica schists; but they are not so extensive or so well-developed as in the district to the south of Oropo, on the confines of Bœotia and Attica.

SECTION 5. Section near MARKOPOULO.

Secondary limestone. Lacustrine gravel.
At B. is a band of lignite.

Section No. 5 crosses this district near the village of Markopoulo, in a line due west from the channel. A narrow strip about seven miles long and two miles wide lies parallel to the shore, which is composed of deposits closely resembling those at Koumi, even to the presence of the lignite; they are however here inclined at a greater angle, viz. 20°, and repose on or surround the secondary limestone, that rises into a higher chain of mountains behind, forming Mounts Parnes and Citheron, which separate Attica from Bœotia.

The gravelly beds also occur here precisely under the circumstances and in the same condition as at Koumi, and unconformable to the lacustrine deposits; and here they form a very important feature in the geology of the country, both from their extent and thickness: they cover the intermediate tract between Markopoulo and the foot of Mount Ktypa, opposite Chalcis, a district twelve miles in length and four broad, forming a long chain of hills separating the valley of Tanagra from the Eubœic Channel, but divided by the Asopus near Oropo. In the freshwater deposits over Markopoulo, I found the same shells as at Koumi; but the fossils in this locality are neither so numerous, so well-preserved, or of such a variety, there being no vegetable remains or fish that I could find or hear of. The shells generally crumble to powder on being extracted from the marly strata in which they are found.

The lignite occurs in about the same position with respect to the amount of the superior strata as at Koumi.

The finding of the coal in this district is more recent than at Koumi. A mine was opened about a year since, and is worked with some activity; the coal being more easily procured and a shorter distance from the sea than the Koumi coal.

The mine exists at the head of a narrow valley behind Markopoulo*. The lignite here is found lying near the surface, the superior strata having been denuded down to it; and when I visited the spot last summer, a portion of the uncovered lignite was burning, the ignition, I was told, having been spontaneous, for which reason no effort was made to extinguish it. The bed of lignite is about eleven feet thick, but thinly laminated throughout, and towards the upper and lower part interstratified by thin layers of a white earthy substance. This was doubtless a sediment deposited during the formation of the lignite, which from its thin lamination appears to have been the result of vegetable matter growing at the bottom of the lake. Some of the separated laminæ have notwithstanding a woody texture, and in viewing a small fragment, one would suppose it to be a portion of a tree, the laminæ representing the concentric rings of growth.

The gravel ridge, extending from Oropo to Mount Ktypa, is of an average height of from 300 to 400 feet throughout, the beds lying horizontal. Upwards of 100 feet of the upper portion of the ridge is composed of beds of gravel and red loam, below which I observed about forty feet of yellowish, brown and grey marls, with thin beds of loose sand intervening. I had no opportunity of examining a deeper section of the deposits of this ridge, and could detect no fossils, either in the marls or overlying bed of gravel; but the mineral character of the former more resembles the marine tertiaries than those of freshwater origin.

As the gravel beds contain only fragments of the older rocks which surround the lacustrine formation, the latter must have been covered by the waters in which the former were deposited, and they most probably extended originally over the freshwater limestones also, but not to so great a thickness in the upraised portions as in the intermediate hollows: to the south of the village of Markopoulo

* Marked B in Section No. 5.

some evidences of this are seen in detached portions of the newer gravel beds, reposing horizontally upon highly-inclined strata of the lacustrine group. It is thus difficult to determine the precise age of these gravels, or how nearly or distantly they may be allied to the deposits of undoubted freshwater origin. The coincidence of their character and conditions in the three described and distant localities of Samos, Koumi and Oropo, denotes the contemporaneous origin of all the gravelly deposits. They may perhaps be referred to that volcanic period when so many eruptions of igneous matter burst over the bed of the lake, to a great extent on the Asiatic coast, and particularly in the Gulf of Smyrna; elevating some portions several hundred feet, and doubtless submerging others to as great an amount.

The addition of these three localities, with freshwater formations apparently identical with those on the Asiatic shore near Smyrna, render it more difficult than ever to define the boundary of this ancient lake; and this is particularly the case with regard to that of Samos, as it before appeared probable that this basin was confined to the northern part of the Ægean Sea. Having now passed that supposed boundary formed by the belt of islands extending from Eubœa to Samos, which renders it probable that the lacustrine deposits of Rhodes, Cos and Cerigo are of the same age, and having found the formation also in Greece, where it is perhaps important to remark that the freshwater strata above Markopoulo are 200 or 300 feet higher than the valley which crosses by Thebes from the Eubœic Channel to the Gulf of Lepanto or Corinth, we have no defined boundary for circumscribing the limits of this lake, which must have been of considerable extent. The question seems to be involved, whether it was a local basin confined to the eastern division of the Mediterranean, or whether it did not rather extend over the whole of it, connecting the Levantine with these eocene freshwater deposits on its border, in the low countries of Provence and Lombardy (and probably also with the freshwater limestone recently found by Mr. Hamilton on a branch of the Arno). These we may suppose were all of them elevated portions of the bed of this great lake, near each of which igneous eruptions of contemporaneous age have taken place.

Knowing the error which may arise in drawing conclusions from the present configuration of the country, and particularly in a district which has so frequently, in all its parts and in all geological ages, been subject to great volcanic disturbances, the extent and amount of which we have no means of ascertaining in that part covered by the sea, the view thus suggested will require the introduction of fewer hypothetical disturbances in order to connect, as parts of the bottom of one great lake occupying the whole of the Mediterranean basin, the several localities in which eocene lacustrine deposits occur, than that which would make each a separate lake of limited extent.

There is another point of considerable geological importance connected with this supposition, which also it tends materially to strengthen, viz. the total absence of any eocene marine formation round the borders of the Mediterranean. None has, I believe, been identified as belonging undoubtedly to this age and of marine origin. Miocene and pliocene formations are the marine tertiary deposits everywhere encircling this basin; thus establishing the fact of its connection with the ocean during these geological periods, and tending greatly to confirm the supposition of its having been a freshwater lake during the eocene period, by the absence of marine deposits of that time. They also indicate that the conversion of the lake to an arm of the great ocean took place at the close of the eocene period, when great eruptions evidently disturbed the area, and most probably opened a channel for its connection.

The arguments bearing on this supposition which my limited means of research have enabled me to collect, will I hope be deemed of sufficient importance to call the attention of geologists to the subject, and induce further inquiry, as I think there are several localities round the borders of the Mediterranean where formations exist, which have been classed as secondary from mineralogical resemblance alone, but which in truth are lacustrine of the eocene age. The close resemblance of some of these lacustrine limestones with the scaglia is at any rate very remarkable.

Mr. Strickland notices the resemblance between the Smyrna freshwater limestones and the mountain limestone of the Ionian Islands; and Mr. Hamilton likewise has stated that he was at first deceived in a similar manner with the Italian freshwater limestone; and for several years I had mistaken the limestone of Samos for secondary, from its resemblance to the nummulite limestone of Asia Minor.

Appendix.—*On the* Fossils *collected by* Lieut. Spratt, R.N., *in the Islands of* Samos and Eubœa. By Prof. E. Forbes, F.R.S. &c.

The collections accompanying Lieut. Spratt's papers include a number of very interesting fossils.

From Samos he has sent several fossil shells and plants, collected in the lacustrine tertiaries of that island. The plants appear to be the remains of large reeds, and impressions of leaves resembling those of the Oleander. The shells consist of a Paludina, closely resembling one in the Eubœa collection, but in bad condition; a Helix, allied to some existing Levant forms, but undeterminable, since the preservation of colour only could enable us to be certain of the species in the section of the genus to which it belongs; and a large cylindrical shell, mentioned in the paper as a Melania, but most probably of terrestrial origin; I regard it as probably a large extinct species of Bulimus, allied to *B. decollatus*. As Lieut. Spratt mentions the occurrence of species of Lymneus and Planorbis in these beds, identical with those found on the tertiaries of the Gulf of Smyrna, the Samos formation may be regarded as most probably eocene.

The collections sent from Eubœa and the neighbouring mainland are of great interest.

The specimens in the freshwater limestone of Oripo are undoubtedly *Lymneus longiscatus* and a Paludina, both characteristic of the Smyrna freshwater tertiaries, and indicating an eocene epoch.

But those from Koumi have a much more recent aspect. In the strata there we find a Planorbis, which is most probably the existing *P. orientalis* ; a Paludina, nearest an existing Greek species ; also a Cyclas, very near one which I found in Asia Minor. With these are numerous and beautifully preserved remains of plants, leaves of a Beech, two species of Oak, a Laurus, a Salix?, a Celtis?, an Oleander, and leaves and fruit of Pine.

The fish, now in the collection of Sir Philip Egerton, have been examined by Prof. Agassiz, and pronounced undescribed.

I infer that the Koumi tertiaries belong to a more recent epoch than those of Oripo and Smyrna.

DESCRIPTION OF THE PLATES TO LIEUT. SPRATT'S PAPERS ON SAMOS AND EUBŒA.

Plate II.

Geographical map of a portion of the Greek Archipelago, to show the relative position of Samos, Eubœa and Smyrna.

Plate III.

Geological map of a portion of the island of Samos.

Plate IV.

Geological map of a portion of the islands of Eubœa and Bœotia.

December 2, 1846.

The Right Hon. Sir E. Ryan, W. Bainbridge, Esq., G. E. Dennes, Esq., and J. B. Birch, Esq., were elected Fellows of the Society.

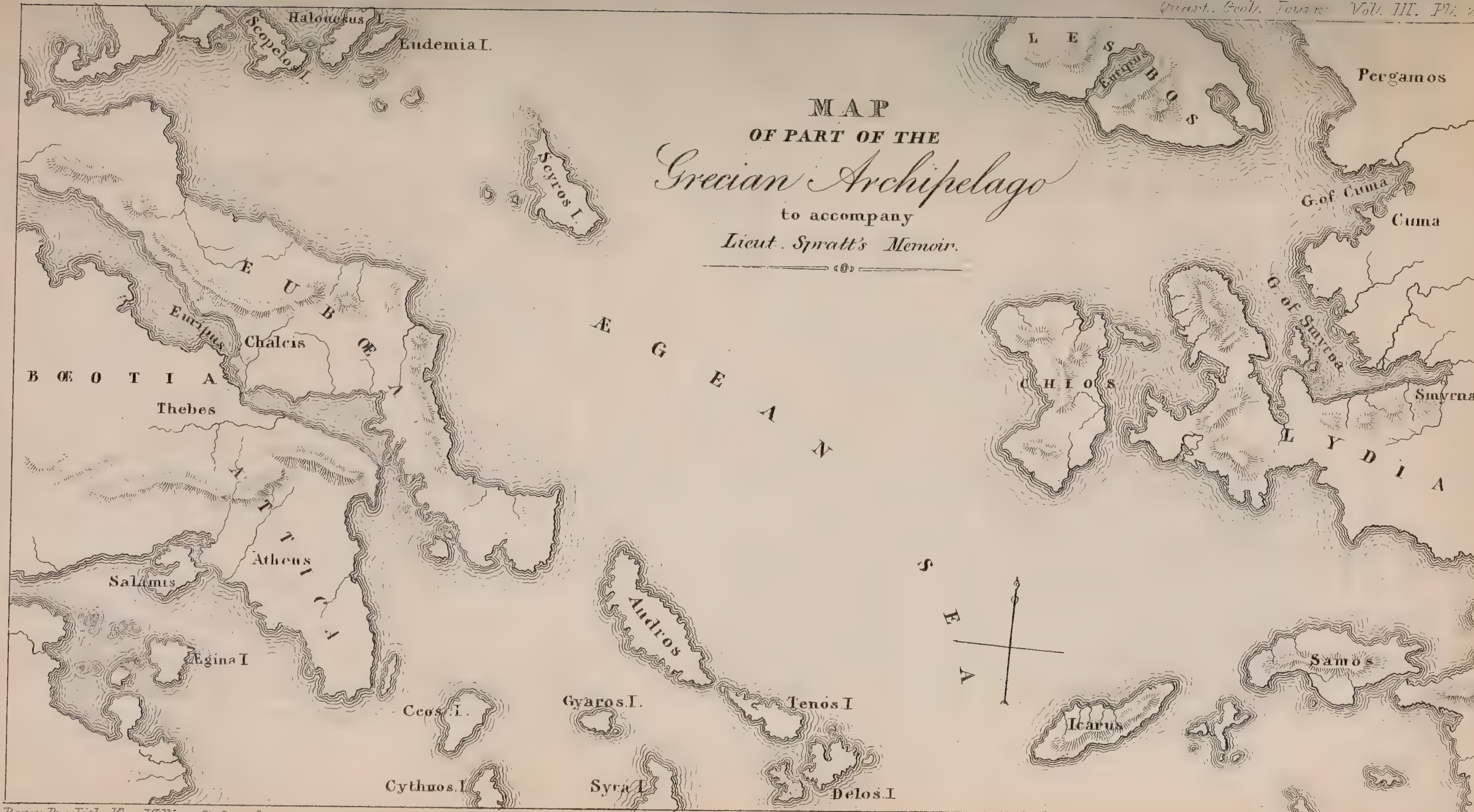
The following communication was read:—

On Slaty Cleavage. By Daniel Sharpe, Esq., F.G.S.

Introduction.

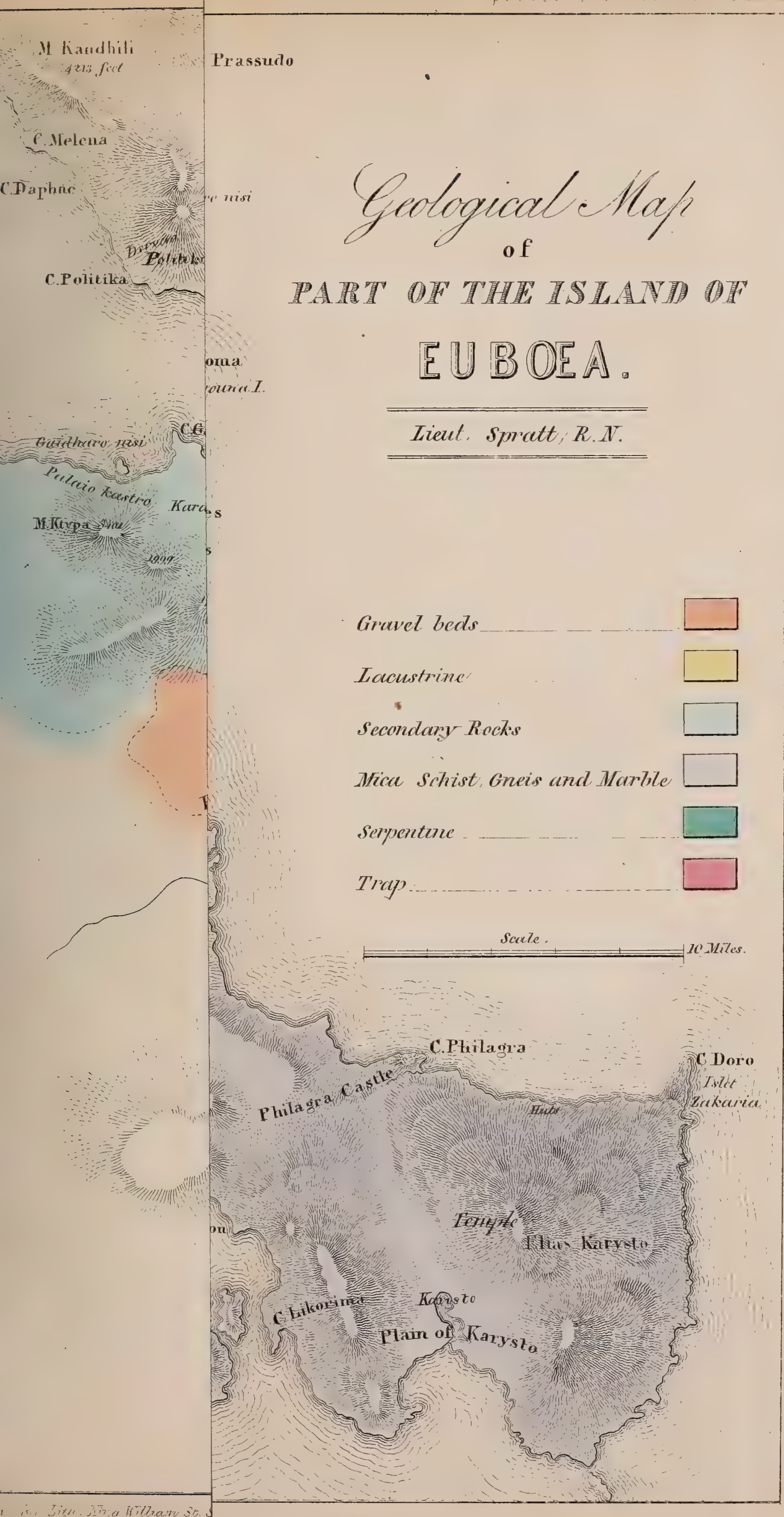
During the last few years the subject of slaty cleavage has gradually attracted the attention of geologists, and much valuable information regarding it has been accumulated. Professor Sedgwick's clear description of the leading phænomena connected with cleavage*, led geologists into the right path, and since the publication of his views in 1835 we rarely meet with those unintelligible descriptions, so common in the earlier writers, in which the cleavage and the stratification are confounded together in hopeless confusion. Subsequent observers have added materially to our knowledge, and various remarks illustrating the subject will be found scattered

* On the Structure of large Mineral Masses, &c. Trans. of Geol. Soc. 2nd Series, vol. iii. p. 469, &c., read March, 1835.



Reeve Bro. Lith. King William St. Strand.


Geological Map
OF
PART OF THE ISLAND OF
SAMOS.
Lieut. Spratt, R.N.
Dascalio
C. Prasonisi
Kokari
PORT VATHI
SAMOS
VATHI
PALÆO KASTRO
Prasonisi
MITELINIOUS
R. Mitelinious
Sect.n No. 1
Ruins of Astypalæa
KHORA
ANCIENT CITY OF SAMOS
P. Mulibraham
STRAIT OF SAMOS
Chapel Island
PORT TIGANI
R. Imbrassus
LYDIA
C. St. Mary
Nero nisi
Panagia nisi
Agios Nikolao


Geological Map
of
PART OF THE ISLAND OF
EUBOEA.
Lieut. Spratt, R.N.
Gravel beds
Lacustrine
Secondary Rocks
Mica Schist, Gneis and Marble
Serpentine
Trap
Scale.
10 Miles.
M. Kandhili
4213 feet
C. Melena
C. Daphne
C. Politika
Prassudo
Gaidharo nisi
Palaio kastro
M. Kiypa
C. Philagra
Philagra Castle
C. Doro
Islet
Zakaria
Huts
Temple
Elias Karysto
C. Likorima
Karysto
Plain of Karysto

Geological Map
of
PART OF THE ISLAND OF
EUBOEA.
Lieut. Spratt, R.N.
Gravel beds
Lacustrine
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C. Politika
C. Castello
C. Gaidharo
C. Maneki
Chalcis
Kara Baba
Plain of Steni
NEGROPONT
M. Delphi
Prassudo
C. Killies
Bay of Koumi
Koumi
Kounistra
C. Octoma
M. Vathia
Plain of Aliveri
C. Petries
P. Petries
Aliveri
Pyrgos
Kastro
Village
Kastros
Vasilika
Bourg
Vathia Bay
Vathia
Vathia nisia
C. Vathia
R. Aliveri
C. Aliveri
Plain of Oropos
Oropo
R. Asopus
C. Kalamos
P. Buffalo
Remo nisia
Stura
Marathon
C. Marathon
Plain of Marathon
M. Pentelicus
Platia I.
C. Marmaron
Petalious Islands
C. Likorini
Plain of Karysto
Karysto
Elias Karysto
Temple
Philagra Castle
C. Philagra
C. Doro
No. 1
No. 2
No. 3
No. 4
No. 5

through the writings of Professor Sedgwick, Sir R. I. Murchison, Professor Phillips, Sir H. T. De la Beche and Mr. Austen, in addition to which Mr. Darwin has just given us a large collection of observations upon cleavage made in various parts of South America, with some important generalizations to which the extended field of his researches gives great weight. The most valuable of his remarks appear to be those which connect together the cleavage of slates and the foliation of gneiss, mica slate, &c.

Still we had no knowledge of the general laws which governed the formation of the cleavage and regulated its direction, and without previously discovering these it was idle to speculate upon the causes which had produced it. I have now endeavoured to supply part of this deficiency and to establish some general laws relating to the subject, which have been deduced from new observations and from combining insulated facts recorded by others. The appearance of symmetry which has resulted from putting these together, gives me great confidence in the soundness of the results, and should those which relate to the connection between the elevation and the cleavage of rocks be confirmed by other observers, they promise when followed out to throw great light on the theory of elevation.

Connection between the distortion of the Organic Remains found in Slaty Rocks and the cleavage of the beds.

In determining the species of the fossils of the older formations, great difficulties arise from the distortion of form which they have frequently undergone; which sometimes makes it impossible to ascertain the species or even the genus to which they belong. This distortion varies very much in specimens from the same locality, and still more so in those from different districts.

While examining the fossil shells from the Ludlow rocks of Westmoreland, most of which are slightly distorted, it struck me that if we could find out that the changes of form in the shells followed any certain law we might make allowance for them, and thus discover the original form of the shell. Following up this idea, I found that whenever the impressions of several shells occurred on one slab of stone, they were all distorted in the same direction; the change having no reference to the original figure of the shells, but to their position on the stone: it appeared as if every specimen had been contracted in the same direction. This remark enabled me to throw together many shells which I was before disposed to consider distinct species.

Examining other specimens to see how far this observation could be extended, I found that it held generally true, and also that there was a connection between the direction of the cleavage planes and what may be called the axis of distortion. Instances were met with showing the greatest variety in the amount and nature of the changes of form in fossil shells, from a slight alteration in the outline to the most extravagant and complicated distortion in which the proportions of the parts were completely changed; but whenever the rock showed a trace of cleavage, there was evidently some connection between the direction in which the specimens had been altered and the direction of the cleavage. But that connection appeared so complicated that I saw no prospect of understanding it without visiting some localities where the phænomena might be examined on the spot on a large scale. Besides certain agreements in the direction of the cleavage and the distortion, it appeared to be nearly a general rule that the shells are most distorted in those beds which are most slaty; which confirmed the idea that the two phænomena were intimately connected.

The only remarks I could find on the subject are contained in a short paper by Professor Phillips, read to the British Association in 1843, 'On certain Movements in the Parts of Stratified Rocks,' from which the following is an extract:—"The layers of shells in slaty rocks were generally distinctly marked by ferruginous lines, caused by their decomposition, and the form of their outlines was often remarkably changed. The Leptænæ in North Devon assumed the form of Nuculæ, and the Spirifers were crumpled up, or else extremely attenuated. The Trilobites of the Llandeilo flags were found in three distinct forms, arising from the distortion taking place in a longitudinal, transverse, or oblique direction; this seemed to be the result of a *creeping* movement of the particles of the rock along the planes of cleavage, the effect of which was to roll them forward, in a direction always uniform, over the same tract of country: the movement does not seem to have affected the hard shells, but only those which were thin, as also the Algæ and Trilobites: the latter are covered with little folds, parallel to the wave of motion. In these distorted fossils the amount of movement might be estimated; as, in the space occupied by a Trilobite, it amounts to a quarter or even half an inch*," &c. It is evident from this extract, that Mr. Phillips had already discovered a connection between the distortion of the fossils and the cleavage of the rocks containing them; but I am not aware that he has followed up the subject.

I had no hesitation in selecting Tintagel and South Petherwin as the most favourable spots to visit for the accomplishment of the object in view; the former locality especially so, as it affords large specimens of Spirifers most extravagantly distorted†. The size of the specimens facilitates comparison and measurement, and it is obviously desirable to have to do with shells originally equilateral; for though distortion may be visible in such shells as Aviculæ, Pterineæ and Posidoniæ, their forms are essentially so irregular that we can form no calculation of its amount. Our colleague Mr. S. R. Pattison, who collected the Tintagel specimens figured in the Geological Transactions, was kind enough to accompany me to Tintagel, and to assist me in my researches both there and in his own neighbourhood of Launceston.

Tintagel stands upon the upper part of the beds of the Devonian system: to the south of the village some large slate quarries have been worked on the face of the cliff, but they are now abandoned.

* Report of the Meeting of the British Association at Cork, 1843, pp. 60, 61.

† Geol. Trans. 2nd Series, vol. v. plate 55.

The fossils are most abundant in Mr. Bishop's quarry. The beds generally dip about 5° to the W.S.W., but they are occasionally a little bent, so that the dip varies in different parts of the quarry. The prevailing dip of the cleavage is to the W.N.W. at 10°; in some parts the bedding and the cleavage have been slightly displaced in the same direction, but this is not usual, and the angle between them is not constant, varying from the smallest angle up to about 10°; in some spots the bedding and cleavage coincide in direction. These differences in the angle at which the cleavage intersects the bedding appear to have had an influence on the amount of distortion of the organic remains, as these are usually most altered in form where the angle of incidence of the two planes is the least. The most abundant fossil at Tintagel is that which Mr. Sowerby has named *Spirifer giganteus**; but there are also some Terebratulæ, stems of Encrinites, &c.: all the shells are more or less distorted, but the impressions of the encrinite joints are rarely altered.

The South Petherwin limestone quarries are worked upon the line of an anticlinal axis running nearly E. and W.; but the beds dip at different angles on the opposite sides of the quarries, and there are also several minor faults. The planes of cleavage are also bent over in a flat arch, of which the axis running E. and W. coincides in direction with the axis of the beds, but the cleavage planes are less inclined than the beds. From these irregularities the angle of incidence of the planes of bedding and cleavage varies in different parts, between 20° and 90°. The upper beds consist of rotten, grey, argillaceous slate, separated by thin beds of soft ochreous earth, crowded with organic remains too frail to bear removal, but whose forms may be seen on the spot. There are many fossils in the slates, especially near their junction with the ochreous beds. Below these are alternations of beds of limestone and slate, containing fewer fossils. The beds of different mineral character have been differently affected by cleavage, which is most seen in the upper slates, and only affects the limestones slightly, but is hardly to be traced in the thin beds of ferruginous or ochreous earth. The distortion of the organic remains in each bed is in proportion to its cleavage; in the slates they are extravagantly distorted, in the limestones slightly so; while in the soft ochreous beds, in which there is little cleavage, the fossils have preserved their form nearly unaltered. Although at present the loss of the calcareous matter of the shell has left these thin beds softer and more rotten than the others, it is possible that when they were full of shells they were better able to resist pressure than the other beds, which are now the hardest. The encrinite joints are usually free from distortion, although nothing remains but the hollow impressions left by them: apparently when the distortion took place these joints were still solid bodies, capable of resisting the force to which the other fossils yielded. This exception does not hold good everywhere: in the slaty beds to the north of Barnstaple, the impressions of the stems of encrinites are often as much compressed as the other fossils. The species found at South Pether-

* Geol. Trans. 2nd Series, vol. v. pl. 55, figs. 1 to 4.

win are very numerous; a list of them has been given by Professor Phillips in the 'Palæozoic Fossils of Cornwall,' &c., p. 142: the most common is the *Spirifer disjunctus*.

For convenience of comparison I shall draw most of my illustrations from the *Spirifer giganteus* and *S. disjunctus* of Sowerby, which I believe to be one species*. At South Petherwin the specimens of *S. disjunctus* found in the limestones are much smaller than those in the slates, from which we learn that lime was not favourable to the growth of the species, and we need not be surprised that it reached a larger size at Tintagel, where no lime is present; but the difference in the size of the South Petherwin and Tintagel specimens appears greater than it really is, owing to the greater distortion of all the Tintagel shells. Moreover, a careful comparison of the series of beds in the two localities convinced me that the Tintagel shells come from the same bed as those of South Petherwin. To establish a term of comparison with the distorted specimens shortly to be described, we require the original form of this species, which will be found in fig. 1, copied and slightly restored from Mr. Sowerby's figure of *Spirifer disjunctus* just referred to. Fig. 2 gives a supposed outline of the section of the same shell, restored from several specimens. These figures give the following proportions: A B the length of the shell, measured from the hinge-line to the bottom of the mesial fold, is half the length of the hinge-line C D; the thickness of the shell E F is two-fifths of the length of the hinge-line C D.

Fig. 1.

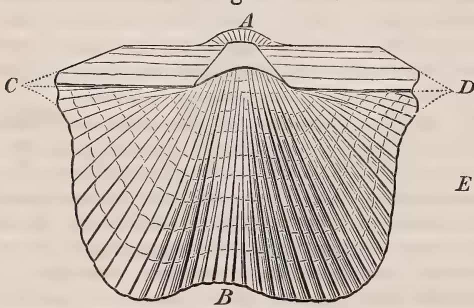
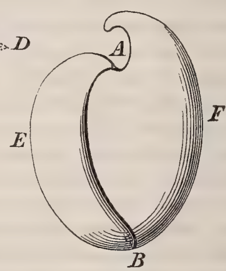


Fig. 2.



The same letters will have the same signification in all the illustrations. The proportions here given are not always true, but they are the best approximations we can get, and as such are used in the calculations which follow.

Besides other causes, partly unknown, the amount of distortion appears to depend upon the angle at which the cleavage cuts the bedding; the distortion being greatest where the angle between them is the least. It has also had a very different effect upon flat and

* See Sowerby, Trans. of Geol. Soc. 2nd Series, vol. v. description of figs. 12 and 13, pl. 54. De Koninck, Déscription des Fossiles de Belgique, p. 254. De Verneuil, Russie, vol. ii. p. 158.

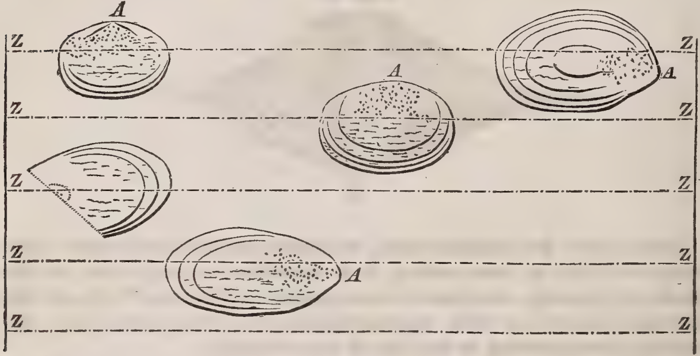
gibbous shells, as in the latter the parts of the shell lie in different directions towards the plane of cleavage.

There are some preliminary points to be mentioned. Among the palæozoic fossils we never meet with the real shell, and seldom with anything representing its substance; we have only impressions and casts, sometimes with a hollow space showing where the shell has been; but frequently this space has been filled up by pressure, and we find on splitting the rock one impression which represents both the inside and the outside of the valve; and among the most distorted fossils there is rarely any appearance of fracture. It must therefore be considered that we are reasoning upon such impressions as are made on wax, of which the form may be altered without breaking it by drawing out or compressing the mass.

In all the arguments drawn from the present forms of the distorted shells, it will be assumed that the original form of the shell is known and its original size unknown; and constant use will be made of the alteration of the markings on the shell in estimating the nature and direction of the distortion; among these markings the ribs of the Spirifers are most useful, from the well-known symmetry of their arrangement. If we had to deal with the changes in the forms in smooth bodies, of which we know only the original form but not the original size, we should find it impossible to analyse the movements which had produced the change; for an impression of a flat circular form might be changed into an oval by the shortening of one of its diameters, by the lengthening of the other diameter, or by a combination of both causes; either of the three explanations would be equally possible: but if the circular impression had been crossed by symmetrical curves, of which the direction and relative distances were known, the alteration in these lines would betray the nature of the change. The same will hold true of a solid.

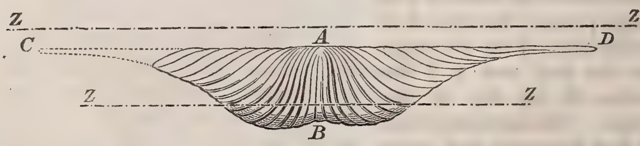
Let us now proceed to the description of the distorted shells, beginning with those found in beds intersected by the cleavage at a high angle. The change is the simplest where the shells are flat, and therefore lie entirely in the plane of the bedding; in these cases the shells all appear contracted in a direction perpendicular to the strike of the cleavage across the bed, and this apparently without any lengthening of the shell in the contrary direction, although it is difficult to be sure of this latter point. This change is shown in fig. 3, where several nearly flat brachyopodous shells are lying in various directions on a slab of slaty rock from Aber-y-Wynant, near Dolgelly: the apex of each is marked A, the direction of the cleavage across the bed is shown by the lines Z Z. Every shell appears shortened in a direction contrary to that of the lines Z Z, as if the whole mass had been pressed together in one direction. The shells probably belong to one of the concentrically marked Atrypæ, but the longer forms might be mistaken for Lingulæ. The surface of each is covered with small wrinkles, parallel to the strike of the cleavage Z Z; in this instance the cleavage cuts the bedding at an angle of about 40°: not having the original form of the shell as a guide, we cannot calculate the amount of distortion accurately, but judging from their present forms, they appear shortened at least twenty-five per cent. in a direction perpendicular to the strike of the cleavage across the bed.

Fig. 3.



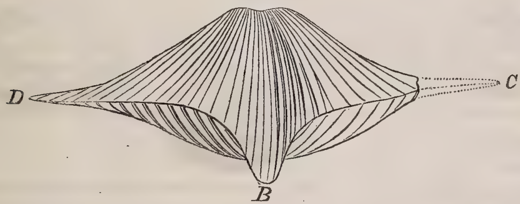
Similar instances are common where flat shells are found in slaty beds: the large Posidoniæ in the black shale above the limestones at the base of the culm-series of Devonshire are frequently distorted in the same manner; at the limestone quarry of Bickington, one mile and a half south of Barnstaple, thousands may be seen in the shale thrown off the top of the quarry, every one of which is contracted in a direction perpendicular to the line of strike of the cleavage across the bed, and which are all covered with folds parallel to that line. The cleavage intersects the bedding at an angle of about 50°. The case of the Trilobites in the Llandeilo flags, mentioned by Professor Phillips in the passage already quoted, is analogous to these. In all these cases the shells appear to have suffered from lateral pressure, which has altered their forms and produced the parallel folds on their surface.

Fig. 4.



The same lateral pressure has produced a different effect on gibbous shells, which are usually flattened in a direction perpendicular to the cleavage and drawn out or squeezed out considerably in the direction of the dip of the cleavage planes. The result is seen in the *Spirifer disjunctus*, represented in figs. 4 and 5, from one of the slaty beds at South Petherwin, met by the cleavage at an angle of about 60°. Figure 4 shows the shell as it lies on the bed, its length reduced about one-half, from A to B, by compression perpendicular to the cleavage planes, the strike of which across the bed is shown as usual by the lines Z Z. In the side view of the same shell, fig. 5, we see that it has been greatly expanded in the direction corresponding to the dip of the cleavage planes.

Fig. 5.



From these and similar cases, we learn that the shells have been compressed by a force acting in a direction perpendicular to the planes of cleavage, and that the compression of the mass between the cleavage planes has been counterbalanced by its expansion in a direction corresponding to the dip of the cleavage.

Where the cleavage intersects the bedding at an angle of 10° or 15°, the present forms of the shells are very various and remarkable, yet the changes may be traced to the operation of the same causes under different circumstances, of which the oblique direction in which the pressure has acted on the shells appears to have had the most important share in modifying their form. The distortion in these cases is much greater than in those already described, and it is of a more complicated character. In a large majority of cases, in which the shell is of an arched form, the changes consist in a great lengthening of one side of the shell, and a comparative shortening of the other side, which is frequently crumpled up and squeezed under the middle of the shell: this will be best understood from the drawings.

Fig. 6.

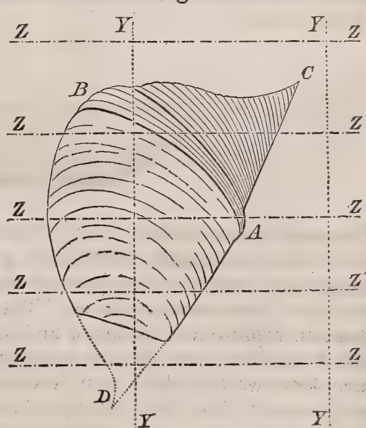
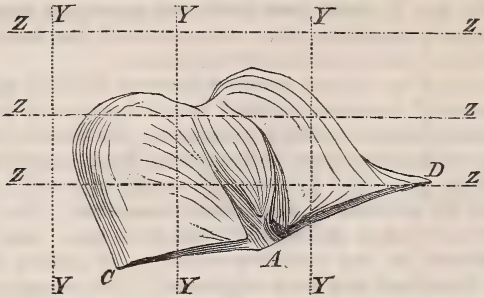


Fig. 6 represents a specimen of *Spirifer disjunctus* from South Petherwin, lying in an oblique direction towards the cleavage planes: the lines Z Z show the strike of the cleavage across the bed, and Y Y the direction of the dip of the cleavage. The specimen is a good deal flattened, and looks as if it had been pressed towards the upper line Z Z by a force moving in the direction of Y Y, and pressing downwards and forwards at the same time; the friction or the resistance of the mass in which it was imbedded retarding the advancement of

Fig. 7.



the front part of the shell, its thickest part is pressed over and partially conceals its upper portion: the unnatural curves assumed by the ribs help to show the direction in which it has given way. Besides this forward pressure, there is evidence, as in the former cases, that the whole has been compressed together in the direction perpendicular to the planes of cleavage and lengthened in the direction of the dip of the cleavage, by which the proportion of the two sides of the shell, and also of each fold and rib, has been altered. Another specimen of a cast of the same species, which has suffered still more alteration, is copied in fig. 7: the larger part of the shell has been squeezed under and concealed, while the remainder is so much expanded that the impressions of the hinge-plates are nearly double their usual length, the expansion being as usual in the direction of the dip of the cleavage.

To understand the effect that must be produced upon an arched body by a contraction of the mass in which it is imbedded in one direction and its expansion in another, we must recollect that the parts of the body lying in different planes will be differently affected by the two forces; for instance, in fig. 8, let C A D be the section

Fig. 8.

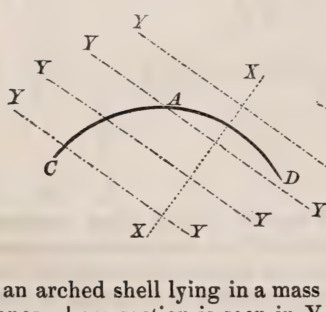
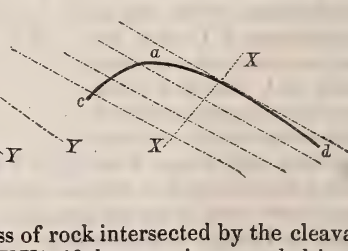


Fig. 9.

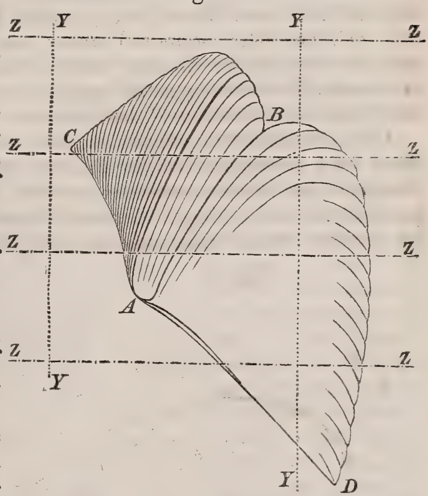


of an arched shell lying in a mass of rock intersected by the cleavage planes whose section is seen in Y Y; if the mass is expanded in the direction of Y Y (the dip of the cleavage) and contracted in the contrary direction X X, drawing with it in each case the impression of the shell, the line C A D of fig. 8 will be changed by one of its sides being drawn out and the other contracted till it takes the form *c a d* of fig. 9. In most cases these two operations appear to have acted uniformly together; the contraction of the one side being in proportion to the expansion of the other.

The origin of the oblique pressure on these fossils is easily found: the expansion of the masses of rock in the direction of the dip of the cleavage must cause an oblique pressure on the surface of every bed which is cut obliquely by the cleavage; the fossil shells lying between an expanding mass and a resisting weight of matter have given way before the pressure in the manner described. But as the expansion of the rock in the one direction may have been caused by its compression in the contrary direction, it follows that all the effects yet described may have originated in the compression of the mass of the rock in a direction perpendicular to the cleavage planes.

The next cases chosen for illustration are those where the angle of incidence of the planes of bedding and cleavage is below 5°. These need not detain us long as they are exactly the same as the last in principle, and only differ in the distortion being more exaggerated. The specimens are from Tintagel, and belong to *Spirifer giganteus* of Sowerby. The shells are placed in the same position relatively to the cleavage as before: that of fig. 10 is analogous to that of fig. 6; the wing D A B lengthened and so much flattened that the ribs are nearly lost; the other wing C A B contracted and with the ribs well-marked. The shell fig. 11 is more distorted; and as the two valves are united, the change of form can be determined accurately: fig. 12 shows a longitudinal section of this shell. The left wings D A B are nearly equally elongated in both valves in the direction of the dip of the cleavage Y Y, their extent, as seen in the section, being D E and D F; the two right wings are so much contracted that in the section they only reach from C to E and F. Many other specimens show a similar result in different degrees; but the most extraordinary that I have seen is the *S. giganteus*, as represented in fig. 13, from a bed at Tintagel intersected by the cleavage at an angle of about 1°. In this cast the elongated half of the hinge-line D A is three times the length of the other half C A: the hinge area and foramen are of an unnatural size, while a great part of the body of the shell is lost. There is here the most distinct proof that a flexible cast of the shell has been pressed forward towards the upper line Z Z.

Fig. 10.



Thus these most distorted cases require the same explanation as the others, and can be accounted for by supposing them to have been subjected to a pressure acting obliquely on the shell and pressing it, as it were, downwards and forwards at the same time. This pressure, acting in a constant direction upon shells scattered about in different positions, has produced the variety of extravagant forms which are to be found at South Petherwin, Tintagel, and every other locality where fossils are found in rocks much cut up by cleavage. The oblique pressure may always be resolved into the same two direct forces, one forwards along the plane of cleavage, towards the intersection of the cleavage and the bedding, the other downwards in a direction perpendicular to the cleavage. These are the directions of the compression and expansion previously demonstrated. Mr. Phillips has apparently alluded to this oblique pressure in the passage already quoted. But the facts already stated and others to be brought forward, show that his explanation is not sufficient to include the variously complicated cases of distortion.

When the bedding and cleavage exactly coincide at Tintagel, the shells

Fig. 11.

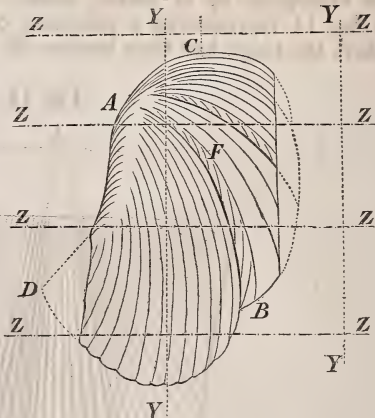


Fig. 12.

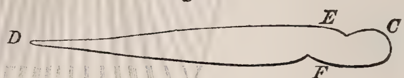
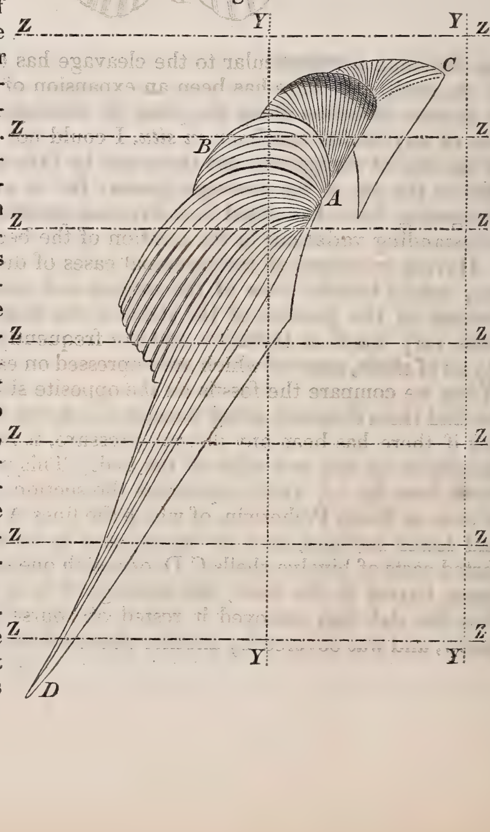
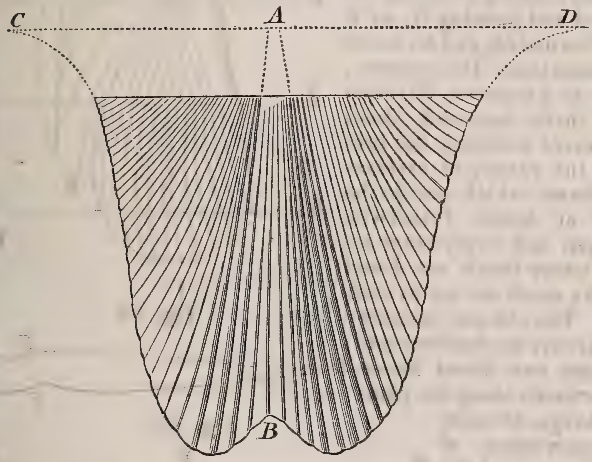


Fig. 13.



are flattened and drawn out considerably in one direction, without the crumpling up or folding under of any part of the shell; as in fig. 14 representing a specimen of *Spirifer giganteus* restored where the hinge had been broken off. The pressure of the rock in

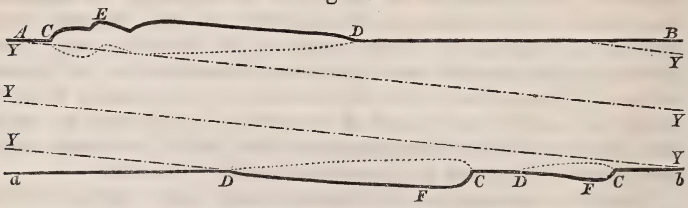
Fig. 14.



the direction perpendicular to the cleavage has caused the flattening of the shell, and there has been an expansion of nearly 50 per cent. in another direction along the plane of cleavage. Not having seen this or any similar specimen *in situ*, I could not learn the direction of the line of elongation, but there can be little doubt that it is parallel to the dip of the cleavage planes; for in every other case the elongating force has acted in a direction parallel to their dip, notwithstanding variations in the position of the bedding.

Having examined all the principal cases of distortion in detail, we may take a broader view of the subject and consider them with reference to the position of the shells in the bedding. The beds of slate vary much in thickness and are frequently separated by thin layers of shells, some of which are impressed on each of their surfaces. When we compare the fossils on the opposite sides of a bed of slate, we find them distorted along lines of which the direction is parallel; but if there has been any oblique pressure, it has acted in opposite directions on the two sides of the bed. This will be better understood from fig. 15, which represents the section of part of a thin bed of slate at South Petherwin, of which the lines A B, *a b*, are the upper and lower surfaces, each of which bears in relief flattened and distorted casts of bivalve shells C D, of which one side is seen, the other being buried in the slate; the cleavage Y Y is very oblique. Before the slab was removed it rested of course upon a bed of rock below, and was covered by another above which offered resistance to any pressure arising within this bed. On the upper side of the slab a specimen of *Spirifer disjunctus*, C E D, has been flattened by an oblique pressure moving from B towards A. On the lower side are two

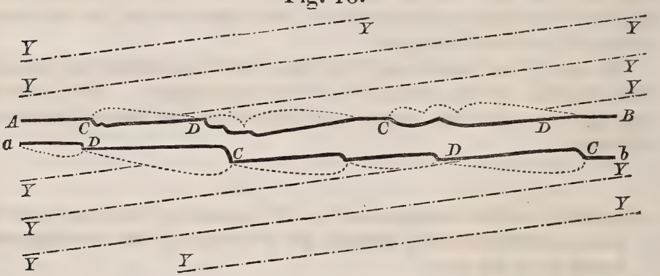
Fig. 15.



specimens of *Orthis resupinatus*, C F D, pressed in a contrary direction, or from *a* towards *b*. But in both cases the pressure is such as would be produced by an expansion of the mass in the direction of the dip of the cleavage Y Y. Such an expansion would produce a pressure on each surface equivalent to a force moving from the centre of the bed, in the direction of the lines Y Y. It is here obvious that there can be no difference in the distortion of the specimens which come from the upper or the under side of a bed; and it is impossible to distinguish them. The same proof of the expansion of the mass along the planes of cleavage may be found in beds of every thickness. A bed of slate from Tintagel not the third of an inch thick exhibits exactly the same phænomena.

The comparison of the two sides of the thin beds of shells which separate the slate beds gives the same result: the shells are pressed in what appear opposite directions, but which are in each case the directions of a force pressing from the centre of the mass towards each surface along the oblique planes of cleavage. Fig. 16 shows

Fig. 16.



the section of two slabs of slate enclosing a thin bed full of shells of the *Spirifer giganteus* from Tintagel: one side of each shell is seen in relief on the surface of the slabs, the other being hid: part of the central bed has dropped away leaving a hollow space. A B, *a b*, represent the surface of the beds and Y Y the cleavage planes. The two surfaces are covered with shells C D, of which those on the upper surface are all pressed from B towards A, and on the lower surface in the opposite direction from *a* towards *b*, the pressure having been towards each surface along the cleavage planes Y Y.

Similar instances will be found in every bed of fossiliferous slate; and they prove that the mass forming each bed of slate has been expanded in the direction of the dip of the cleavage. A motion of the whole mass upwards in the direction of the cleavage would produce a compression of the fossils in one direction only: but a pressure acting equally but in contrary directions on the opposite sides of the same bed, or in other words, a force pressing from the centre of a bed towards each of its surfaces, proves that an expansion of the mass of each bed has taken place, which, as already stated, may have been caused by pressure in another direction.

From this examination of distorted fossils under various circumstances, we may conclude that their present forms may be accounted for, by supposing that the rocks in which they are imbedded have undergone compression in a direction perpendicular to the planes of cleavage, and a corresponding expansion in the direction of the dip of the cleavage. It is true that my proofs have been drawn from a limited district; but similar evidence is found in all the fossiliferous slaty rocks with which I am acquainted, including beds of different ages in Cornwall, Devonshire, Cumberland and North Wales. And if we find certain changes connected with their slaty character to have taken place in all fossiliferous slate rocks, it may be inferred that the same have taken place in all slate rocks; though, in the absence of organic remains, we have not that evidence of the changes which the distortion of the fossils has afforded. Therefore it may be asserted as probable, that all rocks affected by that peculiar fissile character which we usually call slaty cleavage have undergone—

1st. A compression of their mass in a direction everywhere perpendicular to the planes of cleavage.

2nd. An expansion of their mass along the planes of cleavage in the direction of a line at right angles to the line of incidence of the planes of bedding and cleavage; or in other words, in the direction of the dip of the cleavage.

No proof has been found that the rock has suffered any change in the direction of the strike of the cleavage planes. We must therefore presume that the masses of rock have not been altered in that direction.

Symmetry in the arrangement of the planes of cleavage over large areas, and connection between the direction of the cleavage and the position of the beds.

Every one who has attended to the geology of any slate district is familiar with the frequent agreement in the strike of the cleavage and bedding of the slates; this is so remarkable that it has everywhere attracted attention. But unfortunately few geologists have troubled themselves with the dip of the planes of cleavage; even if its direction is loosely mentioned, the exact angles are rarely given.

However, most important results may be drawn from attention to this subject.

To begin with the strike of the cleavage planes: Professor Sedgwick stated in 1835, as a rule subject to few exceptions, "where the cleavage is well-developed in a thick mass of slate rock, the strike of the cleavage is nearly coincident with the strike of the beds*." I adopted nearly the same view many years later, after examining several extensive slate districts†. But a somewhat different statement was made by Professor Phillips, that "the cleavage planes of the slate rocks of North Wales are always parallel to the main direction of the great anticlinal axes‡." This view was taken by Mr. Jukes, who appears to have paid much attention to the subject§. Mr. Darwin has lately added his testimony to the same effect: in summing up his observations upon cleavage in various parts of South America, he says, "the cleavage laminæ range over wide areas with remarkable uniformity, being parallel in strike to the main axes of elevation, and generally to the outlines of the coast||."

The difference between these two views may appear slight, and in districts where, as is frequent, the strike of the beds agrees with "the main direction of the great anticlinal axes," there is no discordance between them; but the two statements really lead to widely different theoretical conclusions. In a case like this, which turns on generalizations drawn from observation, the greatest weight must be given to the geologist whose opportunities of observation have been the widest: in this all must yield to Mr. Darwin; I have therefore no hesitation in giving up my former opinion, and concluding that the direction of the strike of the cleavage is parallel to the main direction of the axes of elevation, and has no necessary connection with the strike of the beds.

The distance for which the cleavage strikes uniformly in nearly the same direction is very remarkable, and has been often noticed: over more than two-thirds of Wales the direction is between N.N.E. and E.N.E., except where it has been modified by what must be considered as local causes of disturbance. Extensive as this area may appear, it is trifling compared with the regions in South America over which Mr. Darwin found a uniformity in the strike of the cleavage planes, and of what he regards as analogous to them, the planes of foliation of the gneiss and mica schists.

Mr. Darwin is the only geologist who appears to have sought for order in the arrangement of the dip of the cleavage planes¶: he

* Transactions of the Geological Society, 2nd Series, vol. ii. p. 473.

† Quarterly Journal of the Geological Society, vol. ii. p. 309.

‡ Report of British Association, 1843, p. 61.

§ Excursions in Newfoundland, vol. ii. p. 324.

|| Geological Observations on South America, p. 163. The reader should study the whole chapter, from p. 141.

¶ When the above passage was written, I had not seen the notice in the Edinburgh New Philosophical Journal, vol. xxxiii. p. 144, of a memoir on the "Cleavage of Slate Strata," presented by Professor H. D. Rogers at the sixth annual meeting of American geologists and naturalists, April 1845, in which Professor Rogers describes the direction of the cleavage planes through the Appalachian says in the sentence following that already quoted, "The dip is as various both in angle and direction (that is, sometimes being inclined to one side and sometimes to the directly opposite side) as the strike is uniform*." And again at p. 164, speaking of gneiss, mica slate, &c.: "As in the case of cleavage, the angle of the dip in foliated rocks is generally high, but variable, and alternates from one side of the line of strike to the other, being sometimes vertical." Again, describing the mount at Monte Video, he states, "It consists of hornblendic slate, which has an east and west nearly vertical cleavage:" "the laminæ on the north and south sides near the summit dip inwards, as if this upper part had expanded or bulged outwards." Again in more general terms at p. 164: "On the flanks of the mountains, both in Tierra del Fuego and in other countries, I have observed that the cleavage planes frequently dip at a high angle inwards, and this was long ago observed by Von Buch to be the case in Norway: this fact is perhaps analogous to the folded, fan-like, or radiating structure in the metamorphic schists of the Alps†, in which the folia in the central crest are vertical, and on the two flanks inclined inwards." Again at p. 135: "I suspect that the varying and opposite dips may be possibly accounted for by the cleavage laminæ, though to the eye appearing straight, being parts of large abrupt curves, with their summits cut off and worn down."

These are all the statements met with tending to elucidate the subject. Following up this information by my own observations, I find that not only is the strike of the planes of cleavage uniform for great distances, but on the same line of strike the direction of their dip is the same, and its angle of inclination nearly uniform; so that each plane appears to hold its course at a certain inclination with great regularity. Lines many miles long will be found along which the cleavage planes are vertical, and on each side of such a line of vertical cleavage the planes usually dip towards that line, first at a very high angle, then at an angle which gradually diminishes in inclination as the distance from the vertical line increases; thus producing the fan-like arrangement noticed by Mr. Darwin. This regularly descending series of planes being found on each side of parallel lines of vertical cleavage, the two series either meet in the centre in a sort of anticlinal axis, or coalesce into an arch; thus forming the figure represented by the section, fig. 18. The irregularities which disturb this arrangement are so trifling in comparison to the general uniformity, that they may be disregarded in all theoretical reasoning.

Thus the arrangement of the planes between two lines of vertical cleavage appears to form a complete whole, and the area bounded by two lines of vertical cleavage may be considered as belonging to

chain, and endeavours to account for it. The Appalachian chain appears analogous, as regards position and cleavage, to the chain of Snowdon, which will presently be described (p. 90). The explanation fails, being built upon a partial view of the position of the cleavage planes.

* Professor Sedgwick says, in the memoir already quoted, "the planes of cleavage are inclined at various angles to the planes of stratification."

† Studer, in Edinburgh New Philosophical Journal, vol. xxxiii. p. 144.

one system of cleavage, and may be called an area of elevation of the cleavage. These general views will be confirmed by the examination of particular districts, where we must first ascertain the lines along which the cleavage planes are vertical.

Area of elevation of Carnarvonshire and Merionethshire.

A line of vertical cleavage runs along the slate beds which lie on the western flank of the Snowdon chain, from the valley of the Lyfni to the coast near Aber on the N.E. of Bangor, a distance of more than twenty miles: this line runs N.E. It cannot be followed farther to the south, as the direction of the beds changes suddenly near Clynog. On the W. of the vertical line there is a long band of greenstone, and then a broad bed of gravel which completely conceal the stratification and cleavage. On the E. side of the vertical line, over an area of about seventeen miles wide, the cleavage dips with few exceptions to the N.W., at various angles which will be stated shortly; farther eastward for a similar distance of seventeen miles, the cleavage planes dip at various angles to some point between S.E. and E : the nearest line at which a vertical cleavage is met with, runs through the great slate quarries between Dinas Mowddy and Mallwyd striking N.N.E. Thus thirty-five miles from the line of vertical cleavage at the W. flank of Snowdon, runs another vertical line nearly parallel to it. Not having followed up this second vertical line, I can only lay down its course by drawing it between those points where the cleavage dips at very high angles towards a common axis: from such help I infer that the cleavage will be found vertical a little to the W. of the pass of Bwlch-y-groes, and thence to the N.N.E. at about two miles E. of the Bala Lake as far as the Dee. From some observations made by Mr. J. E. Davis, I conclude that the line runs from Mallwyd to the coast in a direction from N.E. to S.W., passing about five miles N. of Machynlleth through a mountainous district of some elevation, and reaching the coast a little to the N. of Aber Dovey. We might here give up our line as lost beneath the sea, but Sir R. I. Murchison has recorded that on the N. side of Whitesand Bay near St. David's, vertical cleavage planes, coinciding exactly with the bedding, strike E.N.E. subject to some undulations. The direction of the cleavage planes at this spot and its bearing from the points before stated, show this to be the continuation of the same line of vertical cleavage. The distance from the Dee near Bala to Whitesand Bay is 110 miles.

We have thus established two nearly parallel lines of vertical cleavage in North Wales, the western perfectly straight, the other slightly bent, which enclose an area thirty-five miles wide, within which the cleavage planes usually strike nearly N.E.; except in all that large district between the coast and the porphyritic chains of Cader Idris, the Arenigs, Arran Mowddy, &c., where the cleavage usually strikes N., but is subject to great irregularities both of dip and strike; these porphyritic eruptions appearing to have disturbed the uniformity of arrangement of the cleavage: still we are able to trace a general plan of two series of planes dipping from a central axis towards the boundaries of the area.

On the western side of the area the dips of the cleavage follow certain laws with a great regularity. I measured the dip of the cleavage at every convenient opportunity along two sections. On the Holyhead road proceeding eastward from the W. flank of Snowdon where the cleavage is vertical, there is a gradual decrease in the inclination at which the cleavage dips to the N.W.: at the Penrhyn quarry its angle of dip is 85°, and in crossing the Snowdon chain it diminishes 25°, being 60° at Capel Cerrig; for about six miles it continues at about 60°, and close to the Bryn-Ddinas dike, at the forty-seventh mile-stone, it is 50°; beyond this spot the strike of the beds and of the cleavage changes to E., and we enter suddenly another area of elevation.

The section through the pass of Llanberris, and thence eastward to Bala, gives a complete line across the whole area: in crossing Snowdon the angle of inclination of the cleavage decreases gradually about 25°, being vertical at the Glyn slate-quarries and dipping at 65° to the N.W. at Llyn Gwinant; the regularity is broken by a reversal of the dip near the village of Llanberris for about half a mile, beyond which the series recovers its order. On the E. of Snowdon the angle continues falling with the greatest regularity as we proceed eastward, as may be seen in all the slate-quarries near Ffestiniog, till it reaches 35° about two miles E. of that village: we have then a mile or two of disturbed country at the great anticlinal axis of the strata near Rhaiadr Cwm, between seventeen and eighteen miles from each of the two lines of vertical cleavage which bound the area: at this spot the direction of the cleavage planes is confused. E. of the axis at Rhaiadr Cwm the dip of the cleavage planes suddenly changes to E.S.E. with an inclination of 50°, and it continues to dip either in that direction or to the E. or E.N.E. with a gradual increase of inclination, till we reach the line of vertical cleavage beyond Bala; but there is less regularity here than on the Snowdon side of the area.

E. of the vertical line of Bala and Mallwyd the dip again changes to N.W., and on that side of the line it has a westerly dip all the way from the Dee to St. David's, the greatest variation being between W. and N.W.

Omitting therefore minor irregularities and local disturbances, these statements show a symmetrical arrangement of the cleavage planes over an area thirty-five miles wide, with a dip in opposite directions away from a central axis, their inclination increasing with the distance from the axis, till it reaches the perpendicular at an equal distance on each side. And on the only side which we have the opportunity of examining, we find on passing the vertical boundary the commencement of another similar arrangement.

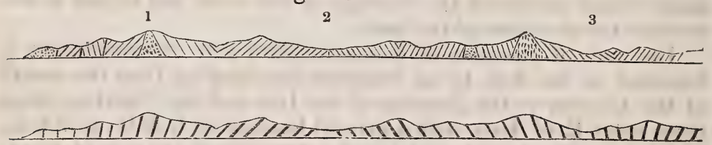
Mr. Darwin suggested in a passage already quoted, "that the cleavage laminæ, though to the eye appearing straight, may be parts of large curves*." The arrangement just described bears out that

* Geological Observations on South America, p. 155.

suggestion, as the lines appear to correspond to portions of curves having a common axis. But as each of the planes runs in the same position for a great distance, if the curves were completed they would represent a series of semicylinders turned over a common axis*.

The arrangement of the planes of cleavage on so symmetrical a plan is in itself deserving of attention; but when their direction is compared with the position of the beds over the same area, we find coincidences too remarkable to be due to accident, and which lead to considerations of great importance connected with the elevation and disturbance of portions of the crust of the globe. The remarks which follow will be made intelligible by reference to my map of part of North Wales†, and to the sections figs. 17 and 18, in which the

Figs. 17 and 18.



1. Snowdon. 2. Rhaiadr Cwm. 3. Bala.

minor irregularities are omitted and only the main features preserved, to prevent the attention from being distracted by minutiæ all subordinate to the larger phænomena. Fig. 17 represents the position of the beds along a section of the country from the W. side of Snowdon to the slate bed E. of Bala, fig. 18 the dip of the cleavage planes along the same line of section.

At Rhaiadr Cwm, which is on the axis of the elevation of all the planes of cleavage of the area, there is an anticlinal axis of the stratification along which the oldest rocks of this part of North Wales are brought to the surface in a low flat arch‡, which forms but a slight feature in the country; this now proves of great significance, as it must be considered the true axis of elevation of the whole area, both of the cleavage planes and the stratification. We cannot trace this axis for more than a few miles either to the N.E. or the S.W., as in both directions it is entangled in great masses of erupted igneous rocks. In Professor Sedgwick's map of North Wales§, the line laid down as the "great Merioneth anticlinal" is parallel to the axis at Rhaiadr Cwm, but is drawn five miles to the S.E. of it.

On both sides of this central axis, there is a relation between the inclination of the cleavage planes and the elevation of the strata: where the dip of the cleavage is at the lowest angle, the elevation of the beds is most moderate and they are but slightly disturbed; where the cleavage dips at a higher angle, the beds are more elevated and disturbed and their dip occasionally reversed; and near the boundaries

* Although in theory we ought to regard the cleavage as arranged in curves, I have continued to use the term cleavage *planes* to which we are accustomed, from dislike to introducing a new term, and because to our senses they appear planes, and not *curves*.

† Quarterly Journal of Geological Society, vol. ii. pl. 12.

‡ *Ibid.* vol. ii. pp. 291 and 293. § *Ibid.* vol. i. pl. 1.

of the area where the cleavage is vertical or nearly so, the beds have been broken up and thrown into great confusion*. Along this section the cleavage planes usually dip 20° or 30° more than the bedding; but this is not general elsewhere, for in the middle of Devonshire and Cornwall they are less inclined than the bedding.

A remarkable point of contrast in the two sections 17 and 18 is, that in this wide area we have only one axis of the cleavage, but there are several anticlinal and synclinal axes of the stratification; these (with the exception of the central one at Rhaiadr Cwm) have had no effect on the cleavage, which follows its own direction indifferently through beds dipping in opposite directions. Still there is so much relation between the direction of the cleavage planes and the position of the beds, that we might infer from this section alone that the cause which produced the cleavage of the rocks had helped to determine the elevation of the beds.

The area of elevation of Carnarvonshire and Merionethshire is bounded on the N.E. by an irregular line reaching from the mouth of the Conway to the junction of the Dee and the Calettwr about three miles E. of Bala, with a general bearing of N.N.W. to S.S.E., which is nearly at right angles to the direction of the axis of elevation. Commencing at the mouth of the Conway, it follows a great fault which for about fifteen miles is nearly on the line of that river; it then runs along or close to the Bryn-y-Ddinas dike: the rest of its course has still to be traced a little S. of the Holyhead road through a district not yet examined. To the N.E. and E. of the district described, the cleavage planes mostly strike E. and W. in conformity with the prevailing strike of the beds, which must be referred to another area of elevation. The south-western boundary of our area is lost in the sea, except from Clynog to Tremaddoc, where a line of beds striking E. and W. forms its limit.

Direction of the cleavage planes in Anglesea.

It will be desirable to ascertain the direction of the cleavage planes through the districts lying on both sides of the area already described. For Anglesea I can only refer to the remarks scattered through Professor Henslow's description of that island in the first volume of the Transactions of the Cambridge Philosophical Society, from which I gather that the strike of the cleavage is almost always to the N.E., and that the most usual direction of its dip is to the N.W. at high angles. But between Dulas and Llanerchymmed the laminæ are vertical, thence to the Menai they are mentioned at some places as dipping to the N.W. In the chloritic slate at the S.W. point of Carnarvonshire the cleavage dips at 50° to the S.E. These slates, lying beyond the Snowdon line of vertical cleavage, must be referred to the area of elevation of Anglesea. Thus there are indications of another arch of the cleavage commencing on the E. side of the Menai and including Anglesea.

* This relation between the inclination of the cleavage and the position of the beds appears to be very general, and has been observed in many other districts.

Direction of the cleavage planes through Pembrokeshire, Cardiganshire and Radnorshire.

Mr. Davis has favoured me with a few observations made in crossing from Cader Idris to Rhaiadr in Radnorshire, showing the cleavage vertical about a mile S. of the head of Tal-y-Llyn with a strike to the E. (which is a local anomaly); the dip then continues towards the N.W., the angle diminishing in six miles from 80° to 70°; near Rhaiadr he again observed it dipping in the same direction 65°, and farther on 45°. The observations are unfortunately few, but they make it probable that from the Mallwyd line of vertical cleavage to Rhaiadr, a distance of about thirty miles, we have a dip to the N.W. gradually diminishing to an angle of 45°, and that a central axis of this area will be found a little to the S.E. of Rhaiadr. In the sections across Pembrokeshire and Cardiganshire of the Geological Survey of Great Britain, the cleavage planes are represented dipping everywhere to the N.W. at the uniform angle of 80°. Along the line of strike the cleavage planes usually dip in one direction at the same angle, but in crossing that line (as in these sections), all other observers have found the angle of dip to vary. As it is hardly probable that this one district should form an exception to so general a rule, I conclude that the lines in the sections of the Survey are to be taken as a conventional manner of expressing slaty rocks, and are not intended to show the angle of dip of the cleavage.

Area of elevation of Devonshire and Cornwall.

The prevailing strike of the cleavage planes over a large part of Devonshire and Cornwall is from W.S.W. to E.N.E., and the usual dip is consequently either to the N.N.W. or the S.S.E.: to this there are many exceptions, but they are trifling compared with the cases which agree with these directions. In the western half of Devonshire and eastern end of Cornwall, to which the following remarks apply, the most usual strike of the beds is from E. to W. or from E.S.E. to W.N.W.; so that it is rare to find the direction of the cleavage coinciding exactly with that of the bedding. This has been noticed by several observers whose evidence I am glad to quote, as the case is not common*.

Following the plan already pointed out, our first search must be for the lines in which the cleavage is vertical. Sir H. T. De la Beche's Report helps us to the southern vertical line, which passes a little to the N. of the mica and chlorite slates of Start Point and Bolt Point. There appear to be two vertical lines running at the distance of about three miles apart, the more northerly near Stoke Fleming, the other near Stokenham, with some confused lamination between them: to the N. of the Stoke Fleming line, the dip of the

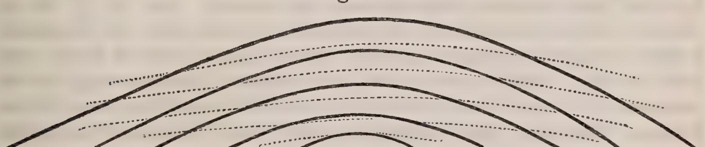
* Viz. at Baggy Point and Croyde, by Professor Sedgwick and Sir R. I. Murchison; Geological Transactions, 2nd Series, vol. v. p. 648. At Brixham, by Sir H. T. De la Beche; Report on Cornwall, &c., p. 45. At Fremington, North Devon, and in the limestone of South Devon, by Mr. Austin; Geological Transactions, 2nd Series, vol. vi. p. 482.

cleavage is southerly ; to the S. of the Stokenham line it is northerly*. A line of vertical cleavage which must be considered identical with that of Start Point appears to run to the N. of the Lizard Point ; at least we are told that on the N. of the serpentine of that point, the laminæ of the hornblende slate dip to the N. and N.W., which being the reverse direction to the rest of the district, shows that we have here passed the vertical line. The bearing of these two places is about W. by S. to E. by N., which is nearly the line of strike of the cleavage for the district.

In the N. of Devonshire the cleavage is vertical in the middle of the quarry of black limestone containing Goniatites at Bickington, a mile and a half S. of Barnstaple. The cleavage here strikes nearly E. and W.; at the N. end of the quarry it dips 70° to the S., and at the S. end 80° towards the N. Between six and seven miles N. of this spot, the cleavage is vertical at Swinham Down with a strike to the E.N.E., and between these two lines the planes usually dip to the N.N.W., but with occasional reversal of dip and irregularity. Between Swinham Down and the Bristol Channel the cleavage always dips S., S.S.W. or S.S.E., the angle diminishing as we recede from the vertical line, so that at Hillsborough near Ilfracombe it has fallen to 60° and at Linton to 35°. The Bickington line of vertical cleavage appears the boundary of the Devonshire area of elevation, and the Swinham line that of another parallel area, of which the northern limit must be sought on the opposite coast of Pembrokeshire and Glamorganshire ; the band between Swinham Down and Bickington being neutral ground lying between the two areas.

We thus establish two lines of vertical cleavage, 60 miles apart, the one at Stoke Fleming, the other at Bickington, to serve as boundaries to the area to be examined. In the centre of this area there is a broad band of country over which the cleavage planes undulate in low flat waves, so that considered as a whole they are nearly horizontal. The axes of these flat curves bear between E. and E.N.E., and the cleavage dips alternately to about N.N.W. or S.S.E. at angles which rarely reach 10°. The curves of the cleavage frequently correspond with an anticlinal arch of the bedding, both having the same axis; but the inclination of the beds is always greater than that of the cleavage. The section fig. 19 would represent any one of these

Fig. 19.



The continuous lines represent the bedding, and the dotted lines the cleavage.

waves as they are seen near Launceston, or on the coast near Tintagel. In other cases the two axes have a slightly different direc-

* Report on Cornwall, &c., p. 77.

tion and the cleavage cuts the beds diagonally. Sir H. T. De la Beche has described the culmiferous beds as "ridged, furrowed and twisted in lines, which, when not much affected by the granitic bosses, have a general direction from a few degrees N. of W. to a few degrees S. of E.*;" and the same author speaking in general terms of such phænomena says, "the lateral pressure in these older movements is very considerable, so that if the multitude of contortions, domes, cavities and flexures into which the beds have been forced were flattened out, the area covered would be far more extensive than that now occupied by the same beds in their squeezed and crumpled state†." This passage is peculiarly applicable to the centre of Devonshire.

But to return to the cleavage: I traced the continuance of low undulations of the cleavage, such as are described above, across a band of more than five miles wide in the neighbourhood of Launceston from Yeolm Bridge to South Petherwin, without seeing its full extent; on the coast it reaches at least fifteen miles from Boscastle to Padstow, and it may extend still farther. With so many similar arches of the cleavage, it is impossible to fix upon any one line as the general axis to the cleavage of the whole district, which must be ascertained by drawing an arbitrary line half-way between the two boundary lines of vertical cleavage.

I can find no record of the dip of the cleavage between the central portion of the district and its boundary at Bickington, nor for some distance to the S. of South Petherwin. But farther southward some few facts may be picked up which may be thus arranged in the order of distance from the centre: near Endsleigh the cleavage dips southward‡; on the Dart below Totness it dips at 45° to the S.§; near Brixham, to the S.E. at a high angle||; at Dartmouth the cleavage dip is southerly¶; at Bigbury Bay its dip is S., but nearly vertical¶.

These scanty materials make it probable that the cleavage planes are arranged across these counties somewhat as in the section across Carnarvonshire and Merionethshire, fig. 18, the principal differences consisting in the greater diameter of the area, and in the flat undulations of the cleavage over the centre of the district. There are here also distinct proofs of the commencement of a fresh system of cleavage elevation on each side of the area described.

The comparison of the position of the cleavage planes with that of the beds along the same line is interesting. Throughout the central area where the cleavage is nearly horizontal, the beds undulate in a succession of waves already described without offering any marked features. These undulations are sharper towards Bideford, where we may expect to find the cleavage highly inclined**. At the Bicking-

* Report on Cornwall, &c., p. 124.
† Memoirs of the Geological Survey of Great Britain, vol. i. p. 222.
‡ De la Beche, Report on Cornwall, &c., p. 108.
§ Sedgwick and Murchison, p. 655.
|| De la Beche, Report on Cornwall, &c., p. 45. ¶ *Ibid.* p. 77.
** See wood-cut at p. 123 of Sir H. T. De la Beche's Report.

ton limestone quarry, where the vertical line of cleavage passes, the beds are most violently contorted. Beyond this line is low ground at Barnstaple, in the band between the two lines of vertical cleavage. From Pilton to Ilfracombe, with cleavage highly inclined, the strata are elevated in high hills, and at Linton, where the inclination of the cleavage is only 35°, the beds seldom dip more than 5°. So again on the S. coast of Devonshire, disturbed and elevated strata occur in company with a highly inclined cleavage. These observations are less complete than those relating to Carnarvonshire, but the theoretical conclusions to be derived from them are the same.

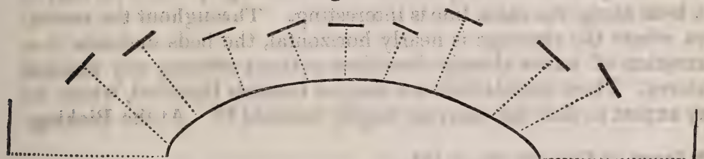
The regularity of the direction of the cleavage is not at all broken in the neighbourhood of the granite of these counties, from which it is to be inferred that the granitic eruptions had taken place and become solid before the cleavage was produced: indeed some remarks of Sir H. T. De la Beche's lead me to suppose that the cleavage is continued through the granite*.

Application of the laws of compression and expansion of slaty rocks to an area over which the position of the cleavage planes has been ascertained.

It has been shown in the first part of this paper, that there was reason to believe *that all slaty rocks had undergone a compression of their mass in a direction perpendicular to the planes of cleavage.* Now that we have discovered the system upon which the cleavage planes are arranged, we may judge of the direction of the pressure which compressed the slates, and endeavour by that means to find out its cause. I have endeavoured to prove, that though each plane of cleavage runs on for great distances in a uniform direction, the planes are so arranged side by side as to make it probable that they are not true planes, but rather portions of great curves having a common axis and bounded by vertical lines.

Assuming these positions to be correct, it follows that the pressure must have radiated either from a point on the common axis, or from a curved surface of which the outline must be similar to the curve into which the cleavage can be resolved. The first case is too improbable to be worth discussing; the second will be made more intelligible by a diagram representing a section of the supposed area. The

Fig. 20.



black lines represent the dips of the cleavage at the various parts of the surface, and the dotted lines point out the direction of the pres-

* Report on Cornwall, &c., p. 163.

sure, perpendicular to the cleavage at each place. The curve below shows the outline of a mass below the surface whose expansion or elevation would produce the pressure which we know to have acted on the mass above.

This is the form which a fluid mass would assume if forced upwards through a fissure below the crust of the earth coinciding in direction with the axis of the area of elevation. As beds of a slaty character are usually found in close connection with igneous rocks, we may refer the elevation to the upheaval of a mass of fluid igneous matter. The area over which the effect of the upheaval has extended, is obviously bounded by the lines of vertical cleavage.

It has also been shown, that *the compression of the slaty mass was compensated by its expansion in the direction of the dip of the cleavage, but that no change was observed in the direction of the strike of the cleavage.* The explanation of these laws is easy, now that the direction of the cleavage and its position relatively to the elevation of the area are ascertained. The elevation of a mass of rock into a curve by increasing the breadth of the surface of the area, would give room for the expansion of the mass in the direction of the curve, in the proportion of the length of the arc thus formed to its chord; and the curve by the terms of the proposition represents the dip of the cleavage. But as long as the elevation continued uniform over a straight axis, nothing would occur to weaken the resistance to the expansion of the mass in the direction of the axis, which is, as already shown, the direction of the strike of the cleavage. If the elevation should prove sufficient to break up the surface, the fissures would be parallel to the boundaries of the area; and when the mass was once broken in longitudinal fissures, its power of resistance to an expansive force would be farther diminished in the direction of the dip, but would still remain the same along the strike.

These considerations relate to the case of a longitudinal area of elevation, or as Mr. Hopkins has appropriately named it, a case of cylindrical elevation*, because these are the only cases in which I have had an opportunity of studying slaty rocks. It would be very interesting to find a case where slate had been formed round a conical elevation, and to check the accuracy of the laws deduced from the cases considered, by observing the modifications required to adapt them to new circumstances.

Depression of an area at some period posterior to its elevation and to the cleavage.

There are several circumstances which tend to show that the centre of an elevated district may have somewhat sunk down again, after the completion of the original elevation and of the cleavage. Such a sinking is probable, in the first instance, from the relaxation of the central pressure when the igneous matter was allowed to escape through the fissures formed at the sides, and again at a later period

* Abstract of a Memoir on Physical Geology, p. 12.

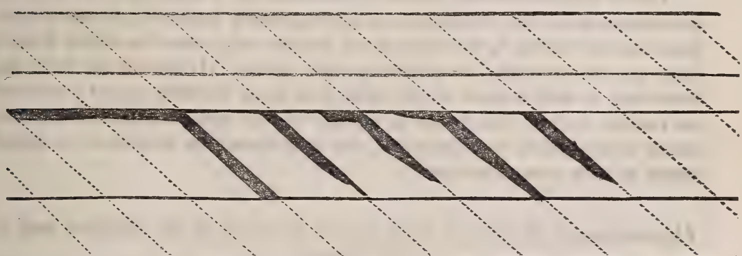
when the heated mass cooled and a contraction took place in consequence.

The undulating surface of the cleavage over the central parts of Devonshire in low waves which either coincide with more boldly arched waves of the bedding, the two having a common axis parallel to the boundaries of the area, or which cut obliquely through the curves of the bedding, is a phænomenon which requires for its explanation the depression of the centre of the area after the formation of the cleavage. The elevation of the bedding in folds parallel to the axis might be regarded as part of the original movement; but not so the undulations of the cleavage; and the peculiarity, that the waves of the bedding and cleavage sometimes coincide in direction and sometimes differ, refers them to two operations, of which the cleavage being the less disturbed seems only to have undergone the later one. This undulation of the cleavage has only been noticed over the centre of the flat arch of elevation of Devonshire: in districts where the beds and the cleavage planes are tilted at considerable angles, a lowering of the arch might have taken place which it would be difficult to detect.

The foreign crystalline matter which is frequently found between the planes of cleavage, shows that at some period after the cleavage was completed the rock had a tendency to gape along them. Mr. Darwin has collected many instances of the kind from his own observations and those of Professor Sedgwick*, of which the most remarkable is the occurrence of trap dikes in Tierra del Fuego between the laminæ of the slates†.

In the cliffs at the foot of Hillsborough and in other places near Ilfracombe, many instances may be seen of the insertion of sheets of quartz between the laminæ of slate, as shown in the section fig. 21.

Fig. 21.



The horizontal lines represent the beds, the oblique dotted lines the cleavage, and the thick black lines the sheets of quartz.

The quartz, which is often an inch thick, lies partly between the beds

* Darwin, Geological Observations on South America, pp. 152, 160 and 163 Sedgwick, Transactions of the Geological Society, 2nd Series, vol. iii. p. 471.

† Had I been aware of this observation, I should have sought for similar phænomena among the greenstone dikes of Carnarvonshire, which strike with the cleavage and bedding of the district, but of which the dip has not been satisfactorily ascertained.

and then turns down the cleavage forming irregular sheets between the slates, which frequently do not cross the whole thickness of the bed of slate. This has apparently followed upon the irregular gaping of some of the cleavage planes.

Both in this case and in the instances mentioned by Mr. Darwin, the cleavage dipped at a high angle. The opening of the rock along the cleavage would have been impossible as long as the original pressure continued, and, to account for it, it requires a cause exactly opposite to that which produced the pressure, such as the sinking of the elevated area.

Position of the beds over a given area of elevation.

I must now consider some theoretical questions connected with the elevation of portions of the crust of the earth, in the hope of finding how to ascertain, from the position of the beds, what is to be considered as one area of elevation, or in other words, of learning the extent of surface over which the present position of the rocks is to be regarded as produced by a single cause. This is not irrelevant to my principal object; for if it can be ascertained, we shall be able to compare conclusions drawn from the position of the cleavage planes with those derived from the stratification, and thus test their accuracy. In this I shall have to pass over some of the ground on which Mr. Hopkins has laboured so efficiently; but as the points at which I am aiming are not exactly those to which his papers are devoted, I shall derive assistance from the general tenor of his arguments, and when unable to refer to particular passages for authority, I shall still be benefiting indirectly by his guidance*.

The districts I have referred to, and of which I wish to explain the phænomena, belong to the case which Mr. Hopkins has appropriately termed *cylindrical elevation*, namely that where the area is of indefinite length and bounded laterally by parallel lines. Mr. Hopkins has so fully explained all that relates to cross fractures and cross lines of elevation, that I shall not touch upon that branch of the subject, but confine myself to the primary lines of elevation, which are those parallel to the boundaries of the area.

We meet with two series of longitudinal cases of elevation, producing very different results on the beds they affect. The simplest is that where a mass of igneous matter has broken through the surface, as in the Malvern Hills. Here the greatest disturbance is close to the line of eruption: the beds nearest to it are highly inclined, and as we recede from the axis we find them less and less raised, till the effect can no longer be traced: the dip in these cases is from the axis of elevation, unless the violent raising of the beds has caused them to give way, and then we may find minor synclinal and anticlinal axes parallel to the main line. In these cases we see the

* Hopkins, Researches in Physical Geology, Transactions of the Cambridge Philosophical Society, vol. vi.; Abstract of a Memoir on Physical Geology; On the Wealden district and Bas Boulonnais, Transactions of Geological Society, 2nd Series, vol. vii. p. 1. I have principally consulted the last two, which are addressed to geologists who are not mathematicians, and have had them always before me in writing the following pages.

disturbing agent, and the connection between it and the effect it has produced are obvious.

A more difficult case is that of an elevated area which has not been broken through in the middle by any great igneous eruption; where we can only infer what was the nature of the disturbing cause from observing the effects it has produced. This is the case of the Wealden elevation which Mr. Hopkins has illustrated. This is also the case of the elevations of Carnarvonshire and Merionethshire, and of Devonshire and Cornwall; for though in all these counties abundant eruptions of igneous matter have taken place, some probably connected with the elevation we have to consider, these are secondary phænomena resulting from a wider-spreading cause; and in Devonshire and Cornwall the great granitic eruptions do not form part of the case under consideration, for they were evidently hardened and solidified on the surface before the elevation took place which was connected with the cleavage and gave it that symmetrical arrangement we now find.

The hypothetical case put by Mr. Hopkins, of a fluid mass below the surface forced upwards along a rent bounded laterally by two parallel walls, and covered over by the beds forming the crust of the earth, is in itself probable, and will be found sufficient to explain most of the phænomena observed. The effects produced on the mass above will depend on the width of the rent relatively to the fluidity of the moving mass, supposing always, for simplicity of argument, that the fluid matter finds no means of escape between the beds, but continues always to press upwards. If the rent is narrow compared to the matter forced into it, the surface must give way in a long crack through which the fluid will escape, as in the Malvern Hills. If the rent is broader the fluid must force up the beds above it in a curve, for the surfaces of the fluid mass must rise more in the middle than at the sides.

Fig. 22.

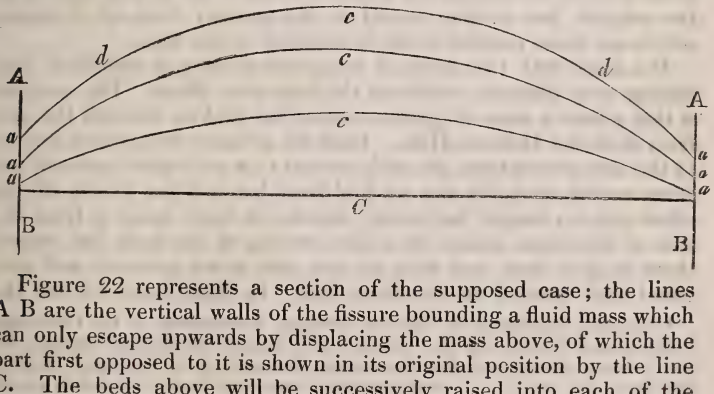
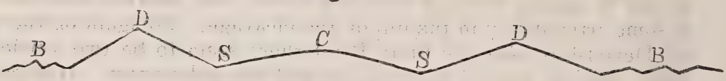


Figure 22 represents a section of the supposed case; the lines A B are the vertical walls of the fissure bounding a fluid mass which can only escape upwards by displacing the mass above, of which the part first opposed to it is shown in its original position by the line C. The beds above will be successively raised into each of the curves *a c a*: since the pressure is greatest in the middle of a fluid column, and the resistance of the mass above is greatest at the sides where the beds join on to undisturbed masses lying beyond the line A B.

If this operation is continued until the beds give way, their fracture must be expected where they are most bent, that is, on each side somewhere about the points *d d*: and as the pressure is upwards, two anticlinal ridges will be formed over those points near the boundaries of the area and parallel to it. Their importance will be much increased if a continuance of the pressure forces part of the fluid upward through the rent thus formed. On each side of this elevated ridge we should expect at least one synclinal axis resulting mechanically from the raising upwards of a portion of the surface. And between the anticlinal ridges and the boundaries of the area, the beds would be much crushed together and broken, but not elevated. Thus in each great area of elevation the principal features of disturbance should be the raising up of the beds in an arch or anticlinal axis along the central line, an important anticlinal axis near each of the boundary lines, with great confusion between that axis and the boundary, and a synclinal axis on each side between the centre and the anticlinal axes: besides these, there may be many other minor disturbances parallel to and depending upon those principal ones. The outline of the area thus described is shown in fig. 23.

Fig. 23.



C. The central arch or anticlinal axis.
D D. The great lateral anticlinal axes.
S S. The principal synclinal axes.
B B. Disturbed districts near the boundaries of the area.

If the preceding reasoning is correct, we should find this combination of features common; the proportions varying in every case, and the whole modified by local causes; and every district presenting all these characters must be considered a complete area of elevation. Of Mr. Hopkins's sections across the Wealden elevation*, Nos. 18, 20, 22 and 23 correspond more or less closely to the ideal section given above. The elevation of Carnarvonshire agrees exactly with this section, and in fact it suggested the view here taken: see fig. 17. Its principal features are the central axis of Rhaiadr Cwm, the synclinal axis between the centre and Snowdon, and the great anticlinal axis of the Snowdon chain, on the outside of which the beds are low but in great confusion. The Snowdon anticlinal has been raised to a disproportionate height by the igneous matter forced up through it. On the Merionethshire side of the area the features are less regular, but some of them may still be seen.

It follows from the preceding reasoning that the elevating movement of which the axis passes Rhaiadr Cwm, and which gave their

* Hopkins on the Wealden District, Transactions of the Geological Society, 2nd Series, vol. vii. pp. 46 and 47.

present position to the beds of Carnarvonshire and Merionethshire traversed by the section fig. 17, ceased to exert its influence at the boundaries which limit the area of elevation of the cleavage; the lines of vertical cleavage serving to mark the boundaries both to the cleavage elevation and to the elevation of the beds. Thus the arrangement of the cleavage planes and the present disturbed position of the beds, appear the consequences of one elevation; which was probably caused by fluid igneous matter forcing its way upwards along a longitudinal rent below the crust of the earth. It is also probable that the greenstones which rise along the centre and flanks of the Snowdon chain are portions of that fluid mass.

In accordance with the preceding reasoning, we find the lines of vertical cleavage passing at the outside of the flank of the principal mountains included within an area of elevation. Thus the line first described runs just to the W. of the extreme flank of Snowdon: the second line described passes between Plynlimmon and Cader Idris. In the case of the Devonshire area this is less marked, still both the vertical lines pass through ground lower than that on each side of it. I have also some evidence to show that a line of vertical cleavage runs close along the southern edge of the Lake Mountains, passing near Coniston and Ambleside.

Near Barnstaple there are two lines of vertical cleavage, the one already described at Bickington, the other six or seven miles more to the N. passing through Swinham Down; and between them there is some irregularity in the dip of the cleavage. So again on the S. of Devonshire near the Start Point there seem to be two vertical lines running parallel between one and two miles apart. It is probable that this will generally be the case. Each line must be considered as the boundary of its own area of elevation, and the narrow band between as neutral ground, in which the dip will probably always be found irregular.

I have not the means of judging whether Devonshire presents the features of elevation here described; as there are several parts of that county where the dip of the beds has never been described, so that no section across it yet published is really complete. But it may be inferred from Sir H. T. De la Beche's account of the joints prevailing in the granite of Devonshire and Cornwall that these counties have been elevated since the solidification of the granite, by the upheaval of a mass below the surface whose axis extended from W.S.W. to E.N.E. The prevailing divisional joints of the district are found in two directions (with many exceptions which are stated); these directions are about from N.N.W. to S.S.E. and at right angles thereto, or from W.S.W. to E.N.E.* The latter of these lines is parallel to what appears to be the axis of the elevation of the cleavage planes. Mr. Hopkins has taught us to expect fissures both parallel to the axis of elevation of an area and at right angles to it, so we may conclude that the axis of elevation of these counties runs nearly from W.S.W. to E.N.E., coincident with the axis of the elevation of the cleavage

* Report on Cornwall, &c., p. 274.

planes; and that the joints bearing from N.N.W. to S.S.E. are secondary fissures at right angles thereto. The variations observed at different places both in the direction of the joints and in the strike of the cleavage, make it probable that the axis of elevation will be found not a straight line, but slightly bent.

Conclusion.

Throughout all the preceding pages I have abstained from expressing any opinion of the cause producing the cleavage; and now that I have gone through the subject, I must still leave the immediate agent in the operation undiscovered; although I hope that its discovery may be facilitated by the progress made in ascertaining the circumstances under which it took place.

Pressure appears to have been concerned in the operation; for the cleavage is uniformly at right angles to the direction in which pressure is seen to have taken place; and also the amount of cleavage appears to bear some proportion to the compression suffered by the rock. On the other hand, there are reasons for thinking that pressure could not be the sole agent in the operation, for the cleavage did not take place on the first upheaval of the district, when the crust not having yet given way the pressure might be supposed the greatest, but only after the beds had assumed their present position and the various anticlinal and synclinal axes had been formed.

Heat may have had some share in producing the cleavage: if the elevation was caused by a heated mass below, the conduction of heat must have followed the same direction as the pressure; and each sheet of slate must from its position have received the heat sooner than the sheet above it while the temperature was increasing, and parted with it later while the mass was cooling.

Galvanism has been supposed to have caused the cleavage of slate rocks, and the experiments of Mr. R. W. Fox*, since repeated and extended by Mr. R. Hunt†, have been brought forward in proof of its agency, and the fact that lamination has actually been produced in clay by galvanic action tells much in its favour; but before it can be admitted to have produced the cleavage, it ought to be shown that the circumstances of the case were such as would have produced galvanic action, and that it would have acted in the direction required.

Lastly, Mr. Darwin has suggested an explanation built upon a combination of mechanical and crystalline forces, viz. "that the planes of cleavage and foliation are intimately connected with the planes of different tension to which the area was long subjected, after the main fissures or axes of upheavement had been formed, but before the final cessation of all molecular movement‡." And that "this difference in the tension might affect the crystalline and concretionary processes§."

These seem to be the agencies among which we have to seek,

* Report of Cornwall Polytechnic Society, 1837.

† Memoirs of the Geological Survey of Great Britain, vol. i. p. 433.

‡ Geological Observations on South America, p. 168. § Ibid. p. 167.

either separately or in combination, for the immediate cause of slaty cleavage. I leave others to decide between them, contenting myself with having supplied some of the materials upon which the decision may be built.

Much remains to be done before the subject can be exhausted, and the direction of the cleavage planes must be examined over many districts before the explanations here proposed can be received as general laws. All that important branch of the subject which is connected with crystallization has been left untouched, and since Mr. Darwin has shown a connection between the cleavage of slate and the foliation and apparent stratification of gneiss and other rocks of similar character*, this alone will require long study in different districts. These inquiries and others to which they may lead, may guide us to conclusions very different from those which we might be disposed to adopt in the present state of our knowledge.

* Geological Observations on South America, chapter 6.

PROCEEDINGS,

ETC.

POSTPONED PAPERS.

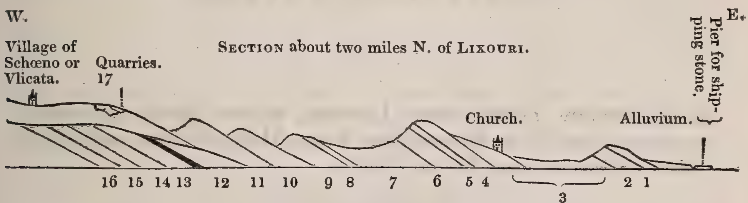
On a Tertiary Deposit near LIXOURI, *in the island of* CEPHALONIA. By W. J. HAMILTON, Esq., M.P., F.G.S., and H. E. STRICKLAND, Esq., M.A., F.G.S.

[Read May 3, 1837.]

[NOTE.—This paper was read to the Society so long ago as in the year 1837, before Mr. Hamilton's return to England (Proc. Geol. Soc. vol. ii. p. 545), but its publication has been delayed till the present time, in consequence of my having sent a selection of the fossils referred to in it for the examination of M. Deshayes, at a time when that eminent naturalist was absent in Algeria. After his return the specimens were mislaid, and I only received them from Paris a short time ago. M. Deshayes has kindly favoured me with his notes upon these fossils, and they have also been examined by Prof. E. Forbes, whose specific determinations are annexed to those of M. Deshayes.—H. E. STRICKLAND, Jan. 1847.]

THE tertiary deposit here described occupies a considerable portion of the peninsula of Lixouri, on the western side of the Gulf of Argostoli. It forms a series of ridges, extending for two or three miles to the north and south of the village of Lixouri, and running parallel to the strike of the secondary rocks of the island of Cephalonia, as well as of the whole of the Ionian isles, which conform in their directions to the great mountain systems of the Apennines and of Dalmatia. The beds slope gradually to the eastward, and present a succession of steep escarpments towards the west. The width of this tertiary zone may be about four miles from the sea on the east to the mountainous ridge of secondary rocks against which they rest on the west. The beds are all perfectly conformable, dipping a few degrees to the north of east by compass, at an angle of from 45° to 55°. Their aggregate thickness may be estimated at about 900 feet. They are remarkable for the great number and variety of fossils which they contain, some of the beds being almost wholly composed of shells, in the most perfect state of preservation, many of which belong to species now existing in the Mediterranean. A large proportion of these shells are identical with species figured by Brocchi from the Subapennine beds, indicating that this deposit must be referred to the Pliocene epoch. This locality is also interesting from the great thickness of the beds, and the variety of material of which they consist. The lowest portion is composed of fine-grained white limestones, which, from their resemblance to the rocks of Malta, are probably referable to the Miocene age. Unfortunately our time was too short to examine this part of the series thoroughly, but it is possible that a transition may here be traced from the Miocene to the Pliocene series.

The accompanying section will show, in descending order, the superposition of these beds. It was made about two miles to the north of Lixouri, where a road descends from the quarries of Schœno to the sea.



No. 1. Very hard thin-bedded limestone of a reddish brown colour, containing casts of recent species of shells, chiefly *Turritella* and *Pecten* of small size. This bed dips at an angle of 50° towards the east, and at some points rises to a considerable height, with a steep westerly escarpment. The thickness of the bed is from ten to twenty feet. About three-quarters of a mile north of Lixouri it consists of a hard conglomerate, with small pebbles of flint and quartz in a hard calcareous matrix.

2. Dirty yellow sand, containing in the upper part many irregular concretionary nodules of limestone, containing *Pecten*, *Ostrea* and *Anomia*. The calcareous concretions gradually diminish downwards, and the lower portion consists of fine sand full of shells, principally *Pecten*, *Cerithium*, *Dentalium*, *Isocardia cor*, *Turritella*, *Venus*, &c. The thickness of this bed may be about 100 feet. It is best seen in a small hill south of the road from the quarries to the sea.

3. Blue marly clay, which in most places immediately underlies the sands of the last stratum, but in some places a band of hard calcareous marl, consisting almost entirely of shells, from three to five feet thick, is interposed between the two. These shells appear to belong almost entirely to the same species as occur in the blue clay below. The latter deposit is about 200 feet thick, and contains a great variety of shells, of the genera *Dentalium*, *Fusus*, *Rostellaria*, *Buccinum*, *Murex*, *Turritella*, *Cerithium*, *Cardium*, *Cardita*, *Venus*, &c. In a lower division of this blue clay Turritellæ are most abundant, scarcely any other shell being found with them, and in an upper portion of the same bed a small oblong species of sponge is very plentiful.

All the above beds are exposed to the eastward of the road which leads from Lixouri to the quarries of Schœno; the following are to the westward of the same road.

4. Limestone resembling No. 1 in colour and general appearance, but not so hard. This bed is about eight or ten feet thick, and contains numerous Pectens of a very large size.

5. Bed of *Lobularia arborea*, about two feet thick, the stems and branches of which are not in the least broken or displaced. Imbedded in them are a few large Pectens and Oysters.

6. Various beds of yellow limestone, sand and marl, with many shells of *Pecten*, *Ostrea*, *Cardium*, *Cardita*, *Terebratula*, *Pectunculus*, and casts of various other bivalves. The Terebratulæ only occur in the very lowest portion of this bed. The whole thickness of these beds may be about fifty feet. They form a hill of considerable height, with an abrupt escarpment on the west, and sloping to the east at an angle of about 45°. A church and the road to Lixouri are at its eastern base, and the road from the quarries to the sea passes to the north. The view from the summit is highly picturesque, and exhibits the structure of the country in a remarkable manner. The alternations of hard and soft strata in this tertiary deposit have produced a series of low parallel hills running north and south, each presenting a steep escarpment on the west, while they slope to the east at an angle equal to the dip of the strata, varying from 45° to 55°.

7. A deposit of blue marl or clay between 200 and 300 feet thick, containing numerous shells, chiefly of the genera *Buccinum*, *Fusus*, *Turritella*, *Cerithium*, *Dentalium* and *Pectunculus*. This bed is well displayed in the broken ground on the south-west and west of the last-mentioned hill.

8. Limestone or calcareous marl, a few feet thick, containing *Pecten varius* and *Caryophyllia*.

9. Alternating blue and white marls, apparently without fossils, cracking into cubical and rhomboidal fragments at right angles to the stratification. The thickness of these beds is about 100 feet, and they are exposed in a hill on the north of the road to the quarries.

10. Hard yellow marly sandstone without fossils, breaking into irregular fragments. It is exposed in the rivulet on the south of the road.

11. Blue and white marl.

12. Gypsum, varying from ten to fifty feet thick, composed of an aggregation of large selenitic crystals. Their weathered surfaces have a curious appearance, resembling the crystallization seen on windows during a hard frost, and are partly finely laminated, varying in colour from clear white to grey. In one place the gypsum rises to a high ridge, on the edge of which the village of Vlicata is situated, and is here of considerable thickness.

13. Yellow or white marly sandstone, containing rarely shells of *Pecten*, *Ostrea* and *Terebratula*.

14. Bands of thin-bedded red and grey limestone, very hard, containing no fossils.

15. Blue clay about twenty feet thick, also without organic remains.

16. Gypsum resembling No. 12, and equally devoid of fossils.

Nos. 10 to 16 are seen on the left of the road in ascending towards the quarries. On the right, at the distance of about 100 yards, the rock No. 17 juts out abruptly and unconformably to the tertiary series. It consists of a fine-grained whitish limestone, similar in appearance to that of Malta, and like it probably belonging to the Miocene age. It is here largely quarried, and transported to Argostoli and other places for building. The stone is soft and easily worked, but decays if much exposed to the sea-air. Fossils are rare in it, but we noticed a large species of Pecten, and were shown one or two shark's teeth which had been found here. At the quarries this rock dips about 10° to the S.S.W., but in a valley half a mile to the east it has an easterly dip, and if viewed at this point alone might be supposed to underlie conformably the bed No. 11 of the tertiary series which composes the opposite side of the valley. The relations of these rocks to the secondary limestones, which form the mountain ridge on the west, must be worked out by observers who have more leisure than was at our command.

APPENDIX BY MR. STRICKLAND.

The Pliocene portion of the beds above described may be classed under three principal divisions,—the calcareo-arenaceous beds, consisting of Nos. 1 and 2 in the section,—the argillaceous, comprising Nos. 3 to 10,—and the gypseous, including Nos. 11 to 16. These divisions are of importance, because a similar arrangement prevails in the tertiary beds of the isle of Zante, of which I have published a description in the Geological Transactions, (2nd Series, vol. v. p. 403).

The total number of fossil species found in these beds is upwards of ninety, but as some of them are not easily determinable, and as the microscopic species are not yet examined, the number included in the following list is only 84. The remarks of M. Deshayes and of Prof. E. Forbes, which were made independently of each other, are respectively distinguished by the letters D and F. Where these letters are wanting, the specific names have been determined by myself from the works of Brocchi and others.

A considerable number of the species enumerated are now living in the Mediterranean. A comparison of their distribution as fossils with that of their recent homologues*, as shown in the valuable tables presented by Prof. E. Forbes in his Report on Ægean Invertebrata (Report of Brit. Assoc. 1843), enables us to determine approximately the depths at which the several beds were deposited. The highly fossiliferous beds 1 to 8 are about 105 fathoms thick,

* The word *homology* having recently been introduced into this country by Prof. Owen as a term of Comparative Anatomy, and being in fact identical with *affinity* as opposed to *analogy* (see Philos. Mag. s. 3. vol. xxviii. p. 357), I venture to recommend the adoption of the word *homologue* in place of the usual but inaccurate term *analogue*, to express those recent and fossil species which are either actually identical or are allied by very close affinity to each other. The term *analogue* might still be retained for those distinct groups of animals which discharged *analogous* functions at successive geological epochs; thus the *Zoophagous Gasteropoda* of the tertiary and recent period are analogues of the *Cephalopoda* which prevailed in the oolitic series, the existing *Chiroptera* are analogues of the *Pterodactyles*, the *Decapodous Crustacea* of the *Trilobites*, &c.

and from their organic remains appear to correspond to Prof. E. Forbes's Regions IV., V., VI., VII., and the upper part of Region VIII., representing a depth beneath the surface of from 20 to 125 fathoms. The marly and gypseous beds 9 to 16, in which organic remains are either very rare or wholly absent, are equivalent to the lower portion of Region VIII., which approaches the zero of animal life. We may therefore infer a tranquil condition throughout the deposition of this Pliocene formation, during which the sea gradually became shallower from the filling up of its bed, and the fauna underwent corresponding modifications. The unconformability of the subjacent Miocene rocks indicates a preceding period of disturbance, while the high angle at which the whole Pliocene series is now elevated, proves an enormous dislocation at a very recent geological date.

List of Fossils from Lixouri in Cephalonia.

The figures in the right-hand column refer to the beds in which some of the species are found, as distinguished in the accompanying section. Those species to which no number is attached were chiefly found in the beds 3 and 7, but their precise position was not noted.

The species of which specimens have been presented to the Geological Society are marked G. S.

			Stratum in which found.
G. S.	1.	Caryophyllia conica?	No. 8
G. S.	2.	Fungia	8
G. S.	3.	Lobularia arborea	5
		Balanus balanoides?, living in the Mediterranean.—F.	
G. S.	4.	Serpula arenaria, *Lin.*, *Brocchi*; Vermetus arenarius, *Desh.*—D.	
G. S.	5.	Serpula.	
G. S.	6.	Serpula glomerata, *Lam.*	
G. S.	7.	Amphidesma pubescens	6
G. S.	8.	Corbula nucleus.	
	9.	Lucina spinifera (*Mont.*), living in Med. and Brit. seas.—F. (Lucina lupinus, *Desh.*—D.)	
	10.	Astarte incrassata, *Brocchi*, pl. xiv. fig. 7.	
	11.	Venus paphia, *Lin.*	
	12.	Venus Boryi, nob. fossile de Morée.—D.	
G. S.	13.	Venus casinoides?	3
	14.	Venus radiata, *Brocchi*.—D. (Venus ovata, *Mont.*—F.)	
G. S.	15.	Cardita aculeata, *Philippi*; Chama aculeata, *Poli*.—D.	3
	16.	Cardita.	
	17.	Circe minima (*Mont.*), living in Med. and Brit. seas.—F. (Cytherea an venetiana? jeune.—D.)	
	18.	Cardium aculeatum	6
	19.	Isocardia cor	2
G. S.	20.	Arca antiquata?	
	21.	Arca	2
G. S.	22.	Pectunculus, appartenant probablement au P. glycymeris, de Linné.—D.	6
G. S.	23.	Pectunculus auritus, *Brocchi*, pl. xi. fig. 9	7
	24.	Nucula minuta, *Brocchi*, pl. xi. fig. 4.	
	25.	Nucula.	
	26.	Chama.	
	27.	Pinna	6
	28.	Pecten	4
	29.	Pecten, from the quarries at Schœno.	

Stratum in which found.

30. Pecten pleuronectes de Brocchi, spec. nov. pour moi.—D. (Pecten cristatus, *Bronn*, a fossil in Italy.—F.)
31. Pecten varius … No. 8
G. S. 32. Pecten opercularis … 2
33. Pecten pusio, living in Med.—F. (P. ornatus ? *Lam.*—D.)
34. Pecten Dumasii, *Payr.*, living in Med.—F.(Mihi incognitus.—D.)
35. Pecten.
36. Ostrea edulis … 6
37. Anomia ephippium … 2
38. Terebratula (like T. perovalis) … 6
G. S. 39. Dentalium elephantinum … 3
40. Dentalium sexangulum, *Brocchi*, pl. xvi. fig. 25.
41. Dentalium fissura, *Lam.*
G. S. 42. Ditrupa coarctata, *Brocchi*, pl. i. fig. 4.
43. Pileopsis ungarica … 6
G. S. 44. Natica millepunctata.
45. Natica tigrina ? *Defr.*
46. Natica, an spec. nov. ? très voisine du N. Dilwynii, *Payr.*—D.
47. Pyramidella suturalis, *Sow.*
48. Pyramidella subulata, *Brocchi*, pl. iii. fig. 5.
49. Solarium plicatum, *Lam.*
50. Trochus agglutinans, *Lam.*
51. Turbo rugosus.
G. S. 52. Turritella triplicata, *Brocchi*, pl. vi. fig. 14 … 3
G. S. 53. Turritella acutangula, *Brocchi*, pl. vi. fig. 10.
54. Turritella ungulina, *Desh.*; Turbo ungulinus, *Lin.*—D.
55. Cerithium vulgatum, *Brug.*
G. S. 56. Cerithium varicosum … 3
57. Cerithium fuscatum, var. living in Med.—F. (C. mediterraneum, var. nob.—D.)
58. Pleurotoma reticulata, var. spinosa, living in Med.—F. (Fusus fusulus, *Brocchi*.—D.)
59. Pleurotoma multiruga, *Bronn*, a rare Sicilian fossil.—F. (P. balteata, *Beck*.—D.)
60. Pleurotoma attenuata (*Mont.*), living in Med. and Brit. seas.—F. (P. vulpeculus, var. *Brocchi*, sp. nov. nobis.—D.)
G. S. 61. Pleurotoma dimidiata, *Brocchi.*
62. Pleurotoma Renieri, *Scacchi*, a Calabrian fossil.—F. (Nouvelle espèce.—D.)
G. S. 63. Fusus nov. spec.—D. … 7
64. Fusus* near F. crispus, but distinct from any species with which I am acquainted.—F. (Confondu par Brocchi parmi les variétés de P. dimidiata, sp. nov.—D.) … 7
65. Fusus vulpeculus, *Brocchi*, pl. vi. fig. 11 … 7
66. Fusus muricatus.
67. Fusus rostratus ?, *Brocchi*, pl. viii. fig. 1.
G. S. 68. Fusus crispus, *Lyell*, pl. 1. fig. 8.
69. Fusus longiroster, *Brocchi*, pl. viii. fig. 7. (F. rostratus, *Oliv.*, living in Med.—F.)
70. Triton cutaceus.
G. S. 71. Rostellaria pes-pelecani … 3
72. Buccinum mutabile.
G. S. 73. Buccinum prismaticum, *Brocchi*, pl. v. fig. 7 … 7
G. S. 74. Buccinum semistriatum, *Lyell*, pl. i. fig. 11 … 7
75. Buccinum, c'est une des espèces confondues avec le B. reticulatum de Linné.—D.
76. Buccinum asperulum, *Brocchi*, pl. v. fig. 8.

* Figured in next page, *F. filamentosus*, Strickland.

Stratum in which found.

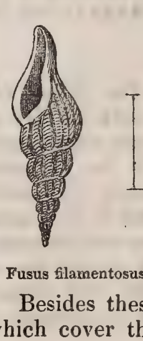
77. Nassa variabilis, living in Med.—F. (Confondu avec le B. turbinellus de Brocchi, spec. distincta, nob.—D.)
78. Purpura.
79. Columbella polita; Fusus politus, *Bronn*; Nassa columbelloides, *Brocchi*.—F. (C. subulata, *Brocchi*.—D.)
80. Mitra plicatula, *Lyell*, pl. i. fig. 12 .... No. 7
81. Mitra philippiana, *Forbes*? living in Med.—F. (Confondu avec le plicatula de Brocchi, pour moi une espèce distincte.—D.)
G. S. 82. Mitra cupressina, *Brocchi*, pl. iv. fig. 6 7
83. Mitra*, large and fine species, not known to me. Not M. zonata, as I supposed.—F. (Nov. spec. mihi incognita.—D.)
84. Conus antediluvianus, *Brocchi*, pl. ii. fig. 11.

The rest of the island of Cephalonia as far as we observed it, consists of Scaglia or Apennine limestone. Fossils are rare, but about a mile north of Argostoli, we observed in it many small spiral univalves, and near the interesting Cyclopian walls of ancient Krani we found specimens of *Nerinæa*. In crossing the island from Argostoli to Samo, the stratification of these secondary limestones is distinctly developed, dipping for several miles about 25° east, and near the middle of this vast formation we found two beds of a plicated *Ostrea*, each about a foot thick.

In Cephalonia and in the range of St. Salvador in the north of Corfu, the secondary or Apennine limestone is admirably displayed, having a regular dip to the eastward, and exhibiting an aggregate thickness of many thousand feet. If a careful observer were to make a section at these two points across this great formation, he might establish a series of mineralogical or palæontological subdivisions, and might determine to what extent this vast calcareous deposit of the Mediterranean basin is equivalent to the secondary series of Northern Europe.

Description of two apparently new species mentioned in the foregoing list. By H. E. Strickland, Esq.

Fusus filamentosus, Strickland.—Small, taper, volutions about nine, tolerably rounded, with a fine suture. Ribs twelve on the first volution, very prominent, regular, and rounded; terminating rather abruptly backwards, and leaving a slight space between them and the suture. The intervals are deep, hollowed, and equal to the ribs. Both ribs and intervals are uniformly covered by fine regular thread-like striations, of which the first volution has about twenty-eight, including those which cover the canal; the second volution has ten, and the third six, some of the alternate ones having disappeared. Besides these striations there are about four much finer ones which cover the



Fusus filamentosus.

* Figured in next page, *M. juniperus*, Strickland.

posterior portion of each volution between the ends of the ribs and the suture. Aperture oblong-ovate, both lips smooth, canal moderately long, and curved to the right. Length ·55 inch, breadth ·15 inch, first volution ·25 inch: angle of spire 30°.

Mitra juniperus, Strickland.—Taper, with ten or eleven slightly rounded volutions. On each volution are from twenty to twenty-two slender, rounded, tolerably regular, longitudinal ribs, becoming evanescent towards the suture, which is distinctly marked by a fine line. The intervals between the ribs are in general slightly wider than the ribs themselves, and are shallow, flattish, and furnished with fine irregular longitudinal wrinkles, especially on the first volution. Both ribs and intervals are crossed by nine or ten fine thread-like striæ, producing a reticulated surface; two of these are at the posterior part of the volution near the suture; in front of these is a smooth zone, equal to about one-fifth of the exposed part of the volution, which is destitute of striæ; the remaining striæ are at the anterior portion of the volution. The anterior portion of the first volution has in addition about twenty more striations, regular and closely compacted, which are concealed by the succeeding volution. Aperture narrow; columella with three strong, rounded spiral folds, the hindermost largest, the anterior one slight, their intervals broad, flat and smooth; between the two anterior ones is a slight trace of another. The medial portion of the outer lip is occupied interiorly by eleven or twelve raised thread-like lines, which penetrate into the mouth as far as can be seen. Length about 1·6 inch, breadth ·45 inch, first volution ·6 inch: angle of spire 18°.

Mitra juniperus.

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.

[Read May 20, 1846.]

IN the spring of 1843 I had the honour of transmitting to the Society a short account of two beds containing freshwater fossils, which were found by me, during the preceding summer, intercalated with the carboniferous portion of the Jurassic series of Brora*. Having been prevented at the time of the discovery from making so detailed an examination of their relation to the rocks with which they were associated as was desirable, I again visited the locality, and now present the result of my observations on that occasion.

My first object was to determine the exact age of the marine bed immediately above the main seam of coal, and with this view I

* Proc. Geol. Soc. vol. iv. p. 173.

collected as many of its fossils as circumstances permitted. These amount to twenty-five species of shells and some fragments of carbonized wood; but, with the exception of two Ammonites (*A. Kœnigi* and *A. sublævis*), they are either enumerated in the lists published by Sir R. I. Murchison*, are undescribed species, or are too imperfect for satisfactory determination.

Eighteen of the shells are also found in different members of the Jurassic (oolitic) series of England, and of these the following occur in the unusually developed Kelloway Rock of Yorkshire†:—

Ammonites Gowerianus, *Sow.*	Pecten lens, *Sow.*
—— Kœnigi, *Sow.*	Modiola cuneata, *Sow.*
—— sublævis, *Sow.*	Trigonia clavellata, *Sow.*
Ostrea archetypa, *Phil.*	Goniomya literata, *Sow.*

The *Ammonites Kœnigi* and *A. sublævis* are also associated in the equivalent strata at Kelloways Bridge, Wilts., and, as well as the *A. Gowerianus*, in the contiguous Oxford clay of Chippenham. These facts afford additional proof that the position long ago assigned to the bed in question by Sir R. Murchison, who regarded it as the representative of the "pier stone" of Scarborough, is the correct one‡.

Fig. 1.

This marine deposit (Section fig. 1) is succeeded, in the descending order, by the following strata:—

a. Coal (main seam), 3 feet.

b. Dark grey shale with seams of coal, 20 ft. 6 inches.

c. Seven or eight seams of black, bituminous shale, full of shells, &c., and alternating with unfossiliferous partings of the same rock. The fossils comprise detached scales of *Lepidotus pusillus* (sp. nov.) and *Pholidophorus cognatus* (sp. nov.), *Paludina conulus* (sp. nov.), *Cyclas angulata*, Sow., *C. subglobosa* (sp. nov.), *C. rhomboidalis* (sp. nov.), *C. solidula* (sp. nov.), *C. unioniformis* (sp. nov.), and *Cypris granulosa*, Sow. There are also portions of an obscure plant, and small fragments of carbonized wood. The thickness of the whole is 5½ inches.

d. Shale like *b*, but without coal, 3 ft. 1 inch§.

e. Black, grey and green clays, including a layer of whitish argillaceous limestone. The fossils, which, although broken and disunited, constitute at least one half of the mass, are *Semionotus punctatus* (sp. nov.), *S. minor* (sp. nov.), *Lepidotus pusillus* (sp. nov.), *Pholidophorus cognatus* (sp. nov.), *Paludina conulus* (sp. nov.), *Perna erecta* (sp. nov.), *P. obliquata* (sp. nov.), *Tellina muriatica* (sp. nov.),

* Trans. Geol. Soc. 2nd Series, vol. ii. pp. 320 and 366.

† Prof. Phillips's 'Geology of Yorkshire Coast,' 2nd edition, p. 111 *et seq.* The shell figured in this work as *Rostellaria composita* is (unless very inaccurately represented) not identical with the fossil from Brora so named in 'Mineral Conchology.'

‡ Trans. Geol. Soc. 2nd Series, vol. ii. pp. 297–8, 316–7.

§ It being impracticable to subject the beds *b* and *d* to direct measurement, their thicknesses were calculated from the usual data.

Cyclas angulata, Sow., *C. subglobosa* (sp. nov.), *C. lenticularis* (sp. nov.), *C. rhomboidalis* (sp. nov.), *C. præ-ovata* (sp. nov.), *C. solidula* (sp. nov.), *C. unioniformis* (sp. nov.), *Unio Murchisoni* (sp. nov.), and *Cypris granulosa*, Sow. At the base of this group there is a seam of brownish-grey clay, full of fragments of vertebrata. Among these there are, besides scales of most of the ganoid fishes enumerated above, portions of *Emys* (?) *Oweni* (sp. nov.), teeth of *Hybodus concinnus* (sp. nov.), *H. ornatissimus* (sp. nov.), *H. reticulatus* (?), Ag., *Acrodus minimus*, Ag., and *Ctenoptychius* (?) *Jurassicus* (sp. nov.). The total thickness of these strata is 1 ft. 4 inches.

f. Fine brown clay with plants.

The groups *c* and *e* appear to be entirely wanting at the Brora Colliery *. This is also the case with respect to the latter at the Water of Brora pit †; but there can be little doubt that No. 37 of that shaft, described as "soft black shale, speckled with white powdery matter 2 inches," corresponds to the strata included under *c* of the coast section; although neither the vertical distance from the main seam of coal, nor the mineral character of the intervening beds agree at the two localities.

The Brora *Cyclades* so much resemble those of some of the Wealden strata of Kent, that, on first meeting with detached fragments containing them, I at once conjectured that a contemporary deposit must exist in the vicinity. After finding the beds *in situ*, however, and tracing them under the coal, (the roof of which Sir R. Murchison had referred to one of the divisions of the middle oolite,) I abandoned my original impression, and was for a time confirmed in the propriety of doing so, when on my return home I failed to identify a single species ‡ with their southern representatives. My esteemed friend Dr. Fleming (at that time personally unacquainted with the geology of Brora) was so struck with the "Wealden aspect" of the shells, as to suggest that the marine bed above might prove to be the equivalent of the lower greensand. This idea I knew to be erroneous, and it was not until after a perusal of Sir R. Murchison's observations on the beds now under discussion §, and a subsequent study of the zoological relations which exist between the Wealden above the Portland stone and the various members of the Jurassic series, that I became convinced of the necessity for associating with the former, not only the coal-field of Brora together with certain strata in the vicinity of Elgin and in the Hebrides, but also the carboniferous series of the Yorkshire coast, as well as such other similar deposits, belonging to the same system, as future researches may bring to light.

At the date of my former communication, I was not aware of the occurrence of freshwater shells in the Jurassic coal-fields of York-

* Trans. Geol. Soc. 2nd Series, vol. ii. p. 326.

† *Op. cit.* p. 325. Sir R. Murchison has however reminded me that these sections were made by miners very slightly acquainted with fossils.

‡ The specimens of *Cyclas angulata*, Sow. were obtained during my second visit to Sutherlandshire, and I only recently recognized the *Cypris granulosa*, Sow.

§ Proc. Geol. Soc. vol. iv. p. 174.

shire. It appears, however, that Mr. Bean described and figured *Unio distortus* and *Cypris concentrica*, from the sandstone and shale of Gristhorpe Bay, in 1836*; and that Mr. Williamson, soon afterwards, discovered a second species of Unio in the same beds†. These strata have been known for some time to possess two plants (*Zamia pectinata*, Ad. Brong., and *Thuytes expansus*, Sternb.) in common with the Stonesfield slate‡; and the Megalosaurus of the latter and of the Wealden of the S.E. of England were, long ago, ascertained by Cuvier to belong to the same species. An indirect connection is thus established between the Jurassic coal series of Yorkshire and the Wealden beds above the Portland stone, and I doubt not that on closer examination they will prove, by the discovery of identical fossils, to be much more nearly related.

The few geologists who still look upon the Wealden above the Portland stone as a member of the Cretaceous series, will doubtless hesitate before adopting the classification above proposed; but when it is recollected that the Maidstone Iguanodon and the *Lonchopteris Mantelli*§ (Brong.) are the only fossils yet recognized as common to the two systems, while the fourteen enumerated below are found between the Purbeck beds and Trias, as well as in the division of the Wealden alluded to, their objections will probably give way.

Megalosaurus Bucklandi, *Cuv.* Stonesfield slate, &c.; Tilgate beds, &c.
Poikilopleuron Bucklandi, *Deslongch.* Caen limestone; Tilgate beds.
Lepidotus minor, *Ag.* Stonesfield slate, Portland stone; Purbeck beds.
Microdon radiatus, *Ag.* Stonesfield slate; Purbeck beds.
Pycnodus Mantelli, *Ag.* Oolite, Ratisbon; Tilgate beds.
Asteracanthus semisulcatus, *Ag.* Stonesfield slate; Purbeck beds.
Hybodus marginalis, *Ag.* Lias, Stonesfield slate; Purbeck beds.
—— apicalis, *Ag.* Lias, Stonesfield slate; Purbeck beds.
—— dorsalis, *Ag.* Stonesfield slate; Tilgate beds.
—— strictus, *Ag.* Portland stone; Purbeck beds.
—— grossiconus, *Ag.* Stonesfield slate; Caen limestone; Tilgate beds.
Ostrea distorta, *Sow.* Portland stone; Purbeck beds.
Cyclas angulata, *Sow.* Brora beds; Wealden *passim.*
Cypris granulosa, *Sow.* Brora coal-fields; S. of England ||.

The Stonesfield slate, Caen limestone, lithographic limestones of Bavaria, and other beds of the same character, must be excluded from the category of the Wealden; for although they all contain certain fossils identical with those of the latter class, it is evident, from the preponderance of their marine remains, that they were deposited in a saline medium. The following remarks will explain the relation in which I conceive these strata to stand to the estuary portion of the Wealden beds and to the marine members of the Jurassic system.

If a continuous section of the various deposits, formed contemporaneously in an estuary and in the adjoining sea, could be

* Loudon's Mag. Nat. Hist. vol. ix. p. 376.
† Trans. Geol. Soc. 2nd Series, vol. v. p. 236.
‡ Phillips, 'Yorkshire Coast,' and Morris, 'Catalogue of British Fossils.'
§ Quart. Geol. Journ. vol. ii. p. 55.
|| The authorities for this list are, Prof. Owen in Report of Brit. Assoc. for 1841; Prof. Agassiz in Brit. Assoc. Report for 1843 and in Poissons Fossiles; and Dr. Fitton in Trans. Geol. Soc. 2nd Series, vol. iv.

obtained, the included fossils would probably be associated in this way. Commencing at the fluviatile extremity of the estuary, we should find, in the first place, strata with terrestrial and freshwater exuviæ only. Proceeding seaward, these would gradually be replaced by true estuary deposits, containing species belonging to marine genera, in addition to the remains of the preceding division. There would next be a transition to marine beds, enclosing, however, along with the beings proper to the region, a considerable amount of such terrestrial organic remains as had been carried out to sea; and we should have, lastly, an assemblage of deep sea fossils, with occasional fragments of wood, or other buoyant terrestrial substances. Certain fishes, like the modern Salmonidæ and Sturionidæ, and also, in all probability (if we may judge from their usual associates), various species of Lepidotus and other allied genera, whose migratory habits carried them alternately into fresh and salt water, would be found to prevail more or less throughout the whole of the beds. Others again, so constituted as to be able to live in the ocean and in brackish water, but not in perfectly fresh water, would occur in the last three, although not in the first, of the above divisions. We may conjecture, on the ground of association above suggested, that the latter class was formerly represented by the Cestraciontidæ and Hybodontidæ.

Of a succession of deposits such as I have supposed, formed during the Jurassic period, the first and second divisions would be referable to the Wealden; the third would closely resemble the Stonesfield slate, Caen limestone, &c.; and the fourth would be identical with one of the marine members of the system. Had the land been in a state of upheaval during the accumulation of the various beds, the first and second classes would overlie the others; but were it, on the other hand, subsiding, the reverse of this would take place. It seems consequently not unreasonable to infer, that Wealden beds may yet be found, in contact with the Stonesfield slate and other similar deposits, their relative position depending upon the upward or downward motion of the land at the time of their accumulation.

The Neocomian question has recently directed so much attention to the junction of the Jurassic and Cretaceous systems, in various countries where the Wealden above the Portland stone does not occur, that, from the universal absence in such localities of any bed not referable either to the last-mentioned rock or the lower greensand group, the addition of other members to this part of the geological series can scarcely be looked for. Assuming this to be the case, I shall proceed to inquire, whether the Wealden of the north of Germany*, south-east of England, and north of France, be

* From the brief account given by M. v. Römer of the Wealden strata of this region (Versteinerungen des Nord-Deutschen oolithen Gebirges; Nachtrag, s. 6 *et seq.*), I suspect that some of the beds are below the Portland stone: thus M. v. Römer mentions that at Klein Süntel the Weald clay is absent, but there are 450 feet of sandstone with seven seams of coal, resting on clay and shale 240 feet thick, "of which at least the lower part belongs to the inferior oolite."

not contemporary with some portion of either the Portland stone or lower greensand.

It is evident that the Wealden fossils enumerated in the list given in a preceding paragraph, together with those of the beds of Yorkshire, Sutherlandshire, &c., must be regarded as the remains of animals and vegetables which inhabited the land, and the fresh and brackish waters of the Jurassic period. Hence it might be supposed, that the Portland stone (under the assumption already made, that it is the newest of the oolites) was more likely than the lower greensand to be the contemporary of the portion of the Wealden now under consideration. But as there is everywhere a sharply defined boundary between the Portland stone and the Purbeck beds in contact with it, and we have the testimony of the "dirt-beds," to prove that a considerable portion of the surface of the former became dry land very soon after the deposition of the latter commenced, the two cannot have accumulated contemporaneously. Nevertheless, if the view which I have taken of the relations of the Wealden and Jurassic series be the correct one, strata belonging to the former, although not yet recognized, must have been deposited in the lakes, rivers and estuaries of the Portland-stone æra, as well as during the periods consumed in the formation of the preceding members of the system.

I shall next consider to what extent the lower greensand can be looked upon as contemporary with the Wealden strata which it rests upon. Before doing so, however, it will be necessary to advert to the proportions of land and water which existed in the European region of the globe during the Jurassic epoch. On looking at a geologically-coloured map of this area, it will be seen that a very large portion of its surface is covered by marine Jurassic rocks, and when to this is added the amount concealed by the superposition of newer strata and that removed by denudation, it is clear that but little of the space could have been occupied by land; and consequently the rivers must have been proportionately diminutive.

We have here a reason for the rarity of Wealden beds throughout the oolites; but on the elevation of the Portland stone, coupled with the upheaval of mountain masses in the interior, which doubtless accompanied the change of level*, the state of matters was changed, and the rivers, their volumes augmented in proportion to the increased area of their hydrographical basins, now poured down correspondently great supplies of sediment. Thus, I think, is explained the enormous development of the Wealden deposits at the termination of the Jurassic epoch.

The number of identical species in the Portland stone and lower greensand of Central and Western Europe is so small, that, in taking for granted the absence of intermediate beds, it seems proper to offer some observations on the means by which this almost total change of organic beings may have been effected. There appears to me to

* Mr. Darwin on Volcanic Phænomena in South America, Trans. Geol. Soc. 2nd Ser., vol. v. p. 601 *et seq.*

be only one natural process capable of producing the simultaneous extinction of the marine species of any region, viz. the sudden elevation and desiccation of the bottom of the ocean in which they lived.

That at the close of the Jurassic period an elevation took place, resulting in the conversion into land of considerable portions of the bed of the ocean in which the Portland stone was deposited, is unequivocally proved by the occurrence of "dirt-beds" in the south-east of England and north of France, as well as by the coal-seams of the same age in Hanover. From the few localities in which the equivalents of the Portland stone have been recognized, it may be inferred that, at the time of its deposition, by much the greater portion of Europe had already been raised above the waters of the ocean; and there is, therefore, nothing unreasonable in the conjecture, that a moderate change of level afterwards sufficed to extend the desiccated area, so as to include, or even exceed, the limits of the territory now exposed to geological investigation. The upheaval must have taken place suddenly, as is shown by the distinct plane of separation, and the absence of alternations observable at the junction of the Portland stone and Purbeck beds. Admitting then that the method suggested above is that by which the extinction of marine animals over a certain area is accomplished, we have, in the changes alluded to in the preceding sentences, a cause for the disappearance of the species of the Portland stone from the European region.

When the alterations in the distribution of land and water, in the depth of the ocean and in the nature of its deposits, as well as other mutations affecting the characteristics of species (all necessarily consequent on the conversion of a portion of the submarine area into a terrestrial condition), are considered, it is not difficult to imagine that the inhabitants of the waters which washed the shores of the new continent would differ as much from their predecessors as the fossils of the lower greensand do from those of the Portland stone. Under such circumstances I conceive the first inhabitants of the lower greensand to have made their appearance.

Transition beds must exist in which individuals of both the old and new races are interred, but they could only have been formed on those parts of the ocean bed which remained submerged after the elevation so often mentioned took place; and as none have been found, notwithstanding the most diligent search in all the better-known countries of Europe, it must be presumed, as already hinted, that the continent extended farther to the westward than it does at present, and that they lie buried under the waters of the Atlantic.

As the "dirt beds" and coal prove that elevation of the European region followed the deposition of the Portland stone, so do the lower greensand strata, which rest upon the Wealden deposits, show that, before they could have assumed the position in which they are now found, subsidence must have happened. The Iguanodon of Maidstone, and the *Lonchopteris Mantelli* of the Isle of Wight, further indicate that the depression was effected gradually, since their occurrence can only be explained on the supposition that portions of the continent remained above the waters, during the accumulation of many feet of the oceanic beds, which, if the evidence afforded by the exclusively marine character of the remains entombed in all but the lowest members of the cretaceous system is to be trusted, ultimately covered it. In the course of such a subsidence, the several rocks constituting the surface of the continent would, on their successive submersion, be enveloped in marine beds, which, although not strictly speaking contemporary, must, from the similarity of the circumstances prevalent during their accumulation, be almost identical with respect to their organic contents. The oceanic strata deposited at the period referred to will thus be found in contact with a variety of the older masses, and certainly the lower greensand fulfils this condition, since, in the region under consideration, it rests on numerous members of the preceding systems.

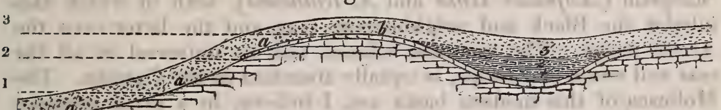
When the elevation of the Portland stone happened, the concavities of the ocean in which it was deposited, having no outlet, would retain their salt water, and form inland seas inhabited by many of the same animals as those which dwelt in it before the event which led to their isolation. It is into these basins that I conceive the river, which produced the Wealden of the south-east of England, north of France and Hanover, must have flowed. There is no reason to suppose that the elevation and extension of the land would destroy the inhabitants of its surface; and it is, therefore, not surprising to find that the Megalosaurus and Poikilopleuron of the oolites also occur in the Wealden beds which rest upon the Portland stone. The identity of the fishes in the two groups seems, at first, less easily accounted for by the hypothesis now proposed, but we know that several species now flourish in the Caspian, as well as in the seas with which it was formerly united. Thus among others it contains two species of Sturgeon (*Acipenser Huso* and *A. Ruthenus*), both of which also inhabit the Black and neighbouring seas, and the latter even the Arctic ocean. The common salmon, too, so universal in all the seas and rivers of Europe, is equally abundant in the Caspian. The Mollusca of this modern basin are, I believe, in a great measure peculiar to itself, and so must those of its prototypes have been, since, except the *Ostrea distorta*, none of the few shells referable to marine genera, which the Wealden contains, are found either in the Portland stone or lower greensand.

The want of correspondence in the number of the "dirt beds," and in the nature of the strata associated with them, at the various localities where they have been observed, shows that the vegetables which gave rise to them, although they must have flourished contemporaneously or nearly so, were not distributed over a continuous surface. They probably grew on low grounds near the mouths of the rivers, or on islets on their deltas. In such situations they would, from time to time, be inundated by the rivers and buried under their deposits, on the one hand, and suffer from the encroachments of the salt-water lakes during storms, on the other. To the effects of the latter agent may be attributed the rolled pebbles of Portland stone found in the "dirt beds*."

It may seem necessary in this place to consider the question, what has become of the beds of marine organic remains formed in these inland seas? To this I regret my inability to offer any satisfactory reply, but I may suggest, as a possibility, that the strata accumulated for some time after the separation of the seas from the ocean were identical with the Portland stone, while, subsequently, the rivers in draining so extensive a surface may have supplied enough of fresh water to render the seas brackish, and so permit the association of marine and fluviatile species (as in certain lagoons on the Mediterranean delta of the Rhone†); in which case all, except the lowest deposits of the basins, would be classed as Wealden.

It is needless to enter upon any further discussion regarding the circumstances which attended the accumulation of these deposits. They present, I think, no phænomena incompatible with the hypothesis, that they resulted from the deposition of sediment conveyed by rivers liable to be copiously flooded and opening into inland seas, the latter being occasionally subject to storms and currents produced by the action of winds or earthquakes. The strata accumulated in these detached basins of the continent and those formed along its coasts would go on increasing independently of, but contemporaneously with each other, and could not come in contact until the barriers which separated the inland seas from the ocean had sunk below the level of the latter. When this happened, the oceanic beds would extend themselves over those which had been formed in the inland seas, and would rest conformably upon them in the same way as the lower greensand does on the subjacent Wealden deposits.

Fig. 2.



In this diagram the lower bed represents Jurassic rocks; the bed shaded by straight dark lines, Wealden, and the dotted bed at the top the Lower Greensand.

The preceding theory will be rendered more intelligible by an inspection of the ideal section, fig. 2, in which the lower bed represents the continent, composed of Jurassic rocks, its uppermost member being of

* The "top cap" of the Isle of Portland, on the surface of which Prof. Henslow observed root-shaped cavities, produced by the trees of the "Black dirt," belongs, together with several feet of the subjacent strata, to the Purbeck series, and not to the Portland stone. (Dr. Fitton, Trans. Geol. Soc. 2nd series, vol. iv. p. 219.) The inference which Mr. Lyell (Elem. of Geology, 2nd ed. vol. i. p. 425) draws from the observation alluded to, viz. that the Portland stone was in a "soft and penetrable condition" at this time, is, therefore, not supported by it.

† Mr. Lyell's Principles of Geology, 6th. ed. vol. i. p. 433.

course the Portland stone; the overlying strata marked by horizontal shading, the Wealden, occupying the former site of an inland sea; and the dotted portion, the lower greensand. The letters *a a a* denote the littoral face of the continent, and *b* the summit of the barrier which divided the ocean from the inland sea. Let it be supposed that, either during the period in which the continent remained stationary in its elevated position, or at any stage of its subsidence, the lower greensand had covered the submerged surface to the extent indicated by the dotted line 1, while at the same epoch, the Wealden had accumulated in the inland sea to the height of 1′; further, that at a later date the two series had respectively reached 2 and 2′, and subsequently 3 and 3′. It is evident, according to this hypothesis, that the horizontal extension of the lower greensand from 1 to 2 and from 2 to 3 took place contemporaneously with the vertical accumulation of the Wealden from 1′ to 2′ and from 2′ to 3′. At length however, in consequence of the continued depression of the continent, the ocean would overcome the barrier *b*, and, by the change of circumstances thus occasioned, lead to the extinction of the inhabitants of the inland sea; while it would, at the same time, begin to extend over the now completed Wealden a series of strata similar, as regards the fossils entombed in them, to those with which it had continuously enveloped the previously submerged portion of the surface of the subsiding land. The flexures of the strata are, of course, very much exaggerated in the figure; on the scale of nature, and seen in such limited sections as are usually exposed to geological observation, the several deposits would appear strictly conformable to each other.

If this division of the Wealden, as has been generally conjectured, was deposited in an estuary, the latter must have communicated with the ocean, during part of both the Jurassic and Cretaceous periods,—the organic remains enumerated (see p. 116) connecting it with the one, and the Iguanodon and Lonchopteris with the other. To the hypothesis, that the estuary opened into the Jurassic ocean, it may be answered, that the Portland stone, beyond whose limits, in the south of England at least, the Wealden does not extend*, appears to be quite as fully developed where overlaid by the latter as in other localities; which could not have happened under the circumstances alluded to. Moreover, as already stated, there is no transition or alternation between the Portland stone and Purbeck beds. We might also expect, in such a case, to find a greater proportion of marine mollusca and other invertebrata of the Jurassic period, either mingled with the freshwater remains, or in separate layers intercalated between the fluviatile strata, than actually occurs. The only shell (*Ostrea distorta*, Sow.) hitherto identified as common to the Portland stone and Wealden, belongs to a genus whose species can resist such changes as would prove fatal to most others; there is, therefore, nothing improbable in assuming, that it survived the separation of the inland sea from the ocean.

If identity of fossils proves the near relationship which exists be-

* Dr. Fitton in Trans. Geol. Soc. 2nd series, vol. iv. p. 332.

tween the Jurassic system and Wealden, the total absence throughout the latter series of a single marine remain common to it and the lower greensand is equally conclusive against the supposition that the strata in question were formed in an estuary communicating with the cretaceous ocean.

Enough has now been said to show cause for the belief, that, at all events, the greater part of the Wealden beds above the Portland stone were deposited contemporaneously with a portion of the lower greensand; and also to indicate the means by which the terrestrial and freshwater, and even some of the marine inhabitants of a period may continue to exist long after the extinction of its truly oceanic tribes.

It may appear to some geologists, that the word 'Wealden,' being no longer exclusively applicable to those interesting deposits which occasionally intervene between the Portland stone and lower greensand, ought to be suppressed; but until the science is so far advanced as to afford criteria for distinguishing the strata of deltas, estuaries and inland seas from each other, it is convenient to have a collective expression for all such beds belonging to the Jurassic system.

In conclusion, I have only to observe, that the hypothesis advocated in the latter part of this paper may, I think, with slight modifications, be rendered explanatory of other geological phænomena than that to which it particularly refers *.

Appendix.

[Dated 2nd December, 1846.]

After an anxious consultation of all the authorities within my reach, I had failed, when the preceding pages were transmitted to the Society, in obtaining sufficient information with respect to the Caspian Sea, to enable me fully to carry out the theory proposed in explanation of the phænomena of the Wealden series above the Portland stone, and of the relations of these strata to the Jurassic and Cretaceous systems; but having subsequently learned, through the kindness of one of its distinguished authors, Sir R. Murchison, that the requisite details were to be met with in 'The Geology of Russia and the Ural Mountains,' &c., I was much gratified, on procuring the volumes, to find that the ample account therein given, of the comparatively modern changes which have happened in the Aralo-Caspian region, tended to support my hypothesis. The passages having reference to the subject, all of which occur in the first volume of the work above mentioned, will be found in the succeeding para-

* The description of the new species from the beds of Brora is postponed until more perfect specimens are obtained. The best of those already met with have been sent to the Geological Society, in order that any one wishing to compare them with the similar remains of other localities may have an opportunity of doing so.

graphs, accompanied by such comments as seem necessary to show their application to what I will venture to distinguish as the "Caspian theory" of the Wealden series above the Portland stone.

The Caspian Sea, instead of being "extremely salt*," is described (except in the vicinity of brine springs) as "so slightly saline, that even in a part of it far removed from rivers and streams, its waters are said to be potable" (p. 308). A communication from M. Eichwald is afterwards quoted, wherein he says, "I can assure you the Caspian is much less salt than the Black Sea, and possesses one-sixth part only of the saltness of the ocean" (p. 323). The Wealden fossils undoubtedly indicate that the rocks containing them were formed in a similar medium, and reasons have been already given for rejecting the estuary theory.

The "zoological character" of the Aralo-Caspian limestones is stated (p. 309) to be "persistent and almost monotonous." This is also the case with the inhabitants of the present sea, and the expression is equally applicable to the aquatic animals whose remains occur in the Wealden beds.

Rejecting, on the authority of M. Deshayes (note, p. 307), the subdivisions of Cardium proposed by M. Eichwald, the shells of the Aralo-Caspian limestones and those of the modern inland sea belong to the following twelve genera (pp. 301 and 306):—*Paludina*, Lymneus, *Melanopsis*, Rissoa, *Neritina*, *Bulla*, Mactra, *Cyclas*, Dreissena, *Mytilus*, Donax and Cardium. Those printed in italics also occur in the Wealden series of the south-east of England; and, except Cyclas, which is only represented by the single *C. ustuertensis*, Eichw., of the Aralo-Caspian limestones, the species referable to each genus bear nearly the same numerical proportion in both the ancient and existing basins.

No remains of fishes appear to have been yet discovered in the Aralo-Caspian limestones; but as regards the modern Caspian, it is said (p. 308), on M. Eichwald's authority, that "the greater number of its fishes belong to freshwater genera and species." As M. Agassiz has not hitherto succeeded in discovering any characters by which the marine and freshwater genera of this class of animals are distinguishable from each other, it would be premature to say whether the observation of M. Eichwald applies to the Wealden ichthyolites or not. Certain genera, whose remains are found both in the Wealden deposits and in the marine members of the Jurassic system, had probably, as previously suggested, the same habits as most of the recent Salmonidæ. It may also be remarked, that although the existing Squalidæ (using the word in its most comprehensive sense) appear to be strictly oceanic, this cannot have been the case with the extinct representatives of the family, since their spines and teeth are of frequent occurrence both in the Wealden beds and in certain so-called freshwater strata of the Carboniferous epoch.

The Aralo-Caspian limestones appear to rest exclusively on Miocene strata. In the same way, the Wealden deposits of the

* Dr. Traill's Phys. Geog. in 7th ed. of Encyc. Brit.

south-east of England have not been found beyond the limits of the Portland stone*. These facts are readily understood, when it is considered that in the one case the Miocene beds, and in the other the Portland stone, were accumulating when the elevations happened which converted the bottoms of the respective oceans into those of inland seas.

Transitions between the Miocene and Aralo-Caspian strata are stated (p. 304) to be "peculiar to the western boundaries of the latter," *i. e.* as is clearly explained, to the region where the ocean and Aralo-Caspian Sea communicated with each other, before the elevation of the barrier which afterwards divided them. From the expression "peculiar" it may be inferred that, in other parts of the basin, the plane of separation between the oceanic and brackish water deposits is, as in the case of the Portland stone and Purbeck beds, distinguishable.

The mineral characters of the Aralo-Caspian rocks of the Crimea are thus summed up (p. 301):—Courses of argillaceous marls, clays, calcareous marls, concretions, ferruginous bands, agglutinated shells (faluns), and soft spongy shelly limestone." The Wealden deposits are quite as diversified, and may, as a whole, be described in nearly the same words.

The examination of the Aralo-Caspian deposits has produced the conviction that they were all (p. 304) "accumulated under one vast inland sea, the inhabitants of which differed as essentially from those of the ocean of that day, as the animals of New Holland now differ from those of the rest of the world." The value of this passage, as corroborative of my hypothesis, will be appreciated, when it is recollected that the inhabitants of the Wealden sea were assumed to have been quite distinct from those of the contemporary (lower greensand) ocean.

The Miocene rocks of the South of European Russia may, in almost every particular, be compared to the Portland stone; the Aralo-Caspian and Caspian deposits, to the Wealden beds; and the oceanic strata, now being accumulated in the Black Sea, &c., to the first formed portions of the lower greensand. There is, however, one remarkable difference between the two series, for the Portland stone is quite as well developed beneath the Wealden deposits as elsewhere, while the marine Pliocene beds of other countries are unrepresented below the Aralo-Caspian strata; in fact, these last-mentioned rocks are themselves believed to be (p. 323) "the equivalents of Pliocene and Post-pliocene deposits." In the former case, therefore, there seems to have been a great and sudden change in the oceanic inhabitants of Europe; while in the latter, with some local exceptions, the mutation of races has been gradual and uninterrupted.

I have already stated my belief that only one cause, viz. desiccation of the ocean bed, can account for such an extinction of marine animals as happened at the close of the Jurassic period.

* Dr. Fitton in Trans. Geol. Soc., 2nd Ser., vol. iv. p. 332.

As an extreme case, and particularly with reference to the distribution of animal life in the Ægean, it was suggested that the elevation which produced this desiccation might have amounted to 200 or 300 fathoms. I am not aware that, under favourable circumstances, there is anything to prevent a change even as great as this taking place; but, with reference to the particular epoch under consideration, it must be admitted that the igneous force which, along the lines of eruption, produced only such comparatively diminutive chains as those of Mont Pilas (Forez), Côte d'Or and the Erzgebirge*, could scarcely have been adequate to raise so extensive an area as the part of Europe then covered by the Jurassic ocean to the height above mentioned. This branch of the hypothesis need not be abandoned, however; for, in the first place, the depth of the ocean at the period referred to may not have been very considerable, and indeed, unless subsidence of the bottom had taken place to an enormous extent during the Jurassic epoch, the accumulation of strata must have greatly diminished its profundity. Secondly, the phænomena do not require that the desiccation should have extended to the zero of marine existence, since there are many species recorded as common to the Jurassic and Cretaceous systems †; and although the number of these may decrease under a more rigid examination than has yet been bestowed on them, others will as surely be found, either among the unpublished fossils now scattered through various collections, or in the rocks themselves, to supply their places.

Igneous action, the eruptive effects of which are visible in the Crimea, the Caucasus, &c., is regarded also as the agent which has "heaved up in broad horizontal masses, to the different levels at which we now find them, the beds of the former great Caspian Sea" (p. 324). In the event of an oceanic submergence of the region, these elevated "older" and "younger" deposits would each be directly overlaid by the same marine strata which covered the more recent sediments of the basin; just as, in many localities towards the interior of England, the Purbeck beds at Quainton, Bucks, the Hastings sand ‡ (?), and elsewhere the Weald clay, are severally succeeded by the lower greensand.

Except in those cases where denudation appears to have taken place, the absence of the Hastings sand and Weald clay between the Purbeck beds and lower greensand must be referred to the operation of the same cause which has prevented the deposition of "younger" and recent strata over certain tracts of the "older" division of the Aralo-Caspian series, viz. the elevation of the latter above the level of the sea. The source of such elevations in the modern basin has been adverted to; and, in the following quotation from a well-known work, there is satisfactory evidence of the activity

* Elie de Beaumont, "Extrait d'une Série de Recherches sur quelques-unes des Révolutions de la Surface du Globe," p. 45.

† *Vide* D'Archiac in Mém. de la Soc. Géol. de France, 1839, vol. iii. p. 261, &c., translated in Leonhard and Bronn's Jahrbuch for 1841, p. 796; also Bronn in Jahrbuch for 1842, pp. 83, 84.

‡ Dr. Fitton, *op. cit.*, p. 290.

of similar forces during the accumulation of the Wealden series of the south-east of England :—" The principal lines of elevation of the Wealden are clearly referable to those movements which upheaved the chalk and incumbent strata; but we may observe, that the deeper beds exhibit traces of extensive faults and dislocations, which seem to belong to previous disruptions, for the fissures and chasms are filled up with broken shale, and clay, and sand, the debris of the Wealden, and contain no intermixture whatever of the marine deposits which may be supposed to have once covered them*."

The "change of animal life," which a comparison of the fossils of the "older" with those of the "younger" members of the Aralo-Caspian series, and of the latter with the inhabitants of the present sea, proves to have occurred, is regarded as "having accompanied the diminution of the Caspian to its present dimensions, and the union of the Black and Mediterranean seas" (pp. 322–323). In like manner, the alterations in the distribution and amount of the waters of the Wealden basin, consequent on the elevation of its older deposits, were probably the chief means of bringing about those mutations of species which are observed to have taken place during the accumulation of Purbeck beds, Hastings sand and Weald clay.

The foregoing analogies between the products of the actual Caspian and the hypothetical Wealden seas are, I think, in a great measure confirmatory of the truth of the theory which it has been my object to elucidate. No notice has hitherto been taken of the Wealden series of Hanover in the present memoir. As previously suggested, some of the brackish deposits of that country are probably inferior to the Portland stone; but there can be no doubt that the circumstances which led to the formation of the strata incumbent on the rock last named, were identical with those to which the corresponding beds of England owe their origin. The general specific distinctness of the German fossils seems to indicate, that their parent strata were formed in a different basin from that in which the contemporary brackish deposits of the south-east of England and north of France accumulated.

The use of the word 'Jurassic' in this memoir may be objected to; but 'oolitic' is so inapplicable to the strata of the region to which the first few pages of the preceding paper refer, that I preferred adopting the former term, and, having once done so, continued it throughout. Every one must allow that 'oolitic,' while it is descriptive of numerous beds in other parts of the geological scale, but ill expresses the character of the majority of rocks belonging to the system which it is intended to distinguish. In accordance with the recent changes in geological nomenclature, a geographical term must soon be applied to the system; and while, so far as the history of the science is concerned, there can scarcely be a difference of opinion as to the propriety of selecting one having reference to the scene of Smith's early labours, it must be remembered that Jurassic (which,

* Dr. Mantell's 'Geology of S.E. of England,' p. 342.

of course, simply intimates that strata of this age are well developed in the Jura chain) is now so universally made use of by continental geologists, as well as introduced into the writings of some of the most eminent of our own body when treating of foreign rocks, that any attempt to substitute another local name for it would be almost sure to fail. There need be no apprehension that English geologists, adopting the continental term, would run any risk of being robbed of the honour of having first defined the system; for, even should the history of this part of geology be lost, the names of Portland stone, Kimmeridge clay, Oxford clay, &c., which are met with in the writings of all the best foreign authors, sufficiently attest the fact.

Finally, I have only to reiterate the opinion hinted at in concluding the paper to which this is supplementary, that many of the mixed deposits, from the Devonian system upwards, will be found to have originated in "Caspians."

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

June 11*th to November* 4*th*, 1846.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

Agricultural Society of England, Journal. Vol. vii. part 1.

American Academy of Arts and Sciences, Memoirs, New Series. Vol. ii.

——— Journal of Science. 2nd Series, vol. ii. nos. 4 and 5.

Asiatic Society of Great Britain and Ireland, Journal. No. 17. part 1.

Athenæum Journal. June to November.

Berlin Academy, Abhandlungen for 1844.

———, Bericht, July to December 1845, and January to June 1846.

Chemical Society, Memoirs and Proceedings. Parts 17 and 18.

Edinburgh, Royal Society of, Transactions. Vol. xvi. part 2.

———, Proceedings. Vol. ii. nos. 27 and 28.

France, Geological Society of, Bulletin. 2nd Series, vol. iii. sheets 16 to 42.

Geneva Natural History Society, Memoirs. Vol. xi. part 1.

Geographical Society, Journal. Vol. xvi. part 1.

Geological Survey of Great Britain, Memoirs. Vol. i. *From Sir H. T. De la Beche, by direction of the Chief Commissioner of H.M. Woods and Forests.*

Linnean Society, Transactions. Vol. xx. part 1.

———, Proceedings. Nos. 25 to 29.

———, List for 1846.

Modena Society, Memoirs. Vol. 23. Part containing the Mathematical Memoirs.

Leeds Philosophical Society, Twenty-fifth Annual Report.

London Geological Journal. No. 1.

New York, Annals of the Lyceum of Natural History of.

Paris Academy of Sciences, Comptes Rendus. Vol. xxii. nos. 1 to 26.

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

Strasbourg Natural History Society, Memoirs. Vol. iii. part 3.

Yorkshire Philosophical Society, Annual Report, 1846.

Zoological Society, Proceedings. Nos. 148–160.

———, Reports of the Council and Auditors, 1846.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names in italics presented by Authors.

Austin, Thos., and *Thos. Austin, Jun.* Monograph on Recent and Fossil Crinoidea. No. 5.

Barrande, Joachim. Notice préliminaire sur le Système Silurien et les Trilobites de Bohême.

Catullo, T. A. Cenni sopra il Systema Cretaceo delle Alpi Venete e descrizione d'Alenne specie di Cefalopodi.

——— Remarques extraites de l'Ouvrage inédit sur la Geógnosie Paléozoique des Alpes Vénitiennes.

Cuvier, Baron. Recherches sur les Ossemens Fossiles. 7 vols. *From Sir R. I. Murchison, V.P.G.S.*

Darwin, Charles. Geological Observations on South America.

Daubeny, Charles, M.D. On the Site of the Ancient City of the Aurunci.

D'Aoust, Virlet. Notice Biographique sur M. Ém. Puillon de Boblaye.

———. Notes sur la Coloration de Certaines Roches en Rouge.

D'Orbigny, Alcide. Foraminifères fossiles du Bassin Tertiaire de Vienne.

Drapiez, M. Notice sur l'Établissement Géographique de Bruexlles. *From M. Ph. Vandermaelen, F.G.S.*

Jukes, J. B. Excursions in and about Newfoundland. 2 vols.

Lindley and Hutton's Fossil Flora. *From J. S. Bowerbank, Esq., F.G.S.*

M'Coy, F. A Synopsis of the Silurian Fossils of Ireland, collected by R. Griffith and described by F. M'Coy. *From R. Griffith, Esq., F.G.S.*

Meyer, Hermann von. Pterodactylus Gemmingi aus dem Kalkschiefer von Solenhofen.

Müller, J. Über den Bau und die Grenzen der Ganoiden und über das natürliche System der Fische.

Murchison, Sir R. I. Address to the British Association, Sept. 10, 1846.

Noble, Daniel. The Brain and its Physiology.

Nyst, P. H. Description des Coquilles et des Polypiers Fossiles des Terrains Tertiaires de la Belgique. Liv. iv. tome xvii.

Orlebar, A. B. Some Observations on the Geology of the Egyptian Desert.

Pictet, F. J. Traité Élémentaire de Paléontologie, ou Histoire Naturelle des Animaux Fossiles. Vol. 4 (completing the work).

Pilla, Leopold. Distinzione del Terreno Etrurio trá Piani Secondari del Mezzogiorno di Europa.

——— Descrizione dei Caratteri del Terreno Etrurio.

Sharpe, Daniel. Contributions to the Geology of North Wales.

Tchihatcheff, P. de. Voyage Scientifique dans l'Altai Oriental et les Parties Adjacentes de la Frontière de Chine. *From Sir R. I. Murchison, V.P.G.S.*

Whittlesey, Charles. A Dissertation upon the Origin of Mineral Coal.

Zejszner, Ludwik. Nowe lub Niedokladnie opisane Gatunki Skamienialosci Tatrowych odkryl i opisal.

——— Kzut oka na budowa geologiczna Tatrów, &c.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

Dec. 16, 1846.

William Twining, M.D., was elected a Fellow of the Society.

The following communication was read:—

On the Classification of the Fossiliferous Slates of North Wales, 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.

Introduction.

Before I proceed to the examination of details (and I wish to avoid details as far as possible), I may state in a few words what are the leading objects of the following paper.

1. I wish to describe some new facts (observed during the past summer) that appear to connect together, and give a consistency to, various sections through the older Palæozoic rocks, which have been exhibited and explained during the meetings of former years, and several of which have been published in the Proceedings and the Journal of the Society. Under the term *Cambrian System* I at present include (in accordance with the original use of the words)

all the rocks in the uncoloured portions of Sir R. I. Murchison's Silurian Map; indeed all the older slate rocks of North and South Wales beyond the limits of the Silurian system, as well as all the older slate groups of the Cumbrian mountains.

2. I shall endeavour to give an approximate view of the successive older groups in South Wales, so as to put these groups in approximate coordination with those of North Wales.

3. I wish to explain the evidence on which we may approximate to the thickness and natural grouping of the successive Cambrian deposits, so as to put them in their true relation to the lower groups of the Silurian system, as published by its author.

4. From a review of the leading facts, physical and zoological, and a comparison of them with the development of a contemporaneous series in the Cumbrian mountains, I shall attempt to point out the true classification and nomenclature of the whole series—from the oldest Cambrian slates to the newest Silurian groups, ending with the Old red sandstone. To discuss these several subjects fully would require a volume: what I have to offer is a bare outline. I purpose, however, to take up these questions in subsequent, and, I hope, early, communications.

For the present I must defer any discussion on the phænomena and theory of cleavage-planes. But I may remark by the way (as my published views have been misrepresented or misunderstood), that I considered cleavage-planes as the *resultants* of all the polar or crystalline forces simultaneously affecting the rocks exhibiting cleavage in any given mountain chain. Consistently with this view, I supposed that even unstratified rocks might exhibit a kind of cleavage; and from the analogy of slate rocks (where the prevailing strike of the cleavage-planes nearly coincides with the strike of the beds, as described in my published paper), as well as from theoretical views, I stated that this cleavage would probably be parallel to the axis of the chain*. Of this arrangement I gave one or two examples from the granitic chain of Cornwall. So far from overlooking the fact, that in large masses of slate the cleavage-planes strike nearly with the beds, I pushed the generalization *too far*. For during the latter years of my surveys in Cumberland (though I could not but observe that there were many exceptions to the rule in the less perfect, and more disturbed, slate rocks of Westmoreland), I *assumed*, during all my traverses among the higher mountains, that the *strike* of the cleavage-planes was *identical* with that of the true beds. To affirm that cleavage-planes are nearly parallel to the axis of a chain—that they run nearly with the beds—or that they are parallel nearly to the principal anticlinal or synclinal lines—are three identical propositions expressed in different words. But what may be the primary forces of aggregation producing this arrangement, is an entirely distinct question which I am not permitted now to discuss.

Neither shall I now discuss the nature of the contemporaneous trappean masses which enter so largely into the composition of the

* Geol. Trans., Second Series, vol. iii. pp. 473, 483.

rocks under notice. At the very least, ninety nine hundredths of the trappean rocks associated with the system of Cambria are contemporaneous; consisting of tabular masses of erupted porphyry (of which the actual centres of eruption are seldom exposed to view), of brecciated masses, of plutonic fragments, of trappean shales (*schaalstein*), of recomposed porphyries, &c. &c., alternating with, and passing into, the regular slate rocks, and sometimes containing organic remains. But in all this complicated series I know not a single instance (either in North or South Wales) of any unequivocal volcanic or subaërial product *. The series is essentially subaqueous or plutonic.

These singular masses form an integral part of almost every section. They often mark the great Cambrian epoch as perfectly as the subordinate fossils (a remark which applies both to Cumberland and Wales), and they belong so essentially to almost every important section, that they may be regarded as a part of the very alphabet in which nature has, at least in our island, written her older records. Without comprehending the part they have played, it is impossible to understand the thickness of the whole series, the nature of its development, or the relative position of the several physical groups. In addition, I may remark (what I have often stated before), that the contemporaneous plutonic rocks partake of common movements, and have the same anticlinal and synclinal lines, with the older slates of Cambria; a fact in itself almost decisive on the question of the general contemporaneity of the aqueous and igneous rocks here noticed.

Sections through the older rocks of North Wales.

From the Menai Straits to the Berwyn chain the older rocks are thrown (as I have often before described them) into a series of great undulations, of which the anticlinal and synclinal lines nearly, though not exactly, coincide with the strike of the principal mineral masses, whether slates or any of the contemporaneous igneous rocks above-mentioned. Thus, for example, the great porphyritic masses which range southwards from Arrenig—the range of Arran Mowddwy and Cader Idris—the enormous masses of porphyry east of the crest of Snowdon, and extending thence down to Pont Aberglaslyn, &c. &c., are all contained within the anticlinal and synclinal lines of a series of nearly symmetrical undulations. To suppose that any one of these ridges (*e. g.* the great ridge of Cader Idris) is an erupted mass of a date posterior to the epoch of the slates, is so untrue to nature as to destroy the value of any section involving such an error. On this point, I need not inform my hearers, Mr. Sharpe and I are at issue. I have not the shadow of a doubt about the general truth of my views; and a little army of good observers is now marching over the country, who will settle points of difference, and give a finish to details, utterly beyond the physical powers of one who

* Some of the igneous products of Devonshire (*e. g.* Brent Tor) appear to have been subaërial. In such cases the earthy beds made out of the igneous products may very conveniently be designated by the term *ash*, so commonly used by Sir H. De la Beche; but I should reserve this term to cases like that just quoted, and not apply it to any plutonic products.

entered the country single-handed, and while it was unknown in all its peculiarities of physical structure.

If, in the papers recently published in our Journal, there is a difference between Mr. Sharpe and myself as to the interpretation of certain phænomena connected with igneous products (a subject undoubtedly obscure and difficult), there is also a difference as to facts, about the interpretation of which there can, I think, be no final ambiguity. Thus, for example, Mr. Sharpe has placed an anticlinal line in the Berwyn chain where I believe no such line exists, and has thereby thrown into some confusion the relations of the neighbouring country. This, however, involves an error of small amount in comparison with one introduced by an hypothetical fault which he places along the strike of the great slate quarries of Penrhyn and Llanberis. By the interpolation of this fault, he has been enabled to refer the whole of the series, west of the Penrhyn and Llanberis slates, partly to the upper division of the Lower Silurian rocks, and partly also to the Upper Silurian rocks: I was staggered at a statement so directly contrary to everything I seemed to know of the structure of North Wales. But I resolved to give this new hypothesis a fair examination; and I commenced my task by revisiting the great quarries of Penrhyn, Llanberis, &c. The result I may state in a few words. My former views and sections were correct. The Penrhyn slates underlie the system of Snowdonia: they are among the older portions of the rocks of North Wales. Of the truth of this there is not, I think, the shadow of a doubt. The fact is proved by one of the plainest sections in North Wales. Certain rocks on the shores of the Menai (called Upper Silurian in the paper to which I am referring) are, I believe, older still. But this is a point of indirect interpretation rather than direct proof, and is made out by analogies which I must discuss in the course of this paper. In short, the slates near Bangor and Carnarvon are among the very oldest rocks of North Wales; of course excepting the crystalline and hypozoic groups of Anglesea and of the south-western shore of Carnarvonshire, which I do not at present wish to notice.

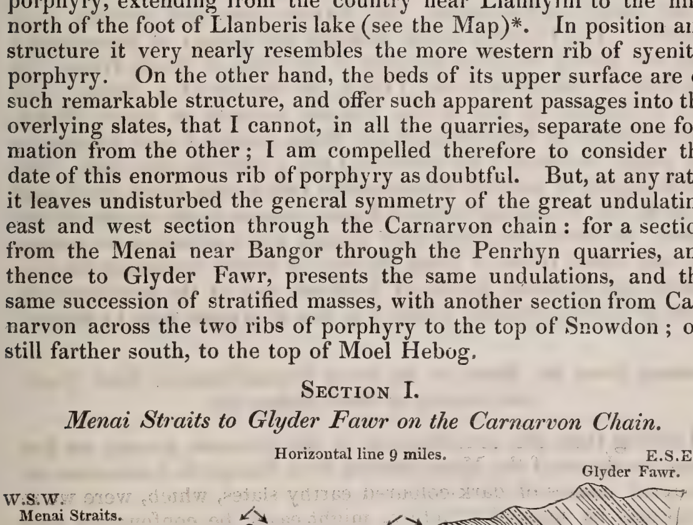
Sections from the Menai to the great Carnarvonshire Slate Quarries, the top of Moel Hebog, &c.

Leaving then the consideration of the hypozoic groups, we find along the shores of the Menai Straits, from Bangor to Carnarvon, interrupted masses of dark-coloured earthy slates, which, were we to judge only by mineral structure, might easily be confounded with Upper Silurian rocks. On the shore near Bangor they alternate with trappean conglomerates and trappean shales (*schaalstein*), and in that respect cannot be distinguished from the old Cambrian slates. The same alternations are seen on the road between Bangor and Carnarvon. They are cut through by a great intrusive rib of syenitic porphyry of a different epoch, which ranges very nearly with the beds, and does not appear to disturb their general relations. These rocks are now traversed by a tunnel connected with the new railroad, and among the materials brought out I was not able to discover a single fossil, not even so much as a fucoid; though I believe the rocks belong to a fossiliferous group. A similar group of dark slates breaks out farther south, and is at length interrupted, and broken up, by the great erupted porphyries of the Rivals. Associated with these rocks we find some irregular beds or masses of iron ore, sometimes highly magnetic, and with a remarkable pisolitic structure. They are probably contemporaneous; and the beds along which they run sometimes pass into the condition of a loadstone, exhibiting a true polarity. I should not have noticed these phænomena had they not been exhibited in several other places among beds which are, I believe, exactly on the same parallel. On the east side of the great intrusive rib of porphyry, above mentioned, and towards the base of the higher mountains of the Carnarvon chain, are several other alternations of slates and contemporaneous trappean rocks. They are, I believe, in symmetrical undulations, which strike nearly with the beds; but the country is low, and much covered with the drift of the higher monntains, as well as with great masses of a northern drift, which (as is well known) contains marine shells to the height of more than 1200 feet.

Again, to the east of this low country is another and larger rib of porphyry, extending from the country near Llanllyfni to the hills north of the foot of Llanberis lake (see the Map)*. In position and structure it very nearly resembles the more western rib of syenitic porphyry. On the other hand, the beds of its upper surface are of such remarkable structure, and offer such apparent passages into the overlying slates, that I cannot, in all the quarries, separate one formation from the other; I am compelled therefore to consider the date of this enormous rib of porphyry as doubtful. But, at any rate, it leaves undisturbed the general symmetry of the great undulating east and west section through the Carnarvon chain: for a section from the Menai near Bangor through the Penrhyn quarries, and thence to Glyder Fawr, presents the same undulations, and the same succession of stratified masses, with another section from Carnarvon across the two ribs of porphyry to the top of Snowdon; or, still farther south, to the top of Moel Hebog.

Section I.

Menai Straits to Glyder Fawr on the Carnarvon Chain.



a. Black slates.
b. Porphyry with traces of bedding.
c. Porphyry and undulating slates.
d. Penrhyn slates.
e. Coarse greywacke.
f. Slate and porphyry.

To the east of the second great rib of porphyry commences the great zone of the Carnarvon slates, ending with the quarries of Penrhyn, Llanberis, Llanllyfni, &c. They alternate with many bands

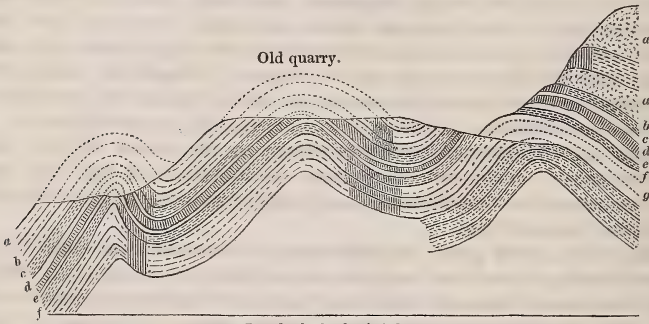
* The Map referred to is that which accompanies Professor Sedgwick's former paper, and will be found in vol. i. p. 5 of the Journal.

of contemporaneous porphyry and recomposed trappean shales; and, without noticing minute puckerings and undulations, they exhibit a

Section II.

Llanberis.

Stratification of Mr. Assheton Smith's Quarries.



Level of Llanberis lake.

a. Sandstone.
a'. Coarse slate.
b. Upper blue slate.
c. Hard ferruginous bed.
d. Red slate.
e. White bands.
f. Lower blue slates.
g. New quarry.

great synclinal, and afterwards an anticlinal line (which cuts through the Penrhyn and Llanberis quarries), and afterwards, at their eastern and upper surface, plunge unequivocally under a vast thickness of beds, composed of coarse greywacke, slate, felspar rock, trappean shales, talc slate with asbestus, greenstone, &c. &c.; the whole mass being most distinctly stratified, and inclined to E.S.E. at a great angle, on the average not less than 50°. I hope in a future communication to describe this great ascending section in more detail, as affording a striking instance of the alternation of aqueous and igneous deposits, and of deposits having a character intermediate between the two.

Counting from the zone of the Penrhyn slates, we have a regular ascending section for more than two miles measured on a horizontal line transverse to the strike of very highly inclined beds. We then meet with a great synclinal trough, which I have traced from Carnedd Llewelyn, Glyder Fawr, Snowdon, and Moel Hebog, a distance along the crest of the chain of about fifteen miles. Bands of fossils*

* Fossils from Llyn Ogwen—
Orthis like calligramma.
—— vespertilio.
—— cambriensis.
Murchisonia scalaris (angulata, former lists).
Favosites fibrosa. Encrinite stems.

Snowdon:
Orthis flabellulum.
— Actoniæ.
— expansa.
— elegantula.
Encrinites.
Turbinolopsis bina.

Moel Hebog:
Orthis expansa.
— Actoniæ.
— flabellulum.
— elegantula.

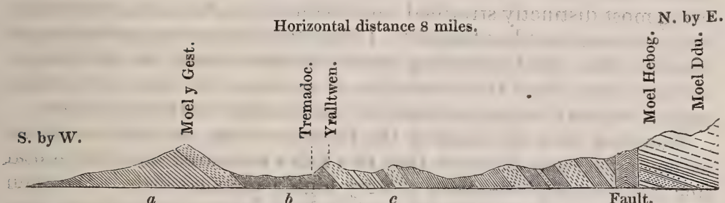
appear here and there in the beds of this trough, first breaking out on the higher part of the brow ascending from the Penrhyn quarries to Llyn Ogwen. Along this line we have a fossiliferous zone about half a mile wide, and it ranges through the higher crests of Snowdon to Moel Hebog, as stated in former papers*. In many extensive tracts it is true that fossils disappear, especially where contemporaneous porphyries and trappean shales are most abundant; but the whole series of undulations, continued from the high crests here noticed, over the Berwyns, and to the edge of Shropshire, belong to one great physical group, the whole of which (where the conditions are favourable to the development of animal life) is fossiliferous.

Such are the sections from the Menai to the crests of the Carnarvon chain; and I cannot estimate the thickness of the beds, before we reach the fossiliferous trough above noticed, at less than six or eight thousand feet.

But there is one great imperfection in these sections—they have no well-defined base; and we have no evidence on which to estimate the thickness of deposits which may have been interpolated between the hypozoic group and the dark, earthy slates of Carnarvon and Bangor. Moreover, it is almost impossible to form any correct estimate of the thickness of the masses occupying the low country between the Menai and the western flank of the Carnarvon chain; we must therefore seek for better evidence in other sections

Section III.

Near Tremadoc.



a. Lingula beds.
b. Black slates with Fucoids and Trilobites.
c. Trilobites, &c.

I have stated in my former papers that a great dislocated group of slates and porphyries (not to be mineralogically distinguished from the general mass of the Carnarvon chain) occupied the promontory south of Tremadoc, and was continued northward till it abutted against the south flanks of Moel Hebog and Moel Ddu, a few miles south of Beddgelert; but I had not seen this group since 1831. Its beds first dip nearly north, and then bending round toward the western side of the great estuary, called Traeth Mawr, the beds dip about N.N.E. Before rising to the flanks of Moel Hebog and Moel Ddu, they reach a great elevation, and become in some places almost

* See Proceedings of the Geological Society, vol. iii. p. 548.

horizontal. At their northern limit we find traces of considerable dislocation, and we then cross a line of fault, and pass to the flank of Moel Ddu, where the beds have the true N.N.E. strike of the Carnarvon chain. The section I am about to notice commences at the south end of the promontory called Gest, and ranging nearly north and south passes through Tremadoc, and is prolonged to the flank of Moel Hebog and Moel Ddu. It is along the south part of this line that Mr. Davis* found certain fossils which had escaped my notice in 1831. I had the advantage of his assistance, during the past summer, in examining the northern end of the section across the line of fault above noticed. The entire section is as follows, and is in an ascending order:—

1. Commencing at the south end of the promontory, we first meet with alternations of highly quartzose slates and gritty bands, in repeated alternations, and intersected by great veins of quartz, some of which are metalliferous. Over these comes a great group of slates with imperfect cleavage, and flags of a singular flaky structure, resembling the well-known pyritous flags of Festiniog. The series is of great thickness, and is surmounted conformably by the greenstone ridge of Moel y Gest. This series contains beds with innumerable fucoids and many specimens of a large Lingula (first described by Mr. Davis)†. There are many interesting mineral phænomena I am compelled to pass over, especially near the junction of the slates with the overlying greenstone.

2. The great tabular mass I have called greenstone has many modifications of structure I cannot notice. It appears to have been erupted in a state of fusion, but no point of eruption is (so far as I know) exposed to view. It is almost exactly parallel to the beds above it and below it; and having the same dip with the beds on which it rests, it hangs at a considerable angle towards the north, and so passes under the next group.

3. Next follows a great group of dark earthy slates, occupying the marshes above Tremadoc. Many parts of this group are without fossils; but in the upper portion of it we found Fucoids, Graptolites, and a few Trilobites‡. It is mineralogically like the dark earthy slates on the shores of the Menai Straits; and, like these slates, it contains large masses of pisolitic iron ore (now extensively worked), and beds of loadstone. Some of these masses are injured by much-disseminated iron pyrites; and such is the case with a similar iron ore on the Carnarvon coast, north of the Rivals. In the upper part of this group are trappean slates (*Schaalstein*) and other contemporaneous igneous products; and the mineral phænomena well deserve a more detailed description.

4. Next follows a second great terrace of igneous rock, almost identical with that of Moel y Gest (No. 2).

5. Then follows a series of slates, flags, and trappean shales.

6. Then a third great band of greenstone, &c.

* Journal of the Geological Society, vol. ii. p. 73.

† Among the specimens are Fucoids, Serpulites, *Lingula*, all in great abundance.

‡ Fucoids, *Graptolites foliaceus*, *G. Murchisonæ*, *Asaphus Powisii*.

7. Again, in ascending order, a series like No. 5, in which fossils are rare. In it we found a Trilobite (*Homalonotus bisulcatus*, also found at Wittingslaw).

8. Then succeeds a fourth great terrace of greenstone; and here we *do meet with* a great vertical mass of greenstone (apparently representing the focus of eruption), above which the greenstone spreads out into a tabular mass that is parallel to the beds above it and below it.

9. Higher still we have alternations almost innumerable, of flags, slates, trappean shales, and igneous products—some of which may have been recomposed; and some truly erupted, and unchanged by any subsequent aqueous action.

10. At length we reach the steep brows ascending towards the summits of Moel Ddu and Moel Hebog*. Slaty cleavage becomes better defined; fossils are more numerous†. The beds are now nearly horizontal, and almost identical in structure with the slates of the neighbouring chain. Large irregular quartz veins mark the passage of a break in the continuity of the strata, beyond which the beds immediately recover the usual strike and dip of the neighbouring ridges of the Carnarvon chain‡.

In conclusion I have to remark, that the base of this section (if I have interpreted it correctly) is not only lower than the base of the sections from the Menai above noticed, but has the great advantage of exhibiting organic remains. I identify (at least provisionally) the dark slates containing the pisolitic iron ore with the dark slates on the shores of the Menai. The higher parts of the Tremadoc section present details very analogous to those of the ascending sections from the Menai to the Snowdonian crest; and all the sections indicate a very great thickness before we reach the limit of the fossiliferous slates which undulate through the higher crests of the Carnarvon chain§.

The beds I have called greenstone are contemporaneous, because they are associated with trappean shales, and other recomposed igneous rocks, which alternate with and pass into the slates. Moreover they cannot have produced the anomalous position of the Tremadoc groups, because they also themselves partake of that anomalous position. Lastly, though this section throws light on the structure of Carnarvonshire, yet, as it ends among contorted and faulted beds, there is some doubt as to its exact upper limit. On this point I have only to remark, that I know not how to separate its upper beds, either by mineral structure or by fossils, from the slates which

* The section might be carried to the top of Moel Hebog, but it is here drawn, a little farther east, towards the top of Moel Ddu.

† Among the fossils are *Trinucleus Caractaci*, *Murchisonia scalaris*, *Leptæna sericea*, *Orthis opercularis*, &c.

‡ It deserves remark, that the *strike of the cleavage-planes* is nearly the same on both sides of the fault here noticed, and that this strike nearly coincides with the mean strike of the Carnarvon chain, of which Moel Hebog and Moel Ddu form a portion.

§ The fossiliferous slates here alluded to are those, above noticed, which range through the top of the Llyn Ogwen pass, by Cwm Idwal, the top of Snowdon, and Moel Hebog, &c.

enter among the undulations of Moel Hebog and Moel Ddu, and hence I believe them nearly of the same age.

I have not gone round the promontory of St. Tudwal's Head since 1831, when I knew little of the structure of North Wales. From what I remember of the structure of this promontory, and from the fact that dark earthy slates occur to the north of it, with pisolitic iron ore like that of Tremadoc, I should place it provisionally on the same geological parallel with the slates and quartzose flags of the promontory south of Tremadoc.

In my former papers I have described the rocks of Carnarvonshire and Merionethshire as one connected system, repeated in a succession of great and nearly parallel undulations. In making a section from the Menai to the chain of the Berwyns, we meet, however, with considerable difficulties, especially from three causes: 1st, from the enormous masses of igneous rocks, which may not always be of one epoch, though the greater part of them alternate with, and pass into, the associated roofing slates; 2ndly, from the manner in which the great Merioneth anticlinal dies away towards the north, so that the beds which cross its extreme northern limit are thrown into a kind of arch, and dip, *at a very low angle*, towards the north-west, the north, and the north-east; 3rdly, from the confusion introduced by great disturbing forces (marked by the two great estuaries Traeth Mawr and Traeth Bach) which have thrown the beds above noticed near Tremadoc, and the beds of the Harlech coast, into positions which are altogether anomalous. Judging however from the best comparisons I could make of the several sections, I concluded that the rocks along the Menai were among the oldest portions of the Cambrian slates; and that the beds along the Merioneth anticlinal were perhaps the very oldest visible beds of the whole series I am describing. The conclusion was chiefly based on this fact,—that we have a regular ascending section from the Merioneth anticlinal through Great Arrenig to the top of the Berwyn chain (a distance of about twelve miles on a straight line) without any material change of dip*. I can now fortify this conclusion by better evidence than I offered before, by help of sections drawn from this anticlinal line through the hills of Festiniog on its north-west side, and through the chain of Cader Idris and other hills on its south-east side.

Passing by the line of the road from Beddgelert to Maentwrog we soon get beyond the disturbed beds connected with Traeth Mawr, and cross a long succession of slates and contemporaneous beds of porphyry, trappean shales, &c. &c., which enter into the structure of the high mountains north-west of Festiniog. For several miles there is a steady dip, and at a considerable angle, about north-west by north; and the same dip is continued on the south side of the Festiniog valley, where a well-known flaky pyritous flagstone rises in very large and well-defined beds, and alternates with a few bands of contemporaneous porphyry. From their mineral character, I concluded them to be of the same age with the flags and

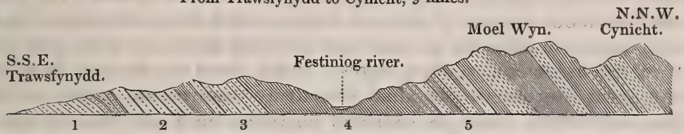
* The same conclusion is indicated by Section 5. See also Journal, vol. i. p. 10, Section 2.

slates south of Tremadoc; and after a careful search among these beds south of Festiniog, I found the *Tremadoc Lingulæ and Fucoids in great abundance.* By help of these beds we have therefore a base-line common to the systems of Carnarvonshire and Merionethshire. The preceding remarks will enable my hearers to comprehend the meaning of two sections which I proceed shortly to notice—one drawn from the Merioneth anticlinal near Trawsfynydd to the hills north-west of Festiniog—the other from the same point, but in an opposite direction, to the hills near Dinas Mowddwy.

Section IV.

From the great Anticlinal of Merionethshire to the Mountains N.W. of Festiniog.

From Trawsfynydd to Cynicht, 9 miles.



The numbers refer to the description below.

If we follow this anticlinal line to the north side of the great Barmouth estuary, we there find the beds on the opposite sides of it dipping at a great angle; but near Trawsfynydd the anticlinal arch becomes much flattened, so that the beds on the opposite sides of its vertex dip only at 10° or 12°. Following the line still farther north, to the latitude of Festiniog, we lose all distinct traces of an anticlinal; but the beds in the neighbourhood (still dipping at a low angle) may be traced on the map round the prolongation of the anticlinal line in the form of an arch, dipping N.W., N. and N.E., as before stated. The section about to be described passes, however, considerably to the N.W. of these flexures, and does not appear to be affected by them. Commencing then a little to the S.E. of Trawsfynydd, we have the following ascending series:—

1. A series of earthy pyritous slates. The structure is extremely varied, and some quarries are partially worked for economical use. A little south of Trawsfynydd these slates have a red colour and alternate with bands of contemporaneous porphyry. A still lower part of this series is exposed on the north shore of the Barmouth estuary. Thickness unknown.

2. Very coarse grits, marked by bands of small quartz pebbles, alternating with finer bands of grit, and thin bands of slate resembling the Festiniog flagstone. They are divided into rhombohedral masses by good perpendicular dip and strike joints. They also alternate (especially in their upper portion) with bands of contemporaneous porphyry. This group is of considerable thickness, and forms great precipices on the flanks, and among the gorges, of the chain which runs from Barmouth towards Maentwrog. Average dip about 12° or 14°.

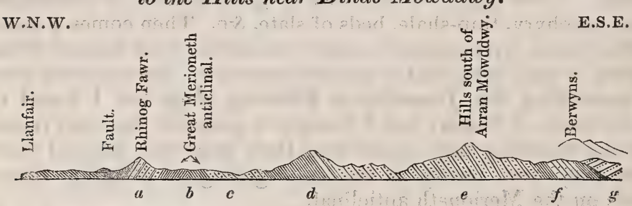
3. Numerous alternations of slate, trappean shales, porphyry, &c. This group is also of considerable thickness, and runs into the crests and eastern flanks of a portion of the chain above mentioned.

4. A great series of beds of flagstone, occupying all the country near Festiniog and Maentwrog, alternating with bands of contemporaneous porphyry, and intersected in several places by dykes of felstone; but *never*, so far as I have observed, by any dykes of augitic trap like those of Anglesea and the Menai Straits. The average dip along this part of the line of section is from 20° to 25°; but towards Festiniog these beds are affected by the flexures at the northern end of the great Merioneth anticlinal, so that the average dips are considerably less. The whole thickness of this group must be very great, and in portions of it are innumerable impressions of *Fucoids* and *Lingulæ*.

5. Over the preceding group are the great slate bands of the Festiniog mountains, alternating with trappean shales and great ribs and contemporaneous beds of porphyry; in structure perfectly identical with the rugged porphyritic crests of the Snowdonian chain, and partaking of a common system of undulations, a common strike, and conditions which (independently of fossil evidence) seem to offer sufficient proof that the Carnarvon mountains and the Festiniog mountains belong to one great physical and inseparable group. This conclusion is, however, now also supported by fossil evidence; for the slates and porphyries of the crests of Snowdon and Moel Hebog are about the same geological elevation above the *Lingula* and iron ore beds of Tremadoc, that the beds of Moel Wyn and Cynicht (at the extremity of this section) are above the *Lingula* beds of Festiniog.

Section V

From the coast south of Harlech, across the Merioneth Anticlinal, to the Hills near Dinas Mowddwy.



a. Very coarse greywacke.
b. Slate and porphyry.
c. Hard grits and porphyry.
d. Supposed Lingula beds.
e. Slate and porphyry.
f. Bala series.
g. Upper Silurian.

If we examine the Merioneth coast between Maentwrog and Barmouth, we first meet with the *Lingula* flags and afterwards a series of superior beds, which come down, with a regular strike and a north-western dip, from the high Festiniog hills. Near the mouth of the estuary (Traeth Bach) the beds above-mentioned are met, on a line of fault, by a great system of disturbed strata, which strike about N.N.W. and dip E.N.E. These disturbed strata may be followed several miles towards the south. They appear to be intersected by a second great fault, ranging about N.E., and entering the sea near the Llandanwg estuary. The north-western strike and north-eastern dip are however continued considerably to the south of that estuary, and also extend into the interior as far as the western skirts of the higher mountains of the Rhinog Fawr chain. The same beds afterwards turn round (whether gradually or by a succession of faults I have not determined) and acquire the ordinary strike of the Merioneth chain, at the same time dipping to a point considerably south of east: and the junction of these beds with those of the neighbouring mountains no longer has the character of a fault, but becomes a true synclinal line, which may be traced into the Barmouth estuary.

The anomalous position of the Tremadoc rocks, the great interruptions to the continuity of the strata manifested by Traeth Mawr and Traeth Bach, and the dislocation of the beds above noticed along the Merioneth coast, were probably all produced by the same set of disturbing forces.

The section I am about to notice commences among these troubled beds of the coast*. Near Harlech they are composed of very coarse grits, which may be compared with the coarse grits (No. 2) of the preceding (Festiniog) section. These coarse grits are overlaid by bedded masses of roofing-slate and some contemporaneous bands of porphyry. The line of section then crosses the chain of Rhinog Fawr, and descends to the Merioneth anticlinal, a few miles south of the point where the former (Festiniog) section commenced, and the details of the two sections (after we cross the above-mentioned line of fault) are in perfect general accordance. Following this line of section beyond the Merioneth anticlinal to the south-east, we first meet with bands of roofing-slate and porphyry, and then pass over a ridge of mountains in which we trace the coarse grits (No. 2 of the previous section), in a somewhat degenerate form, alternating with masses of contemporaneous igneous rock. These again are followed by great masses of contemporaneous porphyry, trap-shale, beds of slate, &c. Then comes a series of rather brown pyritous slates, much intersected with mineral veins, and often of very complicated mineral structure. Among them were beds resembling the *Tremadoc* or ***Festiniog flags***, but I found in them no traces of fossils; but I thought it probable that they represented the Festiniog flags, partly from their structure, and still more because they were nearly at the same geological elevation above the beds on the Merioneth anticlinal.

For the present, leaving the discussion of this point, we may follow the section over some ridges of gnarled hills in which the porphyries and associated trappean breccias and shales almost exclude the appearance of slates. Among these masses are, however, some bands of slate and a few irregular and highly-mineralized masses of limestone. I believe these great mineral masses, considered as a whole, represent the groups S.W. of Great Arrenig, among which we also find bands of a mineralized limestone. The enormous excess of igneous rocks (most of which are unequivocally contemporaneous) easily accounts for the absence of fossils; but I have little doubt that the calcareous bands in this part of the section (as well as those near Great Arrenig, and I may add also some similar bands at the east end of Cader Idris) are about the age of the fossil

* See the western end of the Section No. 5.

bands above noticed, which run along the Carnarvon chain, from Carnedd Llewelyn through Cwm Idwal, and thence by the top of Snowdon and the top of Moel Hebog.

There are probably great dislocations along the valley extending from Dolgelly to Bala, especially as, near the line of section, there is a considerable change of strike; for the masses ranging up to Arrenig, Arran Mowddwy, &c. strike nearly N.N.E., while those to the south of the sectional line strike through the chain of Cader Idris, about N.W. and S.E. Be this as it may, all the bedded masses (with the exception of certain disturbed beds near the valleys) dip in succession towards the S.E.

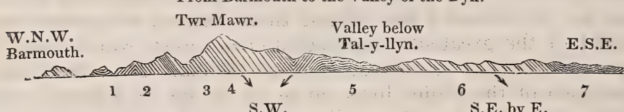
Continuing the section to the south-east side of the valley, we again cross a mountain ridge (connected with Arran Mowddwy), in which we have regular beds of slate with two or three enormous ribs of igneous and other associated rocks. These are followed in the same ascending order by a great series of rocks, through which passes the Bala limestone; and the whole is overlaid (agreeably to the statements of my former papers*) by great disturbed beds of unconformable Upper Silurian rocks.

I do not profess to describe the upper beds of the preceding section. They terminate in a series of rocks nearly on the same parallel with those exhibited in a section drawn from the great Merioneth anticlinal over the top of Great Arrenig, and thence to the top of the Berwyn chain. Indeed these two sections are through the same part of the great Cambrian series. The Arrenig section is however more instructive in some of its details, and contains (at the least) three bands of limestone with numerous fossils, as has been shown in former papers; but it terminates abruptly, and is not overlaid by any Upper Silurian groups.

Section VI.

From the great Merioneth Anticlinal through the Chain of Cader Idris.

From Barmouth to the Valley of the Dyfi.



I suppress, as far as possible, all unnecessary details. All I attempt is, to put the chain of Cader Idris in coordination with the other older deposits of North Wales, and to show that it is included in the same general system of undulations. The group of mineralized slates which (in describing the preceding section) I provisionally identified with the Festiniog flags (*Lingula beds*), passes along the course of the Maw to the point where it enters the plain below Dolgelly. Taking the strike of these beds, from a point near Llanelltyd, as guide for a compass-bearing, I found that the same beds might be looked for on the south side of the Barmouth estuary near Ty Gwyn.

* See Journal, vol. i. p. 10.

I indicated the promontory to my companion John Ruthven; and directing him the day following to certain quarries near Ty Gwyn, he found the same *Fucoids* and *Lingulæ* which characterize the Festiniog and Tremadoc flags. There is indeed no difficulty in finding these fossils, as the neighbouring slate rocks abound with them. Some one had before informed me that fossils were found in the chain of Cader Idris, but I neither knew the species nor the locality. The facts above stated are decisive as to the true geological age of the range of Cader Idris. It is exactly where I had placed it before, on mere physical evidence; and to this we may now add very satisfactory zoological evidence, and a connected series of sections referable to one common base-line. A line drawn from a point on the south side of the Barmouth estuary over the top of Cader Idris, and thence over the ridges of Arran y Gesail to the valley above Machynlledd, will be nearly transverse to the general strike of the country, and will give the following sequence:—

(1.) A series of slates and contemporaneous porphyries, &c. descending towards the parallel of the Merioneth anticlinal. These beds are far better exposed on the north side of the estuary, between the anticlinal (which is there well-defined) and Llanelltyd; and they form a very thick group*.

(2.) The *Lingula beds,* alternating with enormous ribs of porphyry, trap, shale, &c. &c. I have not traced these *Lingula beds* on the exact line of section; but, from the strike of the Ty Gwyn beds, they must pass through the brows above Capel Arthog, near which the line of section passes.

(3.) Higher up the hills are more earthy slates (still alternating with numerous beds of porphyry, &c.) containing the *pisolitic iron ore*, exactly like that of Tremadoc.

(4.) Higher up still is an enormous mass of contemporaneous porphyry, which forms a great feature on the north flank of Cader Idris; and higher still are numerous alternations of slate and porphyry to the very top of the chain. Any section I can draw must fail to convey a true and adequate notion of the magnificence of this sequence. It is now clear that the rocks composing this series must be (as indeed I had placed them before) very nearly on the parallel of the great slaty and porphyritic crests which range from Carnedd Llewelyn to the top of Moel Hebog. It is true that the upper part of the Cader Idris range is, so far as I know, without fossils. But this may be easily accounted for by considering the local conditions which may have been unfavourable to animal life during the period of deposit. And nowhere in these groups are the fossil bands strictly continuous; but only found here and there along given lines of the several sections.

(5.) On the south-east flank of Cader Idris the contemporaneous porphyries begin to disappear; and some soft and rather earthy dark slates descend towards Tal-y-llyn. There is a partial contortion which I have attempted to represent; but a prevailing south-east dip is constant.

* The lowest beds here alluded to do not appear in the accompanying section No. 6, as it commences on the south side of the Barmouth estuary.

(6.) The section next cuts across the ridges which range on the south-east side of Tal-y-llyn nearly parallel to the strike of Cader Idris. Dark soft slate prevails, containing however some harder quartzose bands, and (on the line of strike towards the south-west) some masses of coarse greywacke, also containing beds in which roofing-slate has been extensively worked. Farther to the south-west, on the strike of the beds, are some bands of contemporaneous porphyry. The beds in this division of the section have not a great inclination; still their aggregate thickness must be very considerable. I would include in this great group the slate-quarries of Aberllefeni, and the great quarries opened on the side of the road from Tal-y-llyn to Machynlledd.

(7.) Farther still on this ascending section the rocks gradually change their structure. They become more mechanical,—more regularly thin-bedded,—alternate with gritty bands,—contain few large thick beds of slate fit for economical use, and are violently contorted. The *dips and strikes* continually change, but the *cleavage-planes* remain nearly *constant.* Shells do not (so far as I know) appear among these rocks; but in a few places where the cleavage-planes for a short space become tangents to the curved beds, fucoids are very abundant. This series exhibits a mineral structure of no common interest,—rolls in countless undulations from Machynlledd to Aber Dyfi, and in like manner (with the same undulations and the same structure) is carried to the south side of the Dyfi, and so mingles itself with the great physical system of South Wales.

When I found, during the summer of 1843, that some of the high ridges, extending from the neighbourhood of Mallwyd towards Plynlimmon, were *Upper Silurian,* I supposed it possible that the *whole* of them might be *Upper Silurian*; and by a geographical error, I called them the higher mountains of South Wales; whereas the greater number of them are within the limits of Montgomeryshire, and therefore in North Wales. I thought it probable also (before I began the labours of the last summer), that some of the beds on the line of the Dyfi might prove to be Llandeilo flag. These notions were purely hypothetical, and I now abandon them for reasons to be given in the sequel.

By way of general conclusion to all the previous details, I may now state, that all the higher mountains of Carnarvonshire and Merionethshire, &c. form one vast but connected physical system, which is fossiliferous almost to its base; though many parts of it (which admit of no physical separation from the remaining portions) are, apparently from the effect of local conditions, entirely without fossils.

Sections in the great South-western Promontory of Carnarvonshire.

The rocks of this region are very important in the physical history of North Wales, but my limits permit me to add only a few sentences respecting them. They form the following groups:—

(1.) The zone of crystalline hypozoic slates (above mentioned).

(2.) Great bosses of syenitic rock, which have risen in numerous mountain masses, more or less pyramidal in outline, and are of a date posterior to that of the beds they are associated with—such are the crests of Carn Goch, the Rivals, Carn Boduan, &c. &c.

(3.) Great beds of contemporaneous trappean rocks (greenstones, felstones, trap shales and trap breccias, &c.), striking and alternating with, and passing into, slate rocks with organic remains, and occasionally containing, among their own members, perfect traces of organic remains. These rocks are best developed between Pwllheli and Boduan, near both which places organic remains are numerous.

The oldest stratified rocks of the fossiliferous series are (I think) in the promontory between Hell's Mouth and St. Tudwal's road. These I would compare (provisionally) with the rocks south of Tremadoc. Above them I would place (provisionally, for I have not seen the sections since 1831) some slaty beds, west of Abererch, which contain the pisolitic iron ore. The fossil-bearing rocks near Boduan may, I think, be safely identified with the principal fossil bands of the Snowdonian crest, viz. the bands where the genus *Orthis* first appears in force.

Lastly, the fossil bands alternating with contemporaneous porphyry and trappean shale, &c., W. and S.W. of Pwllheli—similar bands half a mile west of Llanbedrog—and the slate rocks three or four miles north of Pwllheli (on the Clynnog road, near Castell Grogan)—appear to belong to a higher fossil group, and may perhaps represent one of the lower fossil bands east of Great Arrenig.

The following is a list of some of the fossils from the places above named:—

(*a.*) *Boduan Fossils.*—Orthis flabellulum + +.
—— grandis (?) }
—— elegantula } + &c. of a former list.
Leptæna sericea }

(*b.*) *Castell Grogan.*—Homalonotus bisulcatus, MSS.
Encrinite stems.
Fucoids.

(*c.*) *Llanbedrog and Pwllheli* in one table, as follows:—

	Llanbedrog.	Pwllheli.
Homalonotus bisulcatus, MS.	+ +	+
Phacops apiculatus, MS. ...	+	+
Calymene Blumenbachii ...	+	+
Trinucleus Caractaci	+	+
Euomphalus (imperfect) ...	0	+
Pterocardia* (Bala sp.) ...	+	0
Leptæna tenuistriata	+	0
—— sericea	+	+
Orthis calligramma	+	0
—— expansa	0	+
—— elegantula	+ +	+ +
Spirifer radiatus	+ + +	+ +
—— Lynx	0	+ (in π)
Tentaculites annulatus	0	+

To these add for Llanbedrog only, *Favosites fibrosa*; *F.* (*narrow branches*); *F. Petropolitana* (?); *Ptilodictya dichotoma*; and *Stromatopora concentrica.*

* A genus proposed in MSS. for species of Cypricardia, &c. of the Sil. Syst. with elongate hinge teeth.

On this view, the rocks of the Carnarvon promontory are the prolongation of the rocks of the great Carnarvon chain; in confirmation of which I may state that (with some local exceptions) they have a prevailing strike nearly parallel to the direction of the promontory, and therefore not far from the mean strike of the Carnarvon chain. I must here terminate (for the present) my notice of the sections of North Wales, and of their mutual relations, considered as parts of one great system.

System of South Wales.

For the present I use these words in a mere geographical sense, including under them all the slate groups of South Wales (and of a part also of Montgomeryshire) which are expanded through the Principality between the Silurian rocks of Sir R. I. Murchison's map and the sea-coast. That rocks of an enormous thickness, associated with the chain of Cader Idris, plunge under these groups at their northern limit, cannot admit of doubt. Again, at their south-western limit, they are bounded by the slates and porphyries of Pembrokeshire, which are so nearly identical in structure with the older slates and porphyries of North Wales, that I concluded them in 1836, the only time I ever touched on the county of Pembroke, to be of one epoch. This also was the conclusion Mr. Greenough had arrived at when he published the first edition of his Geological Map.

This conclusion is now put out of all doubt by the admirable details of the Ordnance Geological Survey; and it may be at once assumed as a fact, that the principal South Welsh slate groups I am here noticing, occupy a great irregular trough—bounded to the south-west by the older Cambrian slates and porphyries of Pembrokeshire—to the north by the chain of Cader Idris—and on their other sides by the sea-coast and the rocks of the Silurian system. What then are these rocks; and where are they to be placed? To receive a full reply to this question, we must wait for the details of the Ordnance Survey. I profess not to know well this most contorted and perplexing country, for I only made two hasty traverses through it between the Upper Silurian groups and the sea—one from Aberystwyth to Builth, the other from Llandovery to Aber Aeron by Llampeter, and thence back by the road from Llampeter to Carmarthen.

I chose these lines because they were the very lines by which I made hasty traverses through this country in the year 1832, with a view to subsequent operations. My object during the past summer was, not to make out the details of this most difficult country (that would have been a vain attempt, considering the narrow limits of my time), but to form, as far as I could, a general notion of the relative position of the principal mineral groups; or at least to obtain such an insight into the structure of the country as to be enabled to comprehend the descriptions of others, and the admirable sections of the Ordnance Survey, now in progress of publication under the direction of Sir H. T. De la Beche*.

* An unpublished section by Mr. Ramsay, along a line from the Upper Silurian rocks to the sea-coast between Aberystwyth and Aber Aeron, was kindly commu-

I may first remark, that to the south of Radnor Forest (so far as I know the country from personal observation) there are no Upper Silurian groups brought in among the undulations of the South Welsh system. To the north of Radnor Forest the Upper Silurian rocks pass (in many undulations) so far to the west of their line of demarcation, as laid down on our maps, that I once supposed, as above mentioned, that they might be included among the undulations of Plynlimmon and its associated ridges. This extension was hypothetical; and I now withdraw it, as I believe the true demarcation of the Upper Silurian rocks passes in an irregular line from the neighbourhood of Mallwyd to the hills near Llanidloes, leaving the Plynlimmon ridges far to the west. North of Radnor Forest there is a great overlap of the Upper Silurian rocks; so that in the neighbourhood of Mallwyd, and thence round the southern end of the Berwyn chain, they are brought into the anomalous position described in a former paper*.

The coast between Aber Dyfi and Aberystwyth I did not examine; I am therefore not able to estimate (even approximately) the probable thickness of the slate groups between the upper beds of the Cader Idris system and the group which breaks out a few miles north of Aberystwyth, and is thence extended for many miles along the Cardigan coast. But these groups, whatever may be their thickness, are above the whole Cader Idris chain.

Section through the Older Rocks of South Wales.

Commencing at Aberystwyth or Aber Aeron, and taking a section across the older rocks of South Wales as far as the base of the Upper Silurian groups, on either of the lines above specified, it appears that these older rocks may be conveniently subdivided into at least four principal groups: viz. 1. The Aberystwyth group. 2. The Plynlimmon group. 3. The Upper South Welsh slate group. 4. The Cambro-Silurian group. The lower part of this fourth group is composed of slates and conglomerates which can hardly be separated from No. 3. The upper part of the fourth group represents the Llandeilo flag series, at the base of the Silurian system, as published by its author, and stands in the place both of the Llandeilo flag and of the Caradoc sandstone, forming a single and inseparable group, which at its superior limit passes (by almost insensible gradations) into the Wenlock shale, and contains (mixed with its own characteristic fossils) many of those most characteristic of the Wenlock shale.

In 1832 I separated the great series above enumerated into five groups, by striking off the conglomerates of No. 4 from the group of the Llandeilo flag, and enumerating them as a distinct group; for at that time I was partially acquainted with the scheme of arrangement (afterwards adopted in the Silurian system) whereby the Llandeilo flag was cut off from the slates and conglomerates of No. 4. At the

nicated to me by Sir H. T. De la Beche before I visited South Wales during the past summer.

* See Journal, vol. i. p. 5.

same time I saw that this plan of breaking up the fourth group into two parts was not confirmed, but was apparently invalidated, by the evidence of the only two sections I had examined. In making the present attempt at subdivision, I must however state, that the sections are singularly contorted, that the groups are ill-defined, and that the actual order of superposition is obscure; hence I think it not improbable, that rocks, newer than any above enumerated, may in some places have been brought in among the great folds and undulations of South Wales. On the other hand, I may state, that the geographical distribution of the formations of North and South Wales favours the above arrangement; for the newer groups (Carboniferous, Old Red Sandstone, and Silurian) are arranged on the south-eastern limits of the great transverse sections, while the older groups succeed on the north-western limits of any complete lines of traverse; so that the intervening groups are arranged in an ascending order as we traverse from the western to the south-eastern limits of the Principality, along any of the lines of section above indicated. From this remark we must however except the groups in Pembrokeshire and the country immediately adjoining it, where the east and west strike supersedes the more prevailing strike of North and South Wales.

1. *The Aberystwyth group.*—Commencing a section from the coast near Aberystwyth, we find a great group composed of hard, close-grained gritstone, generally of a dark colour, much broken and jointed; and sometimes looking as if made up of distinct concretions rudely placed side by side, and blended one into another. Associated with it are many small quartz veins and strings, and more rarely small veins of carbonate of lime. These gritty beds (which are seldom of great thickness) alternate indefinitely with bands of indurated shale and flagstone; the latter of which sometimes form thick beds, and are used as a building-stone. No shells or corals have (so far as I know) been found in this group; but the flagstones are in some places covered with innumerable fucoids, and with small cylindrical stems, supposed to be of vegetable origin. This group ranges along the coast from a point a few miles north of Aberystwyth to a point several miles south of Aber Aeron, through a distance of about thirty miles; and ranges several miles (five or six on the average) into the interior of the country. The whole group is astonishingly contorted and shattered, yet it must be of great thickness.

2. *The Plynlimmon group.*—This group (which in a more detailed and accurate description might be divided into two or three sub-groups) is also of very great thickness and extent. I include in it provisionally the groups of flags, grits and slates which rise into the hills on the west side of the Aberystwyth group forming the ridges of the Devil's Bridge, ranging thence on the west side of Plynlimmon, and continued to the east of Plynlimmon in repeated undulations (still however giving the indications of an ascending section) to the neighbourhood of Llangurig, on the road from Aberystwyth to Rhayader. In this great group I would therefore include

the highly metalliferous rocks of Coginan, Cwm Ystwyth, &c.—the great alternating masses of grits and slates, so largely developed in the ridges of Plynlimmon (both the coarser beds and the finer often exhibiting cleavage-planes), and all the more soft and earthy slates, grits and flags which extend from the east side of the Plynlimmon ridge, and of Cwm Ystwyth, as far as Llangurig*.

The structure of this great zone is much varied. In the vicinity of the mineral veins we generally find the rock indurated, and the slates sometimes passing into a structure resembling that of the slates of North Wales and of Cumberland, and resembling them also in colour; but generally they are of more earthy structure, and alternate with bands of flagstone and indurated shale, pyritous and decomposing. All the masses exhibit, here and there, a rude concretionary structure; and in a few places we find brown decomposing bands of rotten-stone with numerous impressions of fossils, *e.g.* near Devil's Bridge, Dyffryn Castell, on the south flank of Plynlimmon, and farther east on the road from Dyffryn Castell to Llangurig†.

3. *Rhayader Slates.*—Under this name is included a very remarkable zone of slates, marked, in the Map of the "Silurian System," on the west side of its base-line. They are generally of a pale colour, leaden-grey passing into greenish-grey. They are intersected by beautiful cleavage-planes, generally inclined at a high angle towards the north-west; while the beds are continually thrown into a series of low undulations, the axes of which are ill-defined. Many of these slates exhibit a glossy crystalline surface like the older slates of Cumberland and Wales; but they are not associated with contemporaneous trap, or elevated by the protrusion of any igneous rock which is shown at the surface. Their low angles of inclination and the highly inclined undulations of the masses on both sides of them, make it difficult to ascertain their exact place in the transverse section. I once endeavoured to class them with the Upper Silurian groups, which might, I supposed, be brought in by the undulations, and mineralized into the form of Rhayader slate;

* The coarser grits pass, though rarely, into the form of a conglomerate.

† List of fossils from Devil's Bridge and Dyffryn Castell (Salter MS.).

Spirifer octoplicatus.
Leptæna sericea.
— transversalis.
— small convex species.
Orthis elegantula.
— applanata.
— grandis (?).
— sp. a simple-plaited small shell.
— calligramma (?).
Terebratula (?) with forked ribs.
— marginalis or lacunosa.
Atrypa crassa, young.
— convex species.
Ceraurus Brightii (Dyffryn Castell).
Calymene Blumenbachii.
Encrinites (+ +), &c.

All the species are small.

but this opinion I abandoned; and the position I have here given them appears to be confirmed by some sections taken farther south.

4. *Cambro-Silurian group.*—This group includes, along the line of section, the slates and conglomerates of Dol Fan, and all the Lower Silurian rocks of Builth; and is overlaid by the fine mountain ridge of the Upper Silurian rocks of Mynydd Epynt, &c. Details are here unnecessary, as they appear in the ample descriptions of the "Silurian System," and in the published sections of the Ordnance Geological Survey, under the direction of Sir H. De la Beche. But I may remark, that under this name (Cambro-Silurian) I include rocks of the thickness of several thousand feet, which may be, perhaps, conveniently separated into four sub-groups.

(1.) Conglomerates and slates, both sometimes affected by slaty cleavage, and here and there containing fossils. They are carried by undulations far to the west of the demarcation of the Lower Silurian rocks, as published in the Map of the "Silurian System."

(2.) Lower Llandeilo flag.

(3.) Slates and grits (Caradoc sandstone of Noedd Grug), &c.

(4.) Upper Llandeilo flag, passing by insensible gradations into Wenlock shale, and containing several very characteristic Wenlock shale fossils. In proof of this I may state, that I have seen slabs of the Upper Llandeilo sub-group containing *Phacops caudatus, Ogygia Buchii, Calymene Blumenbachii*, associated with *Leptæna depressa* and *euglypha*;—an association unlike what I have ever seen in any of the lower groups, but not to be regarded as anomalous among what may be considered (on the evidence both of sections and fossils) as passage-beds between the older Cambrian slates and the Silurian system. And to these I may add *defences of fishes*, also found in the *Upper Llandeilo flag*.

Second Transverse Section through the Older Groups of South Wales.

In like manner, commencing at Aber Aeron, and making a complete traverse by Llampeter, Pump Saint, and the old road to Llandovery, we meet with a nearly corresponding succession of deposits in the following ascending order:—

1. The Aberystwyth group—of great thickness and in its most characteristic form.

2. A contorted series of earthy slates, flags, and bands of greywacke, which I would arrange nearly on the parallel of the groups west of Plynlimmon. These extend to Llampeter; and among them are the Annelides discovered by Dr. Olivant, and figured in the "Silurian System." I may remark, by the way, that Annelides, though perhaps of a different species, are also found in the lower beds of the "Cambro-Silurian group," and also among the tilestones at the very top of the "Silurian System;" *e.g.* at the Sugar-loaf, a hill between Llandovery and Llanwrtyd Wells, and in the "Tilestone" ridge south of Llandeilo.

3. A long series of contorted slates and grits, undulating through the hills between Llampeter and Pump Saint, and extending to the

east of the latter place. Near the upper limit of this group (which I place on the parallel of a part of the Plynlimmon group and the metalliferous slates of Cwm Ystwyth, &c.) are many specimens of *Graptolites foliaceus*, and some very obscure traces of Corals and Trilobites.

4. A fine series of ridges composed of pale-coloured subcrystalline slates, with beautiful cleavage-planes, and a structure which brings the group into comparison with the Rhayader slates of the previous section. Among these beds occurs also *Graptolites ludensis*.

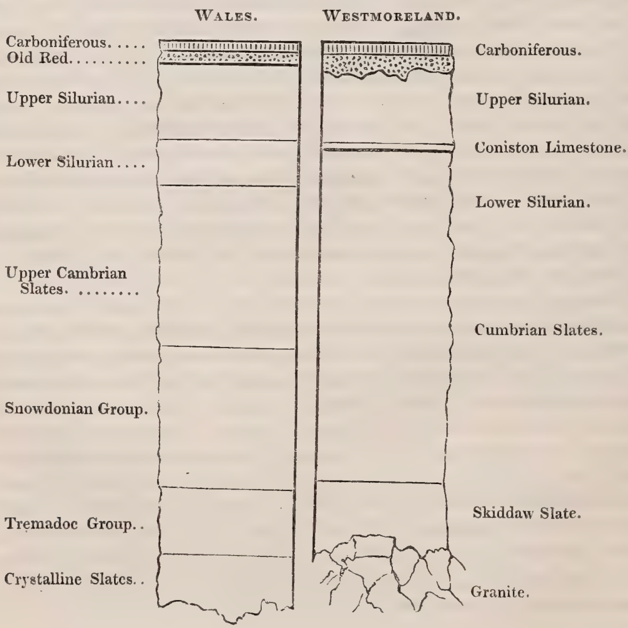
5. Beyond this group (following the line of traverse) we have a series of earthy, shivery slates and flags—sometimes falling into innumerable small prisms—sometimes indurated into flags alternating with bands of grit. The bands of grit are replaced by irregular masses of coarse conglomerate, occasionally containing numerous fossils. The series makes many undulations, and reaches the hills which overhang the valleys and brows descending to the drainage of the Towy. We now enter on the "Silurian System" (as laid down on Sir R. I. Murchison's Map), which, as before stated, may be divided into Lower Llandeilo flag—grits and slates generally of a rather coarse structure, and rarely passing into the form of a conglomerate—and Upper Llandeilo flag, passing into the Upper Silurian rocks.

If I have interpreted these two South Welsh sections correctly, they are in a good general accordance, however much they may differ in certain subordinate details; and they convey, I trust, a notion of the development of a considerable portion of the great slate series of South Wales. They prove that there is a very great thickness of slate rocks, in South Wales, inferior to the "Cambro-Silurian group," which is also of great thickness. Yet all the groups above enumerated are superior to the slates and porphyries of the whole Cader Idris range, and I think also superior to the Bala limestone; but the sections in North Wales are so broken and difficult, that on this last conclusion I cannot speak with perfect confidence. The groups above noticed occupy, as already stated, a kind of trough between the older rocks of Pembrokeshire and the chain of Cader Idris, and are thrown into astonishing undulations. They also exhibit many anomalous changes of strike, which may be partially explained by the fact, that the greater part of their mass has been exposed to two distinct and not contemporaneous movements of elevation. The directions of the cleavage-planes are far more constant than those of the beds, yet exhibit also many anomalies, which I hope to point out in a subsequent communication.

Upper Division of the "Silurian System" in South Wales.

These rocks are finely developed in the parts of South Wales under notice. It would be in vain for me to pretend to add anything material to the beautiful details published in the great work of Sir R. I. Murchison, and in the admirable memoirs and sections of the Government Survey. I only pause to remark, 1st, That the development of these rocks more nearly resembles that of Westmoreland than that of the typical country of Siluria. I believe also that the distribution of the fossils, through the subordinate divisions of these rocks in South Wales, agrees more exactly with their distribution in Westmoreland than it does with their distribution in Siluria—proving that (within the narrow limits of our island) the distribution of fossils through subordinate groups depends far more on physical conditions than on geographical latitude. The highest group (or "Tilestone") contains, in South Wales, a very fine series of fossils, the greatest part of which occur also among the grits, slates and flags of Kirkby Lonsdale, and in the ridges between Kendal and the lower valley of the Lune. 2ndly, With many points of most intimate resemblance between the Upper Silurian groups of Westmoreland and South Wales, there are points of specific difference worth notice. Thus the *Cardiola interrupta* has a much greater vertical range in this part of South Wales than it has in Westmoreland. Again, in these two widely-separated localities, the *Terebratula Navicula* commences nearly on the same horizon. In Westmoreland it does not ascend into the Upper Ludlow series south of Kendal; but in this part of South Wales the species ascends through the whole Upper Ludlow series, and abounds even among the red flags of the "Tilestone," close to the base of the Old red sandstone. My limits forbid me to follow these points of difference and resemblance any farther.

Groups of the whole Cambrian Series, including both North and South Wales.



Taking for granted all the previous details, it follows that the great series of Cambrian slates (omitting in this enumeration the hypozoic rocks of Anglesea and Carnarvonshire) may be subdivided into four or more great groups; and when considered on a wide scale, these groups are as well defined as the groups in the Upper Silurian rocks of Denbighshire and Westmoreland. In the typical country of Siluria, where the physical groups are better defined, the corresponding groups of fossils are also better defined; but this definition is only local.

1. The lowest of these groups may be called the Festiniog or the Tremadoc group. Its lowest portions have no fossils—at least none have been found in them; but in its upper portion we have Fucoids, Lingulæ, and Trilobites. This group is seen on the shores of the Menai, and in the low country to the east of it—in the south promontory of Carnarvonshire (?)—in the Tremadoc promontory—in the hills south of Festiniog—on the west side of the great Merioneth anticlinal, in beds extending from the neighbourhood of Llanelltyd to the ridges west of Great Arrenig—and lastly near the base of the chain of Cader Idris.

2. A great group of roofing-slate and contemporaneous porphyry superimposed, bed upon bed, with greater or less regularity; the former passing into grits, flags, and coarse greywacke in many indefinite alternations—the latter exhibiting indefinite alternations of trappean breccias, trappean shales, and other forms of recomposed plutonic rocks, mixed with those which have been erupted. In some places fossils are abundant, in others they entirely disappear; and they are seen both among the coarser slates and also (though more rarely) among the recomposed plutonic rocks*. This group is seen in the crests of the Carnarvon chain, in the chains of Arrenig, Arran Mowddwy, and Cader Idris, &c. &c. The fossiliferous bands of Snowdon, Moel Hebog, and Llyn Ogwen, &c., seem to be represented in the chain of Arrenig and Cader Idris by irregular masses of crystalline limestone, in which organic remains (if indeed they have ever existed) have been obliterated by the action of the great ribs of porphyry among which they are interlaced. As the genus *Orthis* first appears in this group, it might be called the Orthidian group; or, geographically, the Snowdonian group.

3. A very great group, in which porphyries are much more rare, and in which (between the eastern flanks of Arrenig and the top of the Berwyns) we have three, or more, calcareous bands, and numerous fossils. In this group are included a part of the slate series on the south flank of Cader Idris, descending towards the country near Machynlledd, and all the lower groups of the South Cambrian sections above described. This part of the comparison is however difficult, from the comparative rarity of fossils in the parts of South Wales alluded to—probably indicating deposits formed at a marine depth beyond the ordinary limits of animal life. At the same time, from the absence of contemporaneous porphyries in South Wales,

* See the fossil list, *supra*, p. 149, where the letter (π) indicates a porphyritic rock associated with trappean shale.

there is a corresponding difference in the mineralogical development of these corresponding groups. What is here stated must therefore be regarded as provisional, and I doubt not that on a closer comparison a further subdivision of this part of the series will be hereafter made. So far as I know, from my present list of fossils, Cephalopods first appear in this group. It is eminently characterized by Trilobites; among which *Ogygia Buchii* (the most abundant fossil of the Llandeilo flag) has not yet been found. It might be called the Upper Cambrian slate group, or the Trilobite group, or (geographically) the Bala group.

4. Lastly, the *Cambro-Silurian group*.—In this are included the lower fossiliferous rocks east of the Berwyns between the Dee and the Severn—the Caradoc sandstone of the typical country of Siluria—and the Llandeilo flag of South Wales, along with certain associated slates, flags, grits and conglomerates, above noticed. In the group thus defined the fossils are in infinite abundance, and are now well known (as a group) since the publication of the "Silurian System," of which they form the palæontological base. Among these fossils are found numerous and very characteristic species of the Upper Silurian rocks (Wenlock shale, &c.); but considered as a whole, their affinities connect them more nearly with the fossils of the *lower groups* of North Wales (above enumerated) than with those of the Upper Silurian groups (Wenlock and Ludlow). Hence it must be considered as an error (now admitted on all hands) to have arranged these Cambro-Silurian rocks with the Upper Silurian groups (Wenlock and Ludlow); and, at the same time, to have cut them off from the lower formations above enumerated, which occupy the largest portion of North and South Wales, are of enormous thickness, and form a most characteristic physical system, or collective group, at the base of the whole palæozoic series. But incomparably greater would be the error to regard the Lower Silurian rocks (Caradoc and Llandeilo groups) as the *equivalents* of all the lower groups above enumerated—and, under this erroneous hypothesis, to designate all these lower groups (down to the *Lingula* beds inclusive) as the porphyrized equivalents or representatives of the Lower Silurian rocks—and hence to designate the vast series of rocks in North and South Wales under the name either of the Lower Silurian system, the Lower Silurian division, or any other analogous term—a designation which is not true to the facts of development, and is in antagonism with all analogy to the language by which our successive palæozoic deposits have hitherto been defined. As a matter of fact, the group under notice is a *group of transition* or *passage* (implied in the name *Cambro-Silurian*). Its upper beds blend themselves with the Wenlock shale and Upper Silurian rocks, its lower beds pass into the old slate rocks of North and South Wales, to which the collective name Cambrian has been given—and given correctly, whether we regard palæontological development or geographical propriety of language.

Conclusion.

By way of conclusion, and in confirmation of what has been just stated, I may shortly touch on the principles by which we have hitherto been guided in our nomenclature of the older stratified British rocks*. In every country which is not made out by reference to a pre-existing type, our first labour is that of determining the physical groups, and establishing their relations by natural sections. The labour next in order is the determination of the fossils found in the successive physical groups; and, as a matter of fact, the natural groups of fossils are generally found to be nearly coordinate with the physical groups—each successive group resulting from certain conditions which have modified the distribution of organic types. In the third place comes the collective arrangement of the groups into systems, or groups of a higher order.

The establishment of the Silurian system is an admirable example of this whole process. The groups called Caradoc, Wenlock, Ludlow, &c., were physical groups determined by good natural sections. The successive groups of fossils were determined by the sections; and the sections, as the representatives of physical groups, were hardly at all modified by any consideration of the fossils, for these two distinct views of the natural history of such groups led to coordinate results. Then followed the collective view of the whole series, and the establishment of a nomenclature. Not only the whole series (considered as a distinct system), but every subordinate group was defined by a geographical name, referring us to a local type within the limits of Siluria†. At the same time the older slate rocks of Wales (inferior to the system of Siluria) were called Cambrian, and soon afterwards the next great collective group of rocks (superior to the system of Siluria) was called Devonian. In this way was established a perfect congruity of language. It was geographical in principle, and it represented the actual development of all our older rocks, which gave to it its true value and meaning.

This language, having once become current, was applied to the rocks of distant countries. Thus I have described the third, and highest, collective group of the Cumbrian mountains (the Westmoreland group) as the exact equivalent of the whole Silurian system—the Coniston limestone exactly representing the Caradoc sandstone, and the highest beds (between Kendal and Kirkby Lonsdale) representing the "Upper Ludlow rocks" and the "Tilestone." But in every case in which we have made use of this language, we have assumed that the rocks under notice had their true equivalents and

* The following remarks may also be applied to our secondary rocks; for the principles on which the grouping and nomenclature of our secondary rocks was first determined by Smith were in exact accordance with what is stated in the text.

† The same process of analysis and the same principles of nomenclature were adopted by myself during my whole examination of North Wales, and are the groundwork of every part of the classification offered in this paper.

types within the geographical limits of the country described in the "Silurian System."

In our advancing science the nomenclature must undergo changes commensurate to any necessary change of classification or distribution of the great physical groups, otherwise it must inevitably lead us into verbal incongruity, and sometimes into the perpetuation of error. The "Silurian System" never had any good natural base, either physical or geological. Its base-line was in many places drawn arbitrarily, and in some places, as is now known, erroneously. This assuredly implied that the nomenclature of some of the lower groups in Wales might undergo a partial change to accommodate them to our advancing knowledge. The least change possible, to meet the exigency of the case, would be the best, and above all such a change as did not destroy the original and geographical scheme of nomenclature, or interfere with the natural development of the successive groups, considered both physically and zoologically.

Bearing these principles in mind, I adhere to the nomenclature of our older rocks (Cambrian and Silurian, &c.) as it was originally set forth, only because I am, with a very limited exception, confirmed in my original views respecting the structure of North Wales and the Cumbrian mountains, and the relations of the collective groups one to another. My general views respecting the structure of North and South Wales, since my last revision, are exactly what they were in 1832, however much I may have since then improved my knowledge of subordinate details. In that great country (including in it also the older rocks of the frontier counties of England) there are, at the least, two great physical systems and two nearly coordinate palæontological systems. On this point there is no dispute which does not admit of very easy adjustment. One is the system of Cambria, the other is the system of Siluria. The only difficulty is to draw any well-defined line between them*.

* Should it be contended that the fossil groups of all the rocks here described become so completely blended as to form only one system; in that case I should not object to a modification of nomenclature, and describe as the collective *Cambrian group* what I have called the *Cambrian system*. This indeed is the very nomenclature I proposed in my former paper (see Journal, vol. ii. p. 129). From the first I objected to the word *system* (as applied to Siluria) because it was too definite; that system having no good base-line, either physically or zoologically. In the language of Professor Dumont and other continental geologists, instead of *Silurian system* we should have had "*Terrain Silurien*;" and the word *system* would have been applied to its several subdivisions—Caradoc, Wenlock, and Ludlow; and I think this language would have been more correct than that generally adopted in this country since the publication of the "Silurian System," and that it would not have led to any subsequent misapprehension. Were this the proper place for the discussion, I might state (what I have before stated to the Society during its meetings), that perhaps the best nomenclature of our older rocks would give the name *System* to the whole Palæozoic series. In that case the words Cambrian, Silurian, Devonian, Carboniferous, &c. would define subordinate divisions or collective groups. These collective groups appear to run together through the intervention of the groups of transition or passage, such as the "Cambro-Silurian." On this scheme the *Palæozoic system* would include all the rocks containing the older types of organic life, such as Producta, Orthis, Trilobite,

I never attempted to meet the difficulty just stated, till some time after the publication of the "Silurian System." My mind was then employed on the details of the "Devonian System," to which I devoted the larger portion of five summers. But so far back as 1833, I explained to the British Association, and afterwards to this Society, a section extending from the shores of the Menai to the edge of Shropshire, and exhibiting a series of symmetrical undulations through a great succession of Cambrian slates, forming one great physical system, which I did not then pretend to subdivide into distinct zoological groups, as I have done in the present paper. But I did state, that the highest group of this great undulating series (to the east of the Berwyns and in the neighbourhood of Llangollen) was apparently the equivalent of the lower group (afterwards called Caradoc sandstone) in the typical country of Siluria. I also pointed out, that a great physical group (which I have since called Denbigh flagstone) distinctly overlaid all the rocks above mentioned, and that it was identical with a similar flagstone group in the neighbourhood of Welsh Pool, to which the name "Upper Silurian" has since been given.

It is obvious from this statement, when the words "Silurian System" were used to define the whole series of rocks in Siluria, that the lower groups of that system overlapped the upper groups of the great North Welsh sections, without including in those sections the still higher groups of "Denbigh flag" (Upper Silurian). Still it appeared to me absolutely certain that the greatest portion of the undulating series of North Wales was inferior to the lowest rocks of Siluria; and on that ground I, from the first, objected to the word *system* as applied to the rocks of Siluria, believing them to have, as already stated, no well-defined base, either physically or zoologically. A continuous base-line was however drawn, in the map of the "Silurian System," between the system of rocks in Cambria and the system of rocks in Siluria. With the exception of a demarcation of a few miles in length, at the north end of the Berwyn chain, by which I endeavoured (at the request of Sir R. I. Murchison) to cut off from the highest Cambrian rocks certain fossiliferous beds which I supposed of the age of the Caradoc sandstone, I am in no way responsible for any part of this base-line. It was not I that cut off the older Cambrian rocks from the Silurian; but Sir R. I. Murchison that cut off the Silurian rocks from the Cambrian. This remark is not unimportant, as my share in this demarcation has been misrepresented in one of the published memoirs of our Society. That the demarcation is erroneous is admitted by the author of the Silurian system, and he has now expunged his base-line; and in maps subsequently published, has removed it hypothetically to the western

Orthoceratite, &c. And in like manner, the Secondary system would, in its widest sense (as a first or primary division), contain all rocks with the secondary types of organic life, such as Ammonite, Belemnite, &c. But I am not permitted to follow out a discussion which goes beyond the immediate objects of this communication.

coast of North and South Wales. On this scheme the great Cambrian system (or the great Cambrian division, for which of these terms be used is to me indifferent) is to have neither name nor colour on our geological maps; and all the groups above described (down to the *Lingula* beds inclusive) are to come under the colour of the lower group of the Silurian system; though that group (in the typical country of Siluria) represents only the fourth and highest group of the great Cambrian series of deposits. Why are geographical terms to be retained when we deprive them of their geographical meaning? A good geographical term in geology must refer us to a country which contains a good type of the series of rocks designated by such term. This I consider a perfect axiom in nomenclature. The country described in the Silurian system does not answer this essential condition. The term Lower Silurian, as applied to the older groups of the Cambrian series, cannot therefore be retained with any propriety of language.

The "Silurian System" was first offered to us as a definite upper division of our great series of slate rocks, and it was separated into definite groups, both the system and the several groups having geographical and local names. One value of the new names was this, that they referred to an actual development in nature, and to good local types, whether taken collectively or separately. But a far higher value was implied in the fact, that the Silurian groups completely filled up the chasm between the older British slate rocks and the Old red sandstone. Another great advantage in the publication of the Silurian system was the following: it enabled us to break up into groups or systems the vast series of slate rocks which had hitherto been defined by the names "fossiliferous greywacke," or some other equally indefinite term. So far as it goes, the Silurian system offers us incomparably the best (and in some cases the only) type of the upper division of the British slate rocks; and as it not merely offers us the best physical and zoological type, but, in description, has the priority in time, the name "Silurian System" can never, during the progress of discovery, disappear from a systematic enumeration of British formations. But of the whole protozoic, or older slate series, the Silurian system offers us no type whatsoever; inasmuch as the older Cambrian groups are wanting in that system, as published by its author. To describe these groups, in the technical language of the Silurian system, would therefore be nothing more or less than this—viz. to describe a series of old rocks of enormous thickness, and with well-defined characters, by words which only acquire their meaning by reference to groups of strata of a later period—strata which had no existence at the time these older rocks were deposited: and assuredly to name an old group of rocks by technical terms drawn from a newer group is a process of nomenclature as incongruous as ever was attempted. Yet such (so far as I comprehend it) is the process by which all the old Cambrian rocks are to be included in the lower division of the Silurian system. This extension of the Silurian system makes it stand in the exact place of our "old fossiliferous greywacke;" *i. e.* every fossil-bearing rock, of whatever age, below the Old red sandstone.

Thus are we led to confound what before we had separated; and the new classification is a retrograde movement, and not an advance, in the progress of a good nomenclature. And all this is done with the additional incongruity, that a geographical term is to be retained without a geographical meaning; and under the Lower Silurian groups we are to comprehend great groups of rocks *not found in Siluria.* Nor is this all: we are on this new scheme of nomenclature to expunge the term Cambrian, as applied to the older division of our slate rocks, though the Cambrian region *does contain* (and is the only British country that does contain) *all the fossiliferous groups of this division.* These remarks appear to me at once decisive as to the question in debate, and to settle the natural grouping of our older rocks on a firm basis, provided we retain a geographical nomenclature.

Can the lower division of the Silurian groups (*i.e.* Caradoc and Llandeilo groups) be considered, on any fair interpretation, as the representatives or equivalents of the lower fossiliferous groups of Wales? If so, the name "Silurian System" might be correctly given (though still I think not conveniently) to the whole series of Cambrian rocks. Sir R. I. Murchison seems to have decided this question in the affirmative (misled perhaps by some memoirs read before this Society since the publication of his 'System'), when he expunged his whole base-line and removed it to the western coast of Wales—incorporating in the Silurian system all the older Cambrian groups. I know that this was the interpretation first put on the phænomena; but I now contend that the new nomenclature was not merely an innovation, but an innovation founded on a mistake as to the structure and development of the formations in North and South Wales. At the time the innovation was introduced, I entered no protest against the new nomenclature; but I never adopted it. Wishing only to be guided by facts, I gave it a fair trial; and during 1842 and 1843 I again went over some of the North Welsh sections, and honestly endeavoured so to interpret them that their higher groups might be considered as a great expansion of the Caradoc sandstone, and their lower groups as the representatives of the Llandeilo flag; for at that time I supposed (what I now know to be a mistake) that the Llandeilo flag was a distinct group below the Caradoc sandstone. This attempt was however in vain; and at the end of the summer of 1843 I found, as stated in a former paper *, that the only beds in North Wales I could bring into any close comparison with the Llandeilo flags were at the *top* of the whole Cambrian series, and not (as they ought to have been, in conformity with the new nomenclature) at the *bottom.* This conclusion has been fully confirmed by what I have seen during the past summer;

* Geol. Journ., vol. i. p. 5.

in proof of which I need only appeal to the preceding pages of this paper.

A nomenclature to be good should admit of a general application, and at the same time it ought to disturb as little as possible any previously accepted natural arrangement. The rocks of the Cumbrian cluster of mountains admit of three great collective groups or systems:—1. Skiddaw slate. 2. Green roofing-slate and porphyry. 3. Fossiliferous slate and flagstone. These three subdivisions were established about thirty years since by Mr. J. Otley. The third collective group might very properly have been called the Westmoreland system; and, as above stated, it is the exact equivalent of the Silurian system. Should fossils be ever found in the two lower groups (which fill the exact place of the older Cambrian rocks), there can be no doubt that they would in general specifically agree with the fossils of the lower groups of North Wales, and that several of the species, and probably the greater number of them, would also be identical with those of the Coniston limestone. This might be a good reason for packing the Coniston limestone in the middle Cumbrian group, but could be no reason for describing the great Cumbrian mountains under the name of the Westmoreland system. Such language would not merely be incongruous, but would tend to undermine all previous arrangements, and to throw the geology of this part of England into inextricable confusion. Yet this incongruity would be exactly of the same order with that which is introduced, in defiance of natural sections, natural development, and the geographical propriety of language, by classing all the older Cambrian rocks under the Silurian system.

After the distribution of the principal organic groups has been settled (and it can only be settled by the previous determination of the physical groups), we might easily adopt a congruous nomenclature founded only on palæontological characters. In that case our geographical names ought to disappear from the designation of the successive epochs. But even then we should be compelled, in all local descriptions, to enumerate the successive collective groups (such as Cambrian, Silurian, Carboniferous, &c.), and give them some appropriate name. Geology is not however yet ripe for a mere palæontological nomenclature. Taking it as an advancing science, I think the principles of nomenclature hitherto adopted are best fitted to its condition.

In conclusion, and by way of summary to all that has been stated in this paper, I venture to affirm, that the innovation in the nomenclature of our older British palæozoic groups (against which I have been contending) is not merely based in error and misconception, but also that it involves a change of principle and a very great incongruity of language. I continue therefore the old nomenclature, because more congruous, more natural, and more strictly in accordance with physical and zoological development.

JANUARY 6, 1847.

Charles Fraser, Esq. was elected a Fellow of the Society:—

The following communications were read:—

1. *On the Meaning originally attached to the term* "CAMBRIAN SYSTEM," *and on the evidences since obtained of its being geologically synonymous with the previously established term* "LOWER SILURIAN." By Sir RODERICK I. MURCHISON, G.C.St.S., V.P.G.S., F.R.S. &c.

> [" By such proofs (organic remains) we are enabled to distinguish the Silurian deposits from all others previously described, and through every lithological change we can thereby separate the System into Upper and Lower divisions."—*Silurian Syst.*, p. 9.]

IN a communication upon the Silurian rocks of Sweden, published in the preceding number of the Quarterly Journal of the Geological Society, I stated my objections to some opinions of Professor Sedgwick contained in the previous volume, which suggested a re-arrangement of the recognised divisions of the Upper and Lower rocks of the Silurian system. I was then chiefly called upon to point out the inapplicability of the proposal to remove the Wenlock formation (or a great part of it) from the Upper to the Lower Silurian; for even down to last year Professor Sedgwick had invariably spoken of all the lower palæozoic fossils of North Wales and Cumberland as belonging to one or other of those natural divisions*. In a word, the Upper and Lower Silurian fossils published by me had been appealed to by him as the types by which he worked out their equivalents in the above slaty tracts; and even in his memoir published in 1846, he still divided the older palæozoic rocks of our island into Upper Silurian, Lower Silurian, and Cambrian †. In the memoir, however, which he read at the last meeting, Professor Sedgwick took a new course, for which I was unprepared by his previous publications‡. After indicating the order of the strata in and beneath the Bala limestone, he now puts forth what I can only understand as this general proposition, viz. that although the fossil type of such rocks is essentially what he and others had recognised as "Lower Silurian," the term "Cambrian" ought in preference to be applied to them, because a succession of great physical masses exists in North and South Wales which is not developed in the tracts formerly described in the Silurian region. In this way, the term Lower Silurian would be suppressed, and the Silurian system, deprived of its lower half, would be split up into two systems of fossiliferous strata beneath

* See Quarterly Journal Geol. Soc., vol. i. p. 1; No. 4. p. 442; vol. ii. p. 106.

† Ibid., vol. ii. p. 130.

‡ Let no one suppose, that in consequence of the divergence of our present views on a point of geological nomenclature, there has been the slightest cessation of friendly intercourse between us. Professor Sedgwick wrote to me four months indeed before his memoir was read, and candidly explained his opinions.

the Devonian, instead of continuing to be one natural series divided into two groups, as first established in Britain and subsequently extended to other parts of Europe.

Painful as it is to me to oppose my distinguished associate,—the friend with whom I have so often cooperated, and to whom I dedicated the "Silurian System," I am compelled to resist a proposition, the adoption of which would, I conceive, be productive of great disservice to the progress of geology; and he must therefore excuse me if I defend the ground of Caractacus, with a pertinacity approaching to that of the old Silurian chief.

I shall therefore treat this question under the following heads:—the origin of the terms "Silurian" and "Cambrian"—the nature and progress of the classification to which the term "Silurian" referred, whether in Great Britain or the continent—and the effects of the adoption of the proposed change upon geological science.

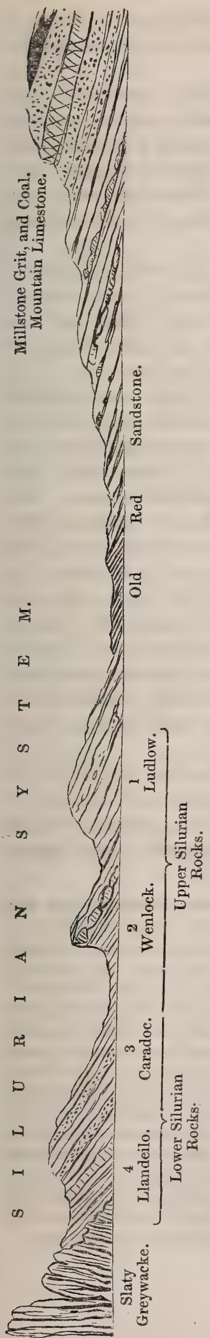
After labouring during four years in certain Welsh and English counties, in which I had traced out and defined a succession of fossiliferous deposits, from the base of the Old red sandstone down to certain older rocks then called "slaty greywacke," I was urged by many geologists to designate such rocks by a distinct name. Accordingly in June 1835* I applied to them the term "Silurian System," thereby to distinguish a series of strata several thousand feet thick, and having a general community of fossil characters within the ancient British kingdom of the Silures. These I divided into two groups, the Upper consisting of the Ludlow and Wenlock, the Lower of the Caradoc and Llandeilo formations; the chief or typical fossils of each, being identified or named by Mr. James Sowerby and myself, were then enumerated in tables†. To make this matter clear, I here reprint the very woodcut and lettering used twelve years ago.

At that time the word "Cambrian" was unknown, and it originated in the following manner‡. In the accompanying diagram of succession, the Upper and Lower Silurian rocks were represented as reposing on *unconformable* strata which were termed "slaty grey-

* Phil. Mag. June 1835, vol. vii. p. 50.

† Even at that early period I guarded against the possible inference that the mineral masses so defined were to be viewed as persistent. I showed, for example, that in some tracts the lower division exhibited great thickness of sandstone beneath flags and limestone; in others *vice versâ*. The same was explained at greater length in the work subsequently published (1839), wherein the evanescence of mineral types being indicated, it was maintained, that the fossils alone could truly indicate the age of the strata. This fact is now mentioned, because notwithstanding all my caution, it has recently been stated that flagstone beds with *Asaphus Buchii* occasionally lie above sandstone to which the word "Caradoc" may be applied. My classification, I repeat, was never based on such mineral succession; for whether the lower rocks were flaglike and calcareous, sandy or quartzose, schistose or slaty; whether the uppermost bed was sandstone and the lowest schist, or the reverse, their age was alone to be determined *by their imbedded fossils*. And as to the mineral base, I will cite my own words:—"Although the calcareous flags of Llandeilo with their accompanying schists are considered to form the base of the Silurian system, their place is sometimes taken, *often indeed they are underlaid* by sandstones of considerable thickness." (Sil. System, p. 8.)

‡ See also Sil. Syst. p. 8.



wacke," which was meant to represent certain inferior unfossiliferous rocks (like those of the Longmynd range of Shropshire). Now on sending a copy of my new classification to M. Elie de Beaumont, that eminent geologist, wishing to mark strata separated by lines of dislocation by separate names, suggested the propriety of further distinguishing those last-mentioned unconformable and inferior rocks by the term "Hercynian," as taken from the Hartz mountain in Germany, where, as he then believed, the oldest slaty group would prove to be of higher antiquity than the strata to which I had applied the word "Silurian." Unwilling that the name for these infra-Silurian rocks should be taken from a foreign country, in which no precise palæozoic horizon had then been fixed, I at once urged Professor Sedgwick to apply to his slaty rocks, which were confidently believed to be inferior to my own, some term, on the same geographical principle by which I had been governed in proposing "Silurian." I even ventured to suggest the word "Snowdonian," because I knew that my friend then considered the N.W. portion of the Welsh chain to be made up of the oldest fossiliferous masses; but preferring a more comprehensive geographical name, he took that of "Cambrian." With this arrangement we both felt certain, that no anomaly could be introduced into the lower palæozoic classification, as the relations and fossil contents of mineral masses which were contiguous, must be eventually cleared up without fear of error or the introduction of theoretical views.

The word "Cambrian" (as far as I know) was first used in print by myself in the year 1836, in describing the structure of Pembrokeshire. But whilst I then spoke generally of such Cambrian rocks, and afterwards at greater length in my large volume, their analysis and examination formed no part of my scope; that task having been specially undertaken by Professor Sedgwick, at a time when I really believed, that from their great thickness, apparent inferiority and different lithological structure, they would be found to contain a suite of organic remains distinct from those I had called "Lower Silurian." Improving in the following years the description of the Silurian region, and having completed as well as I could by my own labours (aided by a few kind friends resident in the country) the collection of its typical fossils, I published in 1839 the "Silurian System," as founded on my own researches. This work was accompanied by a map, which as far as the parts coloured Silurian are concerned, has, I believe, been found little fault with; the distinctions of the Upper and Lower Silurian rocks with their subordinate formations (all perfectly conformable, be it observed, to each other) being accurately laid down in reference to other overlying deposits. But notwithstanding the labour bestowed upon it, this map was necessarily very defective in the boundary-line between the typified Lower Silurian and the *un*typified Cambrian rocks. In the northern part of the map that line was, indeed, for the most part inserted, at my request, by Professor Sedgwick himself*; and in Central and South Wales it indicated, according to my view, little more than that to the west of it, the so-called Cambrian rocks were then neither zoologically nor physically explored—a task which, as repeatedly announced to the Geological Society and expressly declared in my work, was left exclusively to Professor Sedgwick. But although it was, so to speak, a point of honour with me not to trench upon the privileges of the eminent geologist who had engaged to describe the Cambrian region, I can truly say, that I repeatedly urged him to determine the organic remains of those slaty rocks; for I then thought, I repeat, that they would be found to be in that manner essentially distinguished from my Silurian types. Years however rolled on and this desirable end was not accomplished; and no peculiar fossils having to this day been published, the Cambrian system consequently remained without organic characters of its own. It was, in fact, a great physical mass without the vitality of a system.

All that I knew of the fossils of the so-called Cambrian rocks, at the period of the publication of my work, was, that the chief forms which occurred in their Eastern or upper division, as at Bala, were specifically the same as my Lower Silurian types,—a strong proof that there was a gradual transition from the one to the other, and that the boundary-line drawn upon my map between the tracts named Siluria and Cambria was merely provisional, and had been laid down on no fixed geological principle. Thus in speaking of some of these Bala fossils my words were—"As these shells abound also in the Lower Silurian rocks, it would seem that as yet no defined line of zoological division occurs between the Lower Silurian and Upper Cambrian group; *and that as our knowledge extends, we may probably fix the lowest limit of the Silurian beneath the line of demarcation which has for the present been assumed* †." Surely words could not more explicitly show, both that the boundary-line marked in the map was not a natural limit, but simply a geographical (not a true

* See description of the map, Sil. Syst. p. xxix.

† Sil. Syst. vol. i. p. 308.

geological) line which ran between my working-ground and that of Professor Sedgwick; whilst they clearly indicated my belief, that the Silurian system, as distinguished by its fossils, would probably be carried further downwards when the region should have been thoroughly explored.

In fact, the problem to be then solved was—whether the enormous masses of rock which seemed to rise out from *beneath* the Bala beds would be found to contain a distinct group of organic life? If not, I for one should never have thought of considering them as constituting a system equivalent to the Silurian.

In the meantime other geologists began to occupy themselves in North and South Wales. Mr. Bowman made an excellent addition to our acquaintance with the former, by showing the exact equivalents of some of my Upper Silurian strata in Denbighshire; and whilst Professor Sedgwick was renewing his labours, Mr. Sharpe also entered the Welsh arena, and contributed, as the Society knows, many new and valuable data. But whoever was the inquirer, no fossils were reported or heard of but "Silurian." In South Wales Sir H. de la Beche and the Government Surveyors showed, that the rocks of certain quartzose and slaty tracts which had been loosely mapped as Cambrian by myself, were, in truth, physically as well as zoologically, the same Lower Silurian strata I had described on their eastern and southern frontier, and that thus, with the exception of certain limited districts occupied by very ancient unconformable greywacke void of fossils, as at St. David's, &c. (like that of the Longmynd in Shropshire, represented in the woodcut p. 167), the lowest fossiliferous strata in South Wales were all conformable and connected masses. Even in a geographical sense therefore, the question whether the so-called Cambrian rocks could be characterized by peculiar fossils, seemed to be thus narrowed to the space included between Cader Idris, the Menai Straits and Bala.

Having satisfied myself in 1842, in company with Count Keyserling, that the prominent fossils in the rocks of Snowdon were nothing but published species of Lower Silurian Orthidæ with simple plaits, I next learnt from Professor Sedgwick himself, that he could discover no types differing from the Lower Silurian in any tracts of North Wales or Cumberland. Referring, indeed, to his works as well as to those of Mr. D. Sharpe, it was evident that whatever differences of opinion might exist between those authors concerning points of structure, the arrangement of the masses or their geographical boundaries, they both agreed as to the persistence of known and published Silurian types through many of the lower slaty strata of North Wales and the Lake Country. Thus fortified by the assurances of my contemporaries, including the Surveyors of the Government, and by personal visits to North Wales, Westmoreland and Cumberland, I ventured to comment on the facts in my Address to the Geological Society in 1843, broadly stating, that as the whole of the *fossiliferous* series of North Wales seemed to exhibit no vestiges of animal life different from those of the Lower Silurian group, the tract must henceforward be considered of that age. It was on this principle that I then coloured a geological map of England at the request of the Society for the Diffusion of Useful Knowledge.

In the meantime, however, though, for the reason before assigned, I had taken little part in the local question of what might be termed Cambrian *as distinguished* from Lower Silurian, (leaving that point to be finally settled by the Government geological surveyors,) I had, by more extensive surveys in other parts of Europe, gathered positive evidences for coming to a definite conclusion respecting the base of the Lower Silurian rocks. Finding that in Russia the lowest fossiliferous band was unquestionably my Lower Silurian group* (a view which was unanswerably sustained by the inquiries of my associates De Verneuil and Von Keyserling), I further saw this group in Scandinavia (with nothing but fucoids in its lowest beds) resting at once on pre-existing slaty and crystalline rocks. Northern Europe was first distinctly appealed to as exhibiting the base of the series of animal life, and the Lower Silurian was, by observations in Scandinavia, thus shown to be the protozoic group†. Then came the comparison of the lowest fossiliferous strata of North America, by American authors and Mr. Lyell, with a Lower Silurian type similarly related to pre-existing rocks ; and lastly in the first chapters on the geology of Russia in Europe and the Ural Mountains, the grounds were fully explained (1845) on which the conclusion had been generally arrived at, that the Lower Silurian was the protozoic or oldest type of animal life yet discovered.

None of my opinions successively put forth from the year 1843 to the present time were objected to, and I naturally therefore believed, judging indeed also from Professor Sedgwick's new map of North Wales†, that the question of palæozoic nomenclature was settled. I firmly thought, that however thick, however diversified in mineral characters, all Welsh and British as well as all foreign strata, in which certain typical forms prevailed, would be included in the Lower Silurian group. For what, I inferred, could it import in a nomenclature founded on the principle of "strata identified by their fossils," whether the rocks termed Lower Silurian were two or three thousand feet thick in the region where they were first described, or many times as thick in the western parts of North Wales, provided they were in both tracts characterized by the same groups of fossils? I knew for example, that in the very thin but undisturbed bands of Russia, a greater number of species of animals had been found than had then been detected on the same parallel in the greatly expanded North Welsh rocks. It therefore seemed to me to matter little to the geologist occupied with the history of successive races and their apparition on and disappearance from the surface, that he should be told of a tract, in which there was a much grander and more diversified mineral character (with enormous porphyritic masses) than in the region wherein he had previously described similar *zoological* types.

* See announcement to the York Meeting of the British Association, 1844.

† See Geological Journal, vol. i. p. 1 and map.

The names of William Smith remained unchanged, although his original mineral types were in after-times found to be often of very small persistence. It was not proposed to change the name of Lias, when that formation was found to be three times as thick at Whitby (with numberless new inferior strata and many new fossils) as in the South of England where it was first named. Modern geology will stand on an insecure basis, if the principle of identifying strata by their fossils be abandoned. But it is now proposed to abrogate the established name of the type, and substitute for it that of a tract the fossils of which have never been published, long after the Lower Silurian rocks were first named and distinguished by peculiar forms —when the fossils of that age have been so labelled in numerous museums on both sides of the Atlantic, and when geologists and palæontologists of all countries have adopted the term, and already know (through the previous admissions indeed of Professor Sedgwick himself) that the greatest portion of the Cambrian is zoologically nothing more than a downward extension of the Lower Silurian group.

Let me then ask my brother-labourers to adhere to the use of a name which has been so long current, and which for some years has had a definite meaning attached to it both by its fossils and position in various parts of the world. Geologists have already honoured me with their approbation for having worked out certain phænomena, which explained the first clear succession downwards from the base of the Old red sandstone. They will not, I trust, forget the toil by which these results were obtained, nor cease to be alive to the fact, that by the forms which I described, order was at length elaborated amidst various slaty tracts, often highly dislocated and in parts metamorphosed, over which such Silurian types are *now* found to spread. For, even in reference to Britain, the succession of the broken and porphyritic region of North Wales, Westmoreland and Cumberland, might, I apprehend, have long remained undeciphered, if it had not been for the constant appeals which the geologists who have explored those tracts have made to the established Silurian strata. Is then the key which has served to open out such regions to be now thrown away?

But passing for a moment to some of its leading details, let us now see if the memoir recently read by Professor Sedgwick contains anything new to lead us to change the previous arrangements. Enlarging the discovery of Mr. Davis announced to us in 1845*, of the existence of a species of Lingula in the rocks near Tremadoc in Carnarvonshire, Professor Sedgwick tells us, that this band lies many thousand feet beneath the Bala limestone, including however, it will be observed, enormous interpolations of stratified igneous rocks.

I grant that his sections (obscure as he admits some of them to be) afford proofs of an enormously thick succession of "great physical masses." They clearly indicate that in the early days of submarine life, the area of the earth's surface now constituting Merioneth- and Carnarvonshire was much agitated by plutonic eruptions

* Quart. Journ. Geol. Soc. vol. ii. p. 70.

which threw down thick sheets of porphyry, trappean ashes and other igneously formed matter on the bottom of the then sea, and that in relation to them, the quiet sedimentary deposits containing animal life were small. By such operations and by the subsequent eruption of other igneous rocks, the whole series was, in these tracts, greatly expanded and diversified, whilst by other events the masses were thrown up into lofty mountains and underwent much crystallization. But then comes the question, what are the animals which lived during the accumulation of this extravasated and troubled marine series?

Assuming that Professor Sedgwick be perfectly correct in his interpretation of what are really the lowest strata (though as yet we have no proofs like those derived from Scandinavia, that the *hypozoic* rocks of Anglesea are inferior to the lowest fossiliferous beds), we are informed by him, that in passing from W. to E. on several parallels, whether near Tremadoc, near Penrhyn, or again near Cader Idris, there exists an ascending series from lower slaty and quartzose strata through igneous rocks in which no fossils have been observed, and thence into beds charged with a Lingula and fucoids; and that after passing through other alternations of slaty and igneous rocks, the geologist reaches the chief fossiliferous zone of the north-western portion of Wales, as exhibited in the range of Snowdon.

He also points out that the same beds with Lingula occur along the Merioneth anticlinal in the valley of Festiniog, and that in proceeding westwards therefrom, a grand succession is seen up to the well-known horizon of Bala. Admitting that the Lingula of these low beds in North Wales is a new species, that single circumstance cannot surely be of much value in a discussion like this. Lingulæ occur in nearly all the formations or subdivisions of the Silurian system of Britain from the Ludlow rocks to the Llandeilo flags, whilst in North America, as in North Wales, they are found at the base of the whole of the same series of animal life. Again in Russia, where fucoids only have been detected in the lowest strata, the shells immediately above them are Orbiculæ and Ungulites (Obolus), both of them, like the Lingula, small horny bivalves suited to a sandy or muddy sea-bottom in which there had been little calcareous matter. In North Wales, as in other palæozoic countries, the true test of the age of the rocks lies in the lowest zones in which the common and characteristic fossils are found. Now among the lowest of these North Welsh beds Professor Sedgwick mentions the *Asaphus Powisii*, a crustacean first described by myself from the very uppermost beds of the Caradoc sandstone of Shropshire, or rather from the Horderley limestone at the base of the Wenlock shale, its associated fossils near Tremadoc being *Graptolites Murchisonæ* and *G. foliaceus*, both common Silurian forms. A Homalonotus is next cited as pertaining to still higher beds, and is identified with a species from the Lower Silurian beds of Wittingslow in Shropshire.

The *Leptæna sericea*, a species frequent in the Wenlock shale, and which also ranges, as I have shown, throughout the Lower Silurian rocks, is said by Professor Sedgwick to run low down into the Snowdonian group together with the *Trinucleus Caractaci*, the most typical perhaps of all the Caradoc fossils; whilst the associated Orthidæ are nearly all the very same simple-plaited species figured in my work, and on which I have always dwelt as the best and surest types of the Lower Silurian strata; viz. *Orthis calligramma*, *O. vespertilio*, *O. flabellulum*, *O. Actoniæ*, *O. expansa*, *O. elegantula*, *O. Pecten*, &c.

Let these species be found in any part of the world, and I ask if their discoverer can possibly assign to them any other geological name than Lower Silurian fossils?

And here I would say a few words on one of the propositions of my friend Professor Sedgwick. Changing the old name "Lower Silurian" into the new one of "Cambro-Silurian," and showing that there is a considerable intermixture of Upper and Lower Silurian forms in this group, he states with justice that it should never have been cut off from the Cambrian. But why was it so cut off?—simply, I repeat, because the zoological contents of the great mass of the Cambrian rocks were unknown at the period when the original classification was proposed. As soon as this point was cleared up, I hold that the conduct I pursued, so far from being in antagonism with the rules and analogies which have hitherto guided geologists, was in direct obedience to the only canon on which their nomenclature has been based—viz. conformity of succession and similar organic remains. The only error committed was the original one of giving a systematic name to a mass of rocks before its fossils were known; and I venture to declare it to have been not merely my opinion, but that of every geologist who considered the subject, that the continuance of the recognition of a Cambrian system has been considered to be exclusively dependent on the discovery in it of a peculiar type of *life* distinct from that formerly described as Silurian.

In respect to the geographical propriety of language on which my friend insists, I have already said that I was not responsible for the outlines and contents of his Cambrian region; and as to the observation about the Silurian system being now brought by increase of knowledge to mean nothing but "fossiliferous greywacke," I have simply to remind him, that until the Silurian system was fixed, and was followed by tracing the ascending succession of palæozoic life through the Devonian into the Carboniferous and Permian deposits, foreign geologists had indiscriminately applied the word "greywacke" to different members of this great palæozoic series. But I need not dwell on the advantages which followed from that first step in the palæozoic classification, as they have been kindly admitted by my contemporaries, including Professor Sedgwick himself.

Although it is unnecessary that I should deny, what I apprehend no modern geologist can sustain, that peculiar lithological features or extraordinary thickness can constitute any claim for the establishment of a new nomenclature, I may be excused for requesting that reference be now made to my former descriptions of such Lower Silurian strata when I found them intermingled with rocks of igneous origin in the Silurian region. I then specially described districts in the higher and western parts of Shropshire and in Radnorshire, in which contemporaneous submarine volcanic rocks alternated frequently with beds containing Lower Silurian fossils; such masses having been subsequently penetrated by other eruptive matter. Those contemporaneous trap rocks were stated to be made up of many varieties, including felspathic grits, sandstones, conglomerates and breccias, greenstone and hornblendic rocks of many shades, with porphyries, &c. Now, although these rocks had a very different mineral aspect from that with which I was familiar in districts removed from such disturbing causes, I never thought of applying a separate name to them. They had, it is true, a peculiar aspect. They were often much swelled out by the interlacement of porphyries, greenstones, and "volcanic grit," and owing to these conditions, fossils were comparatively rare; but in deciding their age I appealed to the fossils only, and wherever I found certain forms, of Orthidæ, Trilobites, Graptolites, &c., I at once mapped in such masses as "Lower Silurian." As no one has ever doubted that the name was there rightly applied, I request geologists to read the chapters descriptive of these rocks *, and then to tell me if I have not in them given a fair illustration (though on a smaller scale) of the leading features which are said to characterize the infinitely grander masses of North Wales. With the exception of beds charged with Lingulæ and pisolitic iron ore, and marked by a perfect slaty cleavage, there is, I assert, no essential difference, whether mineral or zoological, between the above tracts of Shropshire and Radnorshire and the rocks of Carnarvon and Merioneth; and if the hundreds of feet of the one be expanded into the thousands of feet of the other, and the undulating hills ranging from 1200 to 1800 feet high be raised into rocky ridges from 2000 to 3000 feet high, geologists will have before them, in my opinion, the Cambrian system as now characterized by Professor Sedgwick.

Nature's legends are, in a word, found to be composed of the same fossil types in the western parts of Wales as in the western limits of the Silurian region; the only difference being, that in the former the spaces between the letters are vastly more expanded, and that the whole region is more slaty, igneous and crystalline.

I say it advisedly, and after consultation with good palæontologists, who have examined the North Welsh fossils, that there is no essential difference between them and those of my Lower Silurian tracts. On the other hand, there are considerable variations in the distribution of the Upper Silurian species of the region I first described and those of parts of Wales, Cumberland and Westmoreland which have been recognised by geologists, including Professor Sedgwick himself, as Upper Silurian. Why then does he speak of and apply my Upper Silurian types only throughout his last memoir, and not equally depend on those styled Lower Silurian? Why, indeed, is the term "Lower Silurian" not once employed in his last memoir, though abundantly referred to in all his previous communications, when my types were appealed to? The only answer, it seems to me, which can be given, is that, as the word Cambrian is now de-

* See Silurian System, chapters 22 and 26.

monstrated to be zoologically synonymous with Lower Silurian, Professor Sedgwick will not abandon the name he formerly applied to his great physical group, though such name was used before its fossil contents were known.

The question then is simply: Will geologists find it possible to use two terms to designate the very same succession of animal life upon the surface of the globe?—such terms being relatively made to depend upon the greater or less thickness of the strata and their diversity of lithological structure?

If then greater thickness of the masses be abandoned as a reason for a separate name, some geologists might contend that a physical separation of the upper and lower groups, or the unconformability of the one to the other, would afford grounds for such a distinction. But even this feature is wanting, in reference to the two groups characterized respectively by Upper and Lower Silurian fossils. There are, indeed, districts in which one portion of the Upper Silurian group is unconformable to another; and again, lines of dislocation producing unconformity occasionally affect the subordinate members of the lowest group itself, which Professor Sedgwick recognises as one natural whole. But we already know from the survey of the Government geologists, that all the Silurian strata roll over in conformable folds throughout South Wales, and that there is no general break between the masses occupied by Upper and Lower Silurian fossils in Wales, any more than within the limits of the Silurian region first chosen as a pattern. Indeed, I have strong grounds for believing, that the very rocks of Bala, about which so much discussion has taken place, will prove to be the physical equivalents of the schists, flags, limestones and sandstones which in South Wales have been described by me as Llandeilo flags.

There being, then, no unconformity between my Silurian and the Cambrian of Professor Sedgwick, the only remaining ground for changing the name, is the opinion which he seems to entertain, that the Silurian system, as originally described, is in reality made up of two natural-history groups, and ought therefore to have two names. On this point also it is scarcely necessary that I should go beyond the clear evidences recently afforded by the Professor himself, of the great interchange of fossils between the Upper and Lower Silurian groups*, to convince every one that they are so knit together in Britain as to be geologically inseparable†. When I published the 'Silurian System,' I then knew that a limited number of species only passed from the upper to the lower group, but in succeeding years I learnt, that many more were common to the two groups both in Great Britain and in other countries. My last memoir on Gothland has shown that out of 74 species of shells and crustacea in the Upper Silurian rocks of that island (46 of which are British Upper

* See also Quarterly Journal Geol. Soc., *antè*, vol. ii.

† The researches of the Government Geological Surveyors will presently bring to light facts which will place beyond all doubt, that even in North Wales or Cambria itself, many Upper Silurian forms are intermixed with those of Lower Silurian age; in short, Professor Edward Forbes has assured me, that in North Wales there is but one natural-history system only.

Silurian forms), 9 at least range into the Lower Silurian rocks of Britain, whilst 14 is the number, if the Lower Silurian type of Northern Europe be included. On the plain fact therefore, that there are many species of Trilobites, Orthidæ, and other shells which unite the two groups, I maintain that the Lower Silurian cannot be viewed as a system independent of the Upper.

But it is not on the duration or passage of species from the one group to the other, that I alone depend for the conservation of the zoological unity of my system. The qualifications and character of what I term a system are chiefly based on the assemblage of its classes of animals. Thus, the Silurian was typified as the great system of Trilobites, which crustaceans rapidly dwindle away in the overlying Devonian, and expire in the Carboniferous system. Again, the Silurian system was represented as being the chief centre of Orthidæ, its lower half being specially marked by small species of that genus with simple plaits. It was further spoken of as charged with Graptolites, and also as being the horizon in which certain very peculiar chambered shells are most rife. Of late years its lower strata have been shown to abound in Cystidea, those simple forms which, chiefly by the labours of Von Buch, have been shown to be the earliest created forms of the great family of Crinoids. And here I would beg British geologists to attend to the importance of foreign comparisons, if they wish to see rock systems founded on laws of general distribution of animals. Abounding in the Lower Silurian rocks of Scandinavia and Russia, these Cystidea had not been found by myself in the Lower Silurian rocks of Britain, but the researches of the Government Geological Surveyors detected the common species of Northern Europe (*Echino-sphærites aurantium*) in strata actually described and coloured in the map of the Silurian region by myself as Llandeilo flags, whilst the same observers are now detecting the same in greater quantity in the rocks of Bala and in Ireland.

Even whilst I write, I learn that the only strong distinction which was thought to exist between the Upper and Lower Silurian rocks has vanished by the discovery of the defences of cartilaginous fishes of the genus *Onchus* in the latter, as just announced by Professor Sedgwick; and thus, whilst my view of a period void of vertebrata, founded though it was on very general observation, must be abandoned*, I naturally rejoice in this unexpected additional evidence, whereby the Upper and Lower Silurian rocks are still more firmly united in one system †.

Whilst we are considering what are the natural distinctions of a system, or "terrain" in the sense in which I used the word, I

* See Russia in Europe and the Ural Mountains.

† I also learn from Professor E. Forbes and the geologists of the Government Survey, that they have detected the defence of an Onchus in the limestone near Bala. Professor Sedgwick states that the species he mentions were found in the Upper Llandeilo flags. Professor Phillips has detected fish-remains in the Wenlock shale, and they had been previously observed by the Rev. C. Brodie in the Wenlock limestone. Although the species of North Wales are not yet described, it is rather remarkable that the Onchus of these Lower Silurian rocks is said to resemble, to a great extent, the *O. Murchisoni*, Agassiz, of my Ludlow rocks.

beg to be permitted, without further reference to Russia and Scandinavia, to show how in another portion of the continent, the Silurian system has recently been applied by a French geologist, M. Barrande, to Bohemia, the country of his adopted residence. The slaty fossiliferous rocks of Germany, like those of Devon and Cornwall, are, it is now well known, for the most part of Devonian age; but in Bohemia a long and wide tract consists of a basin of Silurian rocks, the lowest strata of which repose on sedimentary rocks void of fossils, and these again on crystalline schists. With no other guide than my original work, the 'Silurian System,' M. Barrande, after collecting 600 species of Bohemian fossils, 129 of which species are Trilobites, has, of his own accord, come to the conclusion, that the whole clearly indicate a true Silurian series. The lower half of this series is composed of two stages of quartzose and argillaceous strata, which are not merely referred to the Lower Silurian as a whole, but through their mineral characters and their Trilobites, and other organic forms, are even severally compared with the Llandeilo flags and Caradoc sandstone. The upper group, eminently calcareous, presents itself in three stages, the lowest of which M. Barrande (after most assiduous examination of the fossils) compares with the Wenlock limestone and shale, the middle with the Lower Ludlow rock (the chambered shells of which strikingly resemble those of the same formation in England), and the third or upper division with the Aymestry limestone and Upper Ludlow rock. I advert, therefore, with pleasure to such labours, because they prove that the detailed descriptions of certain typical Silurian tracts in England have not been unfruitful, even in reference to other and distant European tracts. I further trust that geologists may regard my late memoir on Gothland as a corroboration quite as striking, of the value of the detailed original description of the types of my own country*. On the other hand, I well know that there are Silurian tracts in the British Isles, which under different conditions of mineral origin present much fewer points of resemblance to the types of the Silurian region than the above-mentioned distant foreign regions†.

But rock systems must not be so formed as to suit one country only. For if it be granted that in Britain the Lower can generally be so separated from the Upper Silurian as to be capable of demarcation on a map, how could the geologist succeed in separating the Upper and Lower Silurian of Christiania in Norway, where these groups, each equally well characterized by fossils as in our own country, fold over together in such small united masses‡?

* See Quarterly Journal Geol. Soc. vol. iii. p. 1.

† Whilst these pages are passing through the press, I have learnt from Mr. M[c]Coy, that several of the Upper and Lower Silurian species of Ireland which he has described and named, are identical with specimens from Bohemia now in the collection of the University of Cambridge; and together with this fact it is curious to remark, that the mineral characters of the rock masses in the two countries coincide, and that in Ireland as in Bohemia, the Upper Silurian is eminently calcareous, the Lower Silurian sandy, quartzose and slaty. (See the Silurian fossils of Ireland 4to., as published by Mr. Griffith and Mr. M[c]Coy.)—9 *April* 1847.

‡ See woodcut, Russia in Europe, &c. vol. i. p. 17, and Quarterly Journal Geol. Society, vol. ii. part 2 (Miscell.), p. 71.

Having stated that the Upper and Lower Silurian rocks of Europe, including all the fossiliferous strata of Wales, are so knit together by fossils and the transitions of the masses, that they must be viewed as one natural-history series, I will now conclude by simply indicating the small area in various countries to which the Silurian system would be reduced, if the meaning of that term were to be changed and restricted to the upper half of the original system.

In England, though prominent in the typical districts of Shropshire and Herefordshire, the Silurian rocks, so dismembered, would occupy a mere band (scarcely to be defined on a general map) in Brecknockshire, Carmarthenshire and Pembrokeshire; whilst all the broad and specially typical Lower Silurian tracts laid down by me in Salop, Montgomery, Radnor and South Wales must be erased, since it is impossible to distinguish them by their organic remains from the groups of Snowdon. In Ireland, from what we already know, whether through the works of Mr. Griffith, Capt. Portlock, or the labours of the Government Surveyors, the system would pretty nearly disappear, as the great mass of the Irish lower palæozoic fossils are found to be Lower Silurian.

In Russia in Europe and in nearly all Scandinavia, Lower Silurian rocks and fossils only prevailing, the very name Silurian would be swept from the map, and the system so attenuated would there be confined to Gothland and some small Baltic isles!

Now, it must be borne in mind, that even when the lower and upper groups are united in one system as at present, the Silurian rocks of Russia do not occupy one-fifth part of the area of either the Devonian or Carboniferous systems of those regions*, whilst in Germany, the whole system, as at present united, bears an infinitely small proportion to the overlying Devonian group. A glance at the Geological Map of America in Mr. Lyell's work, shows to what a small area, in relation to the other palæozoic rock systems, the Silurian would be reduced, if its lower half were abstracted.

Independent, therefore, of the impropriety of mutilating a system established on the community of its zoological contents, the results of such an arrangement would be a violation of the meaning which ought in fairness to be attached to a great natural-history period, which was typified as such before the Devonian system was thought of. There are indeed authors who think, that the Upper Silurian is so linked on to the Devonian, that the former, or a large portion of it, might advantageously be merged in the latter; and if their views prevailed, the only portion of my system or terrain which Professor Sedgwick's proposition leaves to me would also be swallowed up, and thus, by invasions on both sides, the poor Silurian system would be obliterated.

On the principle however of *strata identified by their fossils*, geologists I hope agree with me in the conviction in which I abide, that in whatever rocks and to whatever depths the Lower Silurian types extend, the tracts so characterized must be considered to belong to the "Silurian System."

* See General Map, Russia in Europe and the Ural Mountains.

In contending for the preservation of that system in its unity, I in no way detract from the very great merit of the researches of my friend Professor Sedgwick in developing the physical structure, dislocations, slaty impress, fossil characters and other phænomena of the rocks of North Wales, Cumberland and Westmoreland.

As already stated, I formerly hoped he would also point out in their lowest division the existence of a distinct zoological type which would have entitled those rocks to a separate name; but having failed to do so, it seems to me manifest, that his "Cambrian" cannot now be sustained by dismembering a fossiliferous system which has been so long established, so largely developed, and so widely applied over the world as the Silurian. Whether geologists will use the word "Cambrian" in reference to still older and often unconformable greywacke lying beneath all the beds with Silurian fossils, it is not for me to determine. My chief object in this communication is to explain how, by the progress of research, the protozoic types of various parts of northern Europe, including North Wales, have been shown to be true equivalents of the lower part of a natural system which I proposed twelve years ago, and which geologists of various countries adopted after a careful scrutiny of the evidences on which it was established.

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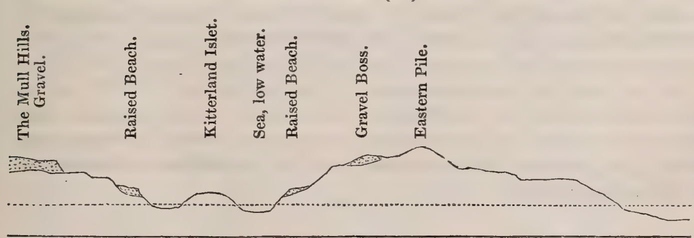
2. *On the Geology of the* CALF OF MAN. By the Rev. J. G. CUMMING, M.A., F.G.S., Vice-Principal of King William's College, Isle of Man.

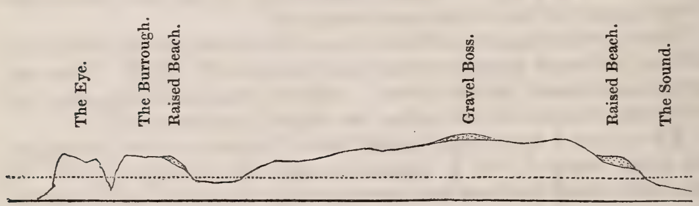
THE Calf of Man is an islet of about 800 acres in superficial extent, situated at the south-western extremity of the Isle of Man, and separated from it by a narrow channel, in breadth not more than 500 yards, called "the Race" or "Sound" of the Calf. Nearly in the centre of this channel, but rather towards its northern side, lies the small rocky islet of Kitterland, between which and the Isle of Man the channel is fordable at low water, and between it and the Calf islet the passage is rendered dangerous by several sunken rocks, the tide rushing through the channel at certain periods of ebb and flow at the rate of nine miles per hour.

Section (1.)



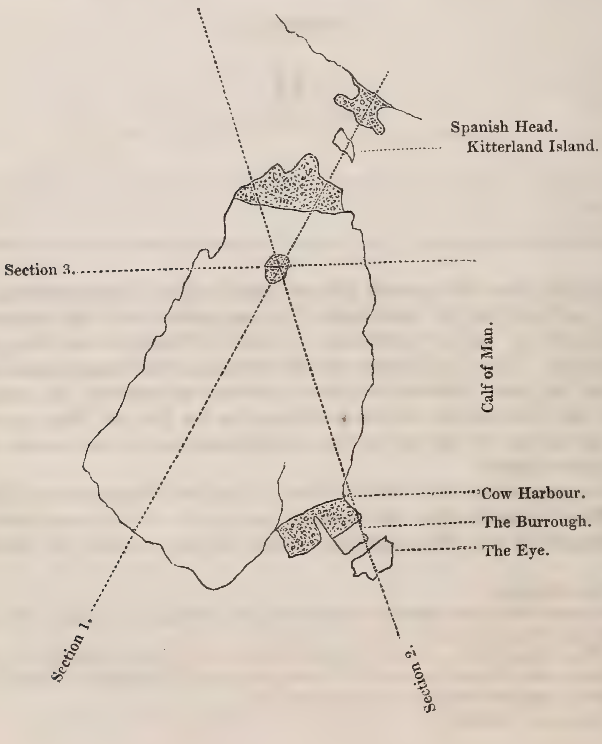
Geologically, the islet of the Calf must be considered simply as a prolongation of the Mull hills, separated from them by a chasm at right angles to the general axis of elevation, and which corresponds, in fact, with the larger chasms, which, when the sea was at a higher relative level, formed channels at Port Erin, Fleshwick and Peel. It rises gradually from the south-western extremity, the northern and

Section (2.)



south-eastern side presenting to the sea precipices to the height of 470 feet, the highest point being at the pile near the ruins of Bushel's

Map of Calf Islet.



house. Off the western point is the dangerous reef of the Hen and Chickens, the two revolving lights on the Calf, when brought in line, bearing upon them.

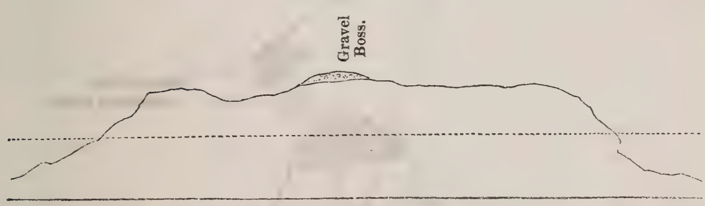
The Stack is a singular pile of rocks near the light-houses, standing out in the sea about fifty feet from the land, as does also the Eye of the Calf, near the Burrough, so called from its being pierced by a natural archway. The Burrough * is pierced in a similar manner, both of them by the continued wearing away of the sea acting at the present, and at a higher relative level, in the direction of the strike of the schists of which they are composed.

These schists (highly inclined) constitute the main body of the islet of the Calf, their general strike being magnetic S. 70° E. Near the before-mentioned highest point a mass of greenstone appears, and in its neighbourhood the schists are slightly metamorphic.

The author† discovered a small vein of copper near the Burrough, its strike being S. 60° E. magnetic, and dip at angle of 70°. It has been stated that lead has been found on the islet, but the author has not himself observed any indication of that mineral.

It is however the object of the present paper more particularly to direct attention to a very singular isolated mass of scratched boulders, gravel and sand, rudely stratified, situated on an elevated point of

Section (3.)



the schist near the eastern pile erected for the Trigonometrical Survey, and at a height calculated, by comparison with the known elevation of the upper lighthouse‡, to be 372 feet above the present sea-level. The explanation of the phænomenon bears upon the solution of some difficulties which present themselves in connexion with the distribution of erratic blocks in the Isle of Man, as well as on the depth of the sea in this neighbourhood at the period of the boulder deposit.

In a paper by the author on the "Tertiary Formations of the Isle of Man," (read before the Society on the 4th of February 1846, and published in the 'Proceedings' in the August number of the Quar-

* See Section 2.

† Though the third person is used here and subsequently, this is the original paper and not an abstract.—Ed.

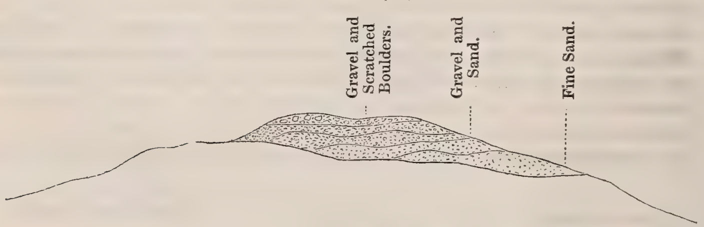
‡ The author thinks that the 550 feet given in Dr. Berger's Report of the Isle of Man, in the 2nd volume of the Transactions of the Geological Society, as the height of Spanish Head, is a misprint for 350.

terly Journal of the same year,) certain deposits were described under the term *Diluvium*, consisting of "yellow sandy loam with patches of gravel, and rounded masses, chiefly of insular rock, developed on the mountain sides, and filling up the valleys in the interior of the island." This formation he ascribed to a transporting diluvial action, principally from the north-east, during the prevalence of an arctic climate. The difficulty presenting itself was, that whilst blocks of the South Barrule granite are found driven over the top of South Barrule 600 feet above the granitic boss, and at a height of 1545 feet above the present level of the sea, and are plentiful on the south-western side, blocks of the same granite are scattered also over the southern area of the island, and are found at points even south-eastward of the granitic boss.

The author is now inclined to place a larger portion of these deposits, than he had previously done, under the head of the Boulder Clay formation, which he supposes to have been aggregated in an arctic climate *below* the then *ordinary* sea-level, and by ordinary currents without any *necessarily violent* diluvial action, though he would not by any means exclude such an action *at intervals* during the formation. He now presumes that an elevation of the sea-bottom to the extent of at least 400 feet has taken place in this neighbourhood since the period of the boulder deposit, and he is inclined to think that the curved line on the southern side of South Barrule, indicating the extent of the tertiary formations (coloured yellow in his general Map of the Isle of Man), points out very nearly the ancient sea-shore of that period. These conclusions are based on an examination of the conditions which seem requisite in order to account for the occurrence of the insulated mass of the boulder formation in the before-mentioned locality in the Calf of Man.

The mass itself (which is about thirteen feet thick and fifty feet across in each direction) consists, as just stated, of boulders, gravel and sand. The sand is chiefly at the base of the formation, and in it occur a few pebbles and laminæ of fine gravel; as we ascend, the size of the fragments of rock increases; we have a bed of fine, then of coarse gravel, and the uppermost portion consists generally of large rounded pebbles with good-sized boulders which are scratched and grooved. Most if not all the rocks are foreign. There are not any which the author can certainly claim as belonging to this locality.

Section (4.)



There are red and grey syenites, porphyries, granites, grits and sandstone, either from Cumberland or the south of Scotland. And though there is no doubt that the drifting currents of this period passed over the limestone area of the south of the island in this direction, the author has not met with a single pebble of the limestone in this mass of boulders and gravel. A good section is developed in consequence of a large excavation having been made into the hillock for the purpose of procuring gravel for the neighbouring road.

It will be observed that the stratification or quasi-stratification is not horizontal; it seems in fact to follow in general the outline of the surface of the hillock itself, and to consist of concentric layers forming a semi-ellipsoidal mass.

As before noticed, it is situated on an elevated ridge of the schist —not exactly on the summit, but rather to the western side; on the eastern side, in the direction over which the materials constituting this hillock must have passed, is a deep depression*, in which is a turf bog, whence a small rill takes its rise. The depression is such that a person standing there has no view of the sea in any direction, yet the author could discover in this hollow no traces whatever of gravel, boulders, or sand, nor in any other similarly situated hollows on the island. The gravel beds on the low ground at the eastern and western extremities of the island† belong to raised beaches of a more recent geological period. At the highest point of the island, near the western pile, he found one or two small boulders of granite, and on the Mull Hills ‡, at a corresponding height, large boulders of syenite and porphyry, where also we have the appearance of a terrace (rather inclining towards the sea) of gravel and loamy sand, but not exhibiting any clear evidence of regular stratification.

With respect to the origin of the gravel boss on the elevated eastern extremity of the Calf, the author cannot conceive it attributable to any violent diluvial action, as the rushing of great waves of translation over the surface of the island, though he has no doubt of the fact of such diluvial action at some period or periods. Any such waves must rather have exercised a denuding force upon so elevated and moveable a mass, and are inconsistent with the occurrence of the large bed of fine sand in the lower portion, as well as with the absence of any like deposit in any of the neighbouring hollows.

The absence of any such deposits seems also to militate against the idea that this boss is to be regarded as a relic of a larger extent of sand, gravel and boulders spread out on the then sea-bottom. It appears perfectly isolated, and at unity only with itself. The only remaining hypothesis, (as it seems to the author,) and the one which he ventures to propose for the solution of the problem, is that of a *grounded iceberg*, melting and depositing quietly its load, subjected however to the gentle action of the drifting current from the E.N.E. (*i. e.* nearly magnetic east), of which the evidence was detailed in

* See Section 3. † See Map of Island.
‡ See Section 1, and Map of the Calf Islet.

his paper on the Pleistocene deposits of the Isle of Man, read in February 1846.

The author is aware of a difficulty in supposing so large a mass of sand, gravel and boulders to have been deposited within so limited an area by the deliquescence of a single iceberg, and he therefore submits the question with diffidence to those who have observed the carrying power and contents of icebergs in the present time, and the character of the deposits resulting from them.

Yet of the agency of ice*, in some shape or other, in the formation of this mass, he thinks the grooved boulders afford a fair evidence; and it only becomes a question of the greater or less depth of sea above this particular locality at the period of its deposit.

Supposing this very point to have been only just within the action of the tides, and to have been left dry at low water, we still have this fact before us, that the sea during the pleistocene or boulder deposit was at a higher relative level with the land than it is at present, by at least sixty fathoms.

It ought also to be borne in mind, as supporting this hypothesis, that the fossils occurring in the boulder deposit of this island, both in the north and south, belong (as Professor E. Forbes has shown†) to the second and third regions of depth‡. We must bear in mind also that the occurrence of boulders of the South Barrule granite, in the boulder formation of the south of the island, is an indication of the existence at the surface of that granitic boss at this period; and there can be no doubt that the *general* contour of the island was then the same as at present. We have also taken the supposition that this mass of gravel on the Calf of Man might be only just within the action of the tide, but in reality it might be many fathoms below the sea-level, and yet be sufficiently elevated to detain an iceberg in its course. The author's opinion, as before stated, formed from the study of this along with other phænomena connected with the boulder clay deposit in different parts of the Isle of Man, is, that the sea-bottom of the glacial period has in this neighbourhood been elevated certainly not less than 400 feet.

We are thus in a condition to interpret more readily the occurrence of the granite boulders of South Barrule in various parts of the southern basin of the island, at points even east of south from the boss where the granite is "*in situ*." With a sea-level 400 feet higher than at the present time, reaching therefore to the base of the granitic boss, and with an arctic or subarctic climate, blocks of

* Some particular condition of *packed ice* may perhaps better assist in explaining the phænomenon.

† Memoirs of the Geological Survey of Great Britain, vol. i. p. 385.

‡ In addition to the fossils from the pleistocene marine formation of the island which were noted in the author's former paper, published in the 'Proceedings' in August 1846, as named by Professor E. Forbes, from the author's cabinet, the following have since been added:—*Nassa macula*; *N. monensis*, described by Mr. Strickland in the 'Proceedings'; *N. reticulata*; *Fusus Sabini*; *Mactra solida*; *Pleurotoma turricula*, a smooth species, No. 127 of Forbes's Memoir in the Geological Survey; *Astarte compressa*, several varieties; *Natica clausa*; *Tellina baltica*; *Corbula nucleus*.

this granite might be floated off by ordinary currents, drifted out a few miles to sea, and there dropped.

With respect to the granitic blocks found near the top of South Barrule and on its western side, it is evident that unless we suppose that point which is now the summit of South Barrule to have been below the granitic boss at the period of the boulder formation and to have been since elevated 600 feet or more, no *ordinary* drifting of icebergs could have transported those blocks to their more elevated position, as the summit of South Barrule is hardly more than a mile and a half distant from the top of the granitic boss.

But we may imagine such an effect produced by the *extraordinary* action of great waves of translation (as described by Sir R. I. Murchison), acting upon masses of ice charged with these granitic blocks, and bearing them to a considerable elevation even above the then sea-level.

Before concluding this paper the author has a few observations to make upon the drift gravel, in addition to his notice of it in his former paper on the Pleistocene deposits of the island. He there stated "it is generally found capping the lower hills, and sometimes spreading out into extended platforms, its materials being evidently derived in great part from the boulder formation." In this deposit he classed a series of rounded hills in the south of the island, situated on a line from Coshnahawin to Kirk Arbory, the chief being the Creggins and Skybright near Malew church. He considered that they might be the relics of the highest level of the drift, and formed by the beating about of the waves during a period of elevation. Now that he has seen this stratified mass of gravel, sand and boulders at so elevated a point as the Calf Islet, he is disposed rather to class them in the "boulder clay formation," restricting the term "drift" to the more regularly stratified deposits of gravel, shingle and sand, forming one extended platform, rising very gradually towards the centre and north of the island, of which the fragments on the lower ground of the Calf Islet and on the opposite side of the Kitterland Strait present the lowest elevation, which is about twenty-five feet above high water.

It indicates that there was a considerable period of quiescence in the elevatory process by which the glacial sea had been gradually becoming shallow. The author is of opinion that it was the *sudden* elevation of this last sea-bottom which connected the Isle of Man with the surrounding countries, and introduced the *Megaceros hibernicus*, whose remains we find in the ancient freshwater alluvia in various parts of the island.

PROCEEDINGS,

ETC.

POSTPONED PAPERS.

Observations on the TEMPLE *of* SERAPIS, *at* POZZUOLI, *near* NAPLES, *with remarks on certain causes which may produce Geological Cycles of great extent.* By C. BABBAGE, Esq. F.R.S. L. & E.

[Read March 12, 1834.]

[This paper, by the request of the author, was returned to him soon after it was read, and has been in his possession ever since. Other avocations obliged him to lay it aside, and he only recently returned it to the Council, ready for publication. An abstract both of the facts and of the theory, drawn up by the author, was however printed in the Proceedings of the Geol. Society for March 1834, vol. ii. p. 72.]

THE facts and observations which I have thrown together in the following paper were collected during the month of June 1828, in company with Mr. Head *. They relate to a monument of ancient art, which is perhaps more interesting than any other to the geologist.

I shall first state the facts which came under my own observation, without assuming that they have not been previously noticed, though not aware of their having yet been collected into one point. I shall then suggest an explanation of the singular phænomena which the temple presents, and afterwards briefly sketch those more general views to which I have been led by reflecting on the causes that appear to have produced the alternate subsidence and elevation of the temple of Serapis.

In the year 1749, the upper portions of three marble columns that had been nearly concealed by underwood, were discovered, in the neighbourhood of the town of Pozzuoli. In the following year excavations were made, and ultimately it was found that they formed part of a large temple which was supposed to have been dedicated to the god Serapis.

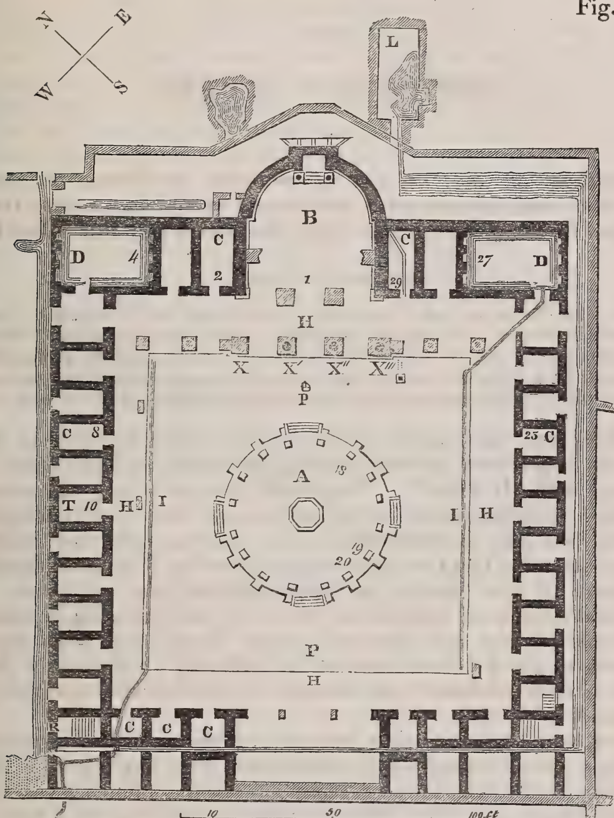
The temple is situated about a hundred feet from the sea, and its form will be better understood by the accompanying view (see Plate I.), taken with a camera lucida, and by the ground plan (fig. 1) which is copied from that in the work of the Canonico Jorio.

The most remarkable circumstance which first attracts the attention of the observer is the state of the remaining three large columns. Throughout a part of their height, commencing at nearly 11 feet above the floor of the temple, and continuing about 8 feet, they are perforated in all directions by a species of boring marine animal, the *Modiola lithophaga* of Lamarck,—which still exists in the adjacent parts of the Mediterranean.

* Now Sir Edmund Head, Bart.

I shall now give a description of the Temple of Serapis from the notes I made in 1828.

Fig. 1.



1. The external walls of the temple are lowest on the side nearest the sea, where they are about 7 feet 6 inches high. They gradually rise in height, until, at the extreme end of the cella, the portion which remains measures 13 feet 4 inches above the pavement of the temple.

2. The three columns X′, X″, X‴, each about 41 feet high and 4 feet 11 inches in diameter at the base, are nearly similar, and are represented in Plate I., X′ being the left-hand column in the plate. The pavement of that part of the temple marked I I, figure 1, is about 5 inches lower than the rest of the internal area.

The height of the top of the base of the shaft above the pavement is 2 feet 4 inches, and the marble of which it is composed is uninjured. That part of the shaft of the column immediately above it presents nothing remarkable up to the height of 5 feet 8 inches.

3. At this point commences a calcareous coating, which covers

the marble for about 1 foot of its height. A space of 1 foot 5 inches follows, which is uncovered and uninjured.

4. It is at this point that the most remarkable phænomenon presents itself. The column is here pierced with a number of holes, in many of which are the remains of the Modiola: these remains are firmly fixed in the holes by a dried paste of sandy mud. The attempts of successive visitors have broken most of the shells, and it is difficult, even where the external aperture of the holes admits it, to extract a perfect specimen. Those which are now before the Society were acquired by many hours of labour, during which I first loosened the paste with a steel wire, and then picked out with a pair of tweezers the particles of mud and sand which clogged up the shells. The length of that part of the column thus perforated is as nearly as I could measure it 8 feet $2\frac{1}{2}$ inches; the lowest perforation being 8 feet 1 inch above the base, and the highest being 16 feet $3\frac{1}{2}$ inches above the same level. Near the top of the perforated portion there appears to be a slight indentation quite round the columns, which seems to mark, by the corrosion at that spot, that it remained for a considerable time the line of the level of water.

5. At 6 feet 6 inches above these perforations, the column X″ appears to be cracked nearly through its whole thickness. There are indications of cracks in the two others, but they are more doubtful, and further information on this point is required.

The remaining 15 feet 8 inches of the column is uninjured; its total height above the pavement was found, by measuring with a tape, to be 41 feet1 $\frac{1}{2}$ inch, which exceeds the sum of the measures of the separate parts by $4\frac{1}{2}$ inches: the height, as found by the means of four measures with a box sextant, was 41 feet $4\frac{1}{4}$ inches.

A number of fragments of columns are scattered about in the temple. They are of three different sizes, which will be denoted by (1), (2), (3). They are described in the following list.

List of Fragments.

6. A fragment of the upper part of a large column (1) of Cipolino marble, 15 feet long, 13 feet girth. It is perforated in every part, along the whole length and also at the two extremities, one hole of a Modiola being actually in the axis. It is represented in the annexed woodcut (fig. 2.) Serpulæ are attached to this column, and some are found within the holes previously occupied by the Modiolæ.

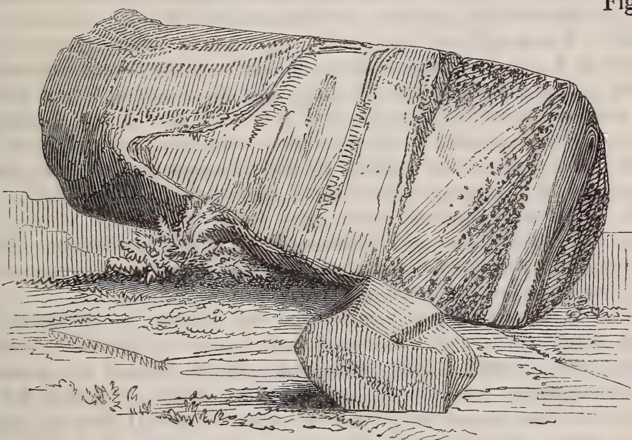
I extracted from the perforations two complete specimens of an Arca, and also one single valve of the same species of shell. The holes in which these occurred were rather larger than the shells they contained. A thin fragment is split off from one end of this portion of a column.

The fragment itself was found at a considerable height above the pavement of the temple, and remained for some time on an elevated bank of sand which the workmen had left. It is so represented in some of the older engravings.

7. A fragment of Cipolino (1), length 10 feet. It is the middle part of a column. There was a tufaceous deposit remaining on this, in which were noticed some very small bits of brick: part of this deposit covers the broken angles and the ends of the fragment.

The part of the column, which was nearly horizontal, was covered with this deposit to the depth of from a quarter to half an inch, and the rain had washed portions of it away, leaving little miniature columns protected by small caps of stones on their tops. These forcibly reminded me of the clay pillars in the valley of Visp, which I had visited several years before in company with my friend Sir J. Herschel. Several of those pillars were from 50 to 70 feet high, whilst none of these on the fallen fragments of the columns of the temple attained as many hundredths of an inch. There were no marks either of shells or of Serpulæ on this fragment.

Fig. 2.



8. A fragment of the bottom of a column (1), 17 feet long. The upper edge of the calcareous coating (see par. 3) is 6 feet 4 inches from the base; the breadth of the zone about 1 foot; height to lower edge of disintegrated part of column, 8 feet 7 inches. This fragment is perforated on the upper or broken end almost in the axis, and the disintegrated part is perforated.

The three preceding fragments appear from their dimensions to have formed parts of one column. Their united length is 42 feet, which is about the height of the columns that remain standing. I did not however record in my notes whether the broken ends favoured this supposition.

9. A fragment (1) 7 feet 4 inches long, perforated at both ends, and all over.

10. A fragment 11 feet 4 inches; from base to beginning of calcareous zone 6 feet 7 inches; breadth of zone 1 foot 4 inches; from base to beginning of disintegration 7 feet 11 inches: not perforated at the base.

11. A fragment (2) of lower portion of a column of African breccia, length 6 feet 10 inches; from base to beginning of disintegration 4 feet: not perforated at the end.

12. A capital of white marble perforated; but only four decided marks were observed.

13. A fragment of Cipolino, 9 feet long, the upper end of a column; from the upper end to the beginning of disintegration 7 feet: disintegrated, but not perforated at the fracture.

14. This fragment is half-buried; it is perforated, but not at the end.

15. The lower part of a column (2) of Cipolino, length 12 feet 6 inches; the base is smooth; length from base to top of calcareous zone 3 feet 11 inches; depth of that zone 1 foot; from the top of the zone to the bottom of the disintegration is 7 inches.

16. The lower part of a column of African breccia, length 6 feet 5 inches; it is smooth at the base; from base to upper edge of calcareous zone 3 feet 9 inches; breadth of zone 1 foot 10 inches: not perforated at broken end.

17. Two small fragments; short, and both perforated.

18. A fragment (2) of African breccia, length 8 feet 5 inches, the lower part of a column; from base to top of calcareous zone 2 feet 8 inches; breadth of zone about 1 foot; base to disintegration 4 feet: end not perforated.

19. A fragment, the bottom part of a column (2) of Cipolino, length 9 feet 8 inches; calcareous zone indistinctly marked; from base to disintegration 3 feet 4 inches.

20. A split fragment 7 feet long; it is disintegrated, and has Serpulæ upon it along its whole length, and also at the end.

21. A column of Cipolino, 13 feet 6 inches long; top diameter 1 foot 7 inches; lower diameter 1 foot 10 inches: no perforation or disintegration.

22. A fragment (2) not perforated at the fractures.

23. Fragment of the bottom of a Cipolino column, length 9 feet; from base to disintegration 4 feet 6 inches; zone indistinct; breadth of zone 1 foot 11 inches; height of top of zone from base 4 feet 2 inches: no deposit on the fractured end; no perforations on the fracture.

24. A fragment of the bottom of a column of African breccia, 12 feet 6 inches long; from base to disintegration 3 feet 8 inches: no calcareous zone; end perforated.

25. A fragment of a granite column, length 7 feet 8 inches; from base to lower edge of zone 4 feet 3 inches; breadth of zone 3 feet.

26. A fragment of a granite column, length 9 feet 2 inches; from base to lower edge of zone 4 feet 3 inches; breadth of zone 3 feet 4 inches.

27. Fragment of granite column, length 11 feet 2 inches; from base to lower edge of zone 4 feet 4 inches; breadth of zone 2 feet 10 inches.

28. Fragment of bottom of a column (2) of Cipolino, 12 feet 9 inches long; from base to disintegration 6 feet 6 inches: not perforated at end.

29. Three fragments perforated.

30. There are two fragments of small entablatures with the holes drilled for working the leaves, but they are not chiselled.

31. An unfinished cornice at the door of T 10, and an unfinished slab at the door of T 5, partly covered with calcareous deposit.

32. A square block eaten (so in Notes, query perforated?).

	ft.	in.
33. The diameter of the large columns is..............	4	11
The diameter of the second size................	2	6
Height of the base on which the shafts of the large columns stand............................	2	4
Height of the base on which the columns in the elevated central part A stand	1	4
Height of elevated central part A above floor of temple..................................	3	7
Step from pavement H down to the pavement I P surrounding the central part..................	0	5

Par. where described.	Material of column.	Portion.	Size of column.	Length of fragment.	Great incrustation. Height of top of calc. zone.	Great incrustation. Breadth of calc. zone.	Height of bottom of decomposing part.	State of fragment.	Position on plan.
				ft. in.	ft. in.	ft in.	ft. in.		
2, 3, 4	Cipolino . . .	whole	(1)....	38 9½	6 8	1. 0	8 1	.. ..	1
6	Cipolino . . .	top . .	(1)....	15 0	.. .. ..	.. .. ..	.. .. ..	Perforated all over, and at both ends	2
7	Cipolino . . .	middle	(1)....	10 0	.. .. ..	.. .. ..	.. .. ..	No perforations. . .	3
8	Cipolino . . .	bottom	(1)....	17 0	6 4	1 0	8 7	Perforated at top, and in axis......	4
9	.. ..	.. ..	(1)....	7 4	.. .. ..	none	.. .. ..	Perforated all over, and at both ends	5
10	.. ..	.. ..	.. ..	11 4	7 11	1 4	7 11	Not perforated at the end..........	6
11	African breccia	bottom	(2)....	6 10	.. .. ..	.. .. ..	4 0	Not perforated at the end..........	7
13	Cipolino . . .	top . .	.. ..	9 0	.. .. ..	.. .. ..	7 0	Not perforated at the fracture......	9
14	.. ..	.. ..	.. ..	.. ..	.. .. ..	.. .. ..	.. .. ..	Perforated, but not at the end.......	10
15	Cipolino . . .	bottom	(2)....	12 6	3 11	1 0	5 6	.. ..	11
16	African breccia	bottom	.. ..	6 5	3 9	1 10	.. .. ..	Not perforated at fracture.........	12
17	.. ..	.. ..	2 frags.	short	.. .. ..	.. .. ..	.. .. ..	Perforated........	13
18	African breccia	bottom	(2)....	8 5	2 8	1 0	4 0	End not perforated	14
19	Cipolino . . .	bottom	(2)....	9 8	.. .. ..	indist.	3 4	.. ..	15
20	.. ..	.. ..	.. ..	7 0	.. .. ..	.. .. ..	.. .. ..	Serpulæ at end, and on whole length..	16
21	Cipolino . . .	.. ..	.. ..	13 6	.. .. ..	.. .. ..	.. .. ..	Not perforated....	17
22	.. ..	.. ..	(2)....	.. ..	.. .. ..	.. .. ..	.. .. ..	Not perforated at fractures........	18
23	Cipolino . . .	bottom	.. ..	9 0	4 2	1 11	4 6	Perforations--none on fractured end	19
24	African breccia	bottom	.. ..	12 6	.. .. ..	.. .. ..	3 8	End perforated....	20
25	Granite	bottom	.. ..	7 8	7 3	3 0	.. .. ..	.. ..	21
26	Granite	bottom	.. ..	9 2	7 7	3 4	.. .. ..	.. ..	22
27	Granite	bottom	.. ..	11 2	7 2	2 10	.. .. ..	.. ..	23
28	Cipolino . . .	bottom	(2)....	12 9	.. .. ..	.. .. ..	6 6	Not perforated at fractures........	24
			3 frags.	.. ..	.. .. ..	.. .. ..	.. .. ..	Perforated........	25

Of the Dark Incrustation.

34. On examining the internal walls of the temple, there appears in several of its chambers a dark brown incrustation. Several horizontal lines darker than the rest indicate that this incrustation is a deposit from water, which must have remained in the temple at various heights, from about 2 feet 9 inches to 4 feet 6 inches.

35. The incrustation is of a deep brown colour, varying in thickness

from one-sixtieth to about one-twentieth of an inch. It does not adhere very strongly to the walls, which may probably be one reason for the small quantity that remains attached to them. Mr. Faraday, who kindly undertook to examine this, as also the other deposits which will be alluded to, states that "it consists principally of carbonate of lime; but there is also present a little combustible matter, pretty universally diffused through the mass; there is also a portion (small) of peroxide of iron present."

36. The following are my notes made on the spot. The dark incrustation is seen in the chamber marked C 2, fig. 1. It extends over (covers) a piece of marble panelling, and is visible on the walls where there is no panelling. Serpulæ occur upon the incrustation on the marble panelling. Its height from the floor to a dark well-defined line about its middle is 3 feet 6½ inches.

It is again visible in the chamber marked 23 C, but no Serpulæ were observed: height to about its middle 3 feet 4 inches.

In the chamber 29 C, the same deposit is seen extending over the stucco and over the fragments of marble imbedded in it. Its height from the floor to the lower edge is 2 feet 9 inches.

Of the Great Incrustation.

37. At the height of about 9 feet from the floor of the temple a level line runs round several of the chambers, which marks the upper edge of a thick incrustation, evidently deposited from water. The average depth of this incrustation is about 2 feet, but the lower edge, although perfectly well defined, is not a level line; it is in several places slightly inclined and irregular, as it would have been if the lower part of the temple had been filled up with ashes or sand or any other substances. The incrustation covers pieces of wrought marble, African red, &c., and does not fill up certain small holes in the walls but incrusts the inside; also the joints between the marble slabs are indicated by a re-entering in the incrustation.

38. This deposit is visible both on the outside and the inside of the temple. At the north corner, on the outside just beyond the archway, five or six dark lines could be traced, as if each had successively been the line of water-level: the moulding of the archway is in many parts covered with this deposit.

In the chamber marked C 8, on the wall as you enter on the right-hand, the upper edge of the deposit is level, but the lower edge inclines towards the centre of the temple.

39. On the inner walls at the south or sea side the deposit is scarcely visible, but it may be seen decidedly to exist in the chambers C to the west of the great entrance. It extends over the marble panelling which remains, as well as over the broken plaster.

It is not visible on the top of the walls on the upper broken edge.

40. The height of the upper edge of this incrustation above the pavement of the cella B is 9 feet 4 inches, and its average depth about 2 feet.

This incrustation varies in thickness from one-tenth to nearly one-fourth of an inch; it is hard, and appears to consist of layers deposited in succession, the inner layers being rather more crystalline than the outer.

The exterior surface shows a number of large striæ extending in a vertical direction, and in some parts presents the appearance of being mammellated.

Mr. Faraday informs me that "this deposit consists principally of carbonate of lime. A little sulphate of lime is present, and also a little oxide of iron with silica and alumina, but all these together do not probably make more than four or five per cent. I can find no magnesia, nor any but the minutest trace of muriates."

Of the Strata in which the Temple was imbedded.

41. At the north corner of the temple on the outside, behind the chamber D 4, I found a good section of the bed by which the temple was covered up. It is about 20 feet high, and I regret that although I measured and noted the thickness of some of the strata and brought away specimens, yet I did not examine them with that minuteness which my subsequent reasonings upon the facts convince me they well deserve.

No. 1, commencing from the present surface of the adjacent country, is a bed which appears to be a modern accumulation of rubbish. The foundation of a stone wall penetrates this bed, but does not enter the next.

No. 2 is a bed of coarse sand apparently volcanic, and of pebbles mixed with sea shells : it is about 1 foot 3 inches thick, and resembles No. 6, except that it has shells and contains more crystals.

No. 3 is a dark grey sand about 6 inches; it is almost entirely composed of crystals, and is clearly volcanic.

No. 4 is composed of coarse sand and pebbles, and is about 8 inches thick.

No. 5 is composed of waterworn brick, sea-shells and shingle. In it occur masses of rolled brick-work, some of them measuring a foot in each direction. Serpulæ are attached to them, and in their interstices shells are found sometimes in good preservation. This bed also contains portions of mosaic, and is about 1 foot 8 inches thick.

No. 6, or the lowest bed, is probably volcanic tuff. It resembles it in colour, and in the roughness and angularity of its aggregated grains ; in the silky pumice-like appearance of some parts, and in containing very minute black grains, possibly hornblende and specular iron. It is pulverulent like that above Pompeii. I did not observe any shells in it, nor are there any indications of its having been rolled by the sea, although in one part of the section there was an efflorescence of salt.

I believe these beds succeed each other, but unfortunately I omitted to measure their height above the pavement of the temple, and I only possess specimens of Nos. 2, 3 and 6.

Various Observations.

42. The water of the Mediterranean enters the temple by a channel A A of masonry, about 3 feet deep and about $1\frac{1}{2}$ foot wide.

At the back of the temple a hot spring L exists. This supplies a bath, which then runs over and mixes with the sea water.

At low water the taste of the water in the channel leading to the sea is that of water impregnated with sulphuretted hydrogen; at high water it is that of weak sea water. Frogs were observed in it.

43. About 5 feet below the pavement of the present temple another was discovered very richly ornamented. This may either have been the floor of a former temple, or the bottom of a bath designedly built below the level of the sea. This latter purpose would however have been attended with this inconvenience, that from the extremely small rise of the tides its water would not have been frequently changed.

44. The circular walls of the inner extremity B are disconnected from those of the temple, as if they had been built at a different period.

45. In the upper part of the north-west wall of the chamber 27 D are parts of three windows, two of which appear to have been repaired. In the centre window is a slab of marble containing an inscription.

A considerable crack extends downwards from another of the windows, and there is another crack at the corresponding window on the right, which extends across the whole floor of the room.

Pebbles were found on the top of some of the walls of the temple.

46. The Canonico Jorio remarks that the pavement does not appear to have been broken as if by the fall of heavy bodies; this is generally correct, but the pavement on the step of the sea-side has been removed.

47. The temperature of the bath into which the water from the hot spring flowed was in June 1828—

Bath	99° Fahr.
Air	77
A few days previously I had found	
Water in a vessel in the grotto del Cane	90° Fahr.
In air	70·5
In grotto of Posilipo	65·5

Facts showing a change of the relative Level of the Land and Sea in the neighbourhood of the Temple of Serapis.

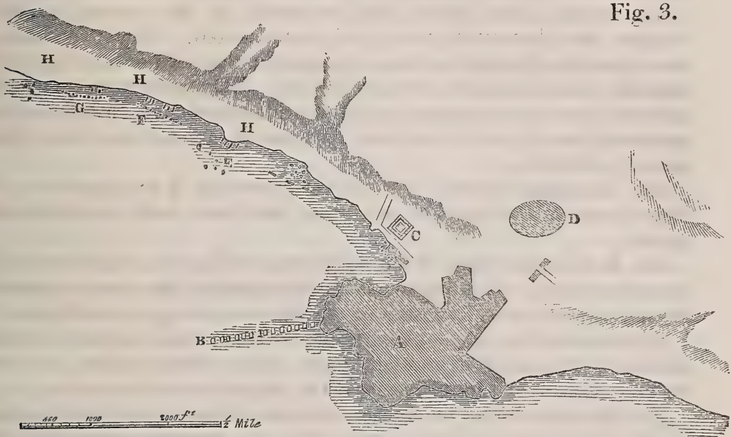
48. About half a mile along the sea-shore towards the west, and standing at some distance from it, in the sea, are the remains of columns and buildings which bear the name of the temples of the Nymphs and of Neptune. See fig. 3.

The tops of the broken columns are nearly on a level with the surface of the water, which is about five feet deep.

49. At the east foot of Monte Nuovo an ancient beach may be seen for about fifty yards, which is two feet higher than the present beach, and which is covered by about seventeen feet of tuff. The part of this older beach which is nearer to Pozzuoli is covered by a stratum consisting of fine sand, shells, and water-worn fragments of brick and pottery.

The whole plain called La Starza, which lies between the inland cliffs and the sea, is of modern formation and consists of beds of pumice or sand, containing recent marine shells, bones of animals and fragments of building not rounded by attrition.

Fig. 3.



A Pozzuoli.
B The Bridge of Caligula.
C The Temple of Serapis.
D The Amphitheatre.
E The Arch of Antoninus Pius.
F The Temple of Neptune.
G The Temple of the Nymphs.
H La Starza.

There are also the remains of two Roman roads, at present under water; one of these reached from Pozzuoli to the Lucrine lake.

50. Another vestige of the art of a remote period which exhibits decided evidence of a change of level, is the series of piers placed in the sea, projecting from the town of Pozzuoli, and known by the name of the bridge of Caligula.

The general depth of the sea around these piers is from thirty-five to fifty feet. There are thirteen piers standing, and two others appear to have been overthrown, as the soundings between the sixth and seventh piers and between the twelfth and thirteenth prove.

51. At the height of about four feet above the present level of the sea on the sixth pier* is a line of perforations, apparently by the Modiola or other boring animal. There are also Serpulæ and other indications of a line of sea-level. I did not find any remains of the shells, and the holes appeared to have been much worn by water.

The depth round this pier, at very small distances from it, was from thirty to fifty feet.

52. On the last pier but one there are great numbers of similar perforations, but I did not discover in them any of the shells: there are also adhering to the bricks great quantities of Serpulæ, and something which appeared like a Flustra. I think these holes are incon-

* I am not quite certain from my notes whether the pier here described is not the fifth, but I am inclined to think not.

testably those of some perforating shell, and they reach as high as ten feet above the present level of the sea.

The structure of this pier is curious; it appears to be formed by fragments of stone and brick, connected by a strong cement, and containing within it, near its end, three small piers of brick, from which apparently the arches connecting it with the adjacent piers sprang.

There are also in this pier long cylindrical holes, both vertical and horizontal, about eight inches in diameter. Some of the piers seem to be cased with brick. These remarks, almost accidentally noticed and perhaps not strictly admissible in a geological memoir, are nevertheless added with the hope of inducing those who may have the opportunity, to measure and examine one of the most interesting records of ancient art.

53. Another instance of alteration of level, although probably of much more ancient date, occurs on the road from Naples to Pozzuoli, near the island of Nisita. The road is cut through a point of rock which projected into the sea. On the inland side a cliff rises, which presents an appearance of a line of sea-level. On examination I found a line containing many perforations, and I extracted from them several casts and bits of shells. One of these is a cast of a species of Lithophagus. After the death of the animal, some small Serpulæ appear to have attached themselves to the inside of its shell, and it was then filled up with tuff. No vestige of the shell remained when I extracted it, but the tufaceous cast is very perfect.

54. In several of these perforations I found casts of a species of Arca; they are small, and do not appear to have been those of the *Arca Noæ*. In one of them I detected a portion of a shell of this genus, which I extracted, and was fortunate enough to find a small fragment which contained the hinge.

Other indications of the former presence of sea-water are the barnacles, which re-appear at intervals adhering to the tuff along this line of perforations.

Inferences from the above facts relative to the Geological History of the Temple.

55. Whether there existed a former temple on the spot occupied by that whose ruins now remain, it is not necessary to discuss.

The rich pavement mentioned (par. 43) as existing five feet below that of the present temple has led to the presumption of a previous building. Had that been the case, the subsidence of the ground on which the old temple stood must have been observed, and would probably have prevented the erection of that with which we are acquainted on the same spot. If this pavement is the remains of a more ancient bath, subsidence previous to the building of the present temple need not necessarily be inferred. Upon this point facts are wanting, and I shall make no conjectures.

There is, *a priori*, considerable probability that a temple, to which were attached a hot spring and baths, was originally built at, or nearly at, the level of the sea, and such I shall presume to have been the case.

56. Beginning at the floor, the first fact we arrive at is the dark incrustation covering the walls of some of the chambers. It occurs in those marked C 2, 23 C, and 29 C.

Now this incrustation could not have arisen from water confined to these chambers only, because two of them (C 2 and 29 C) are at distant parts of the temple, and the height of the lines of the incrustation are almost the same.

57. Neither could this incrustation have arisen from the water of the hot spring alone, for there are Serpulæ attached to it; unless it be supposed that after its deposit the sea entered the temple, in which case a larger quantity of remains of marine animals ought to have been found.

58. The incrustation could not have arisen from sea-water alone, because the water of the Mediterranean does not, in that neighbourhood at least, leave any such deposit. To prove this, I examined an ancient Roman house in very excellent preservation, which stands partly in the sea in the immediate neighbourhood of Naples, and well deserves more attention than I could bestow upon it. The house consists of three stories and the basement. The walls are remarkably thick, and the different stories separated by arches.

59. The basement stands in the sea and is open to it, and may have been used as a bath, a boat-house, or a reservoir for fish. I entered it in a boat for the purpose of examining the wall, which had probably been exposed to the action of the sea ever since the building of the temple of Serapis; but I found no calcareous deposit, as the portion I have placed on the table will testify.

60. This incrustation must have been made either before the temple was ruined, or since it was cleared out. We know it has not happened in the latter period.

61. The reason for asserting that it must have occurred previous to the destruction of the temple, is, that there is no indication of any uneven termination at its lower boundary, as there is in the other great incrustation, and as there would have been if the pavement of the temple had been covered with the rubbish caused by its destruction.

62. The conclusion to which these facts point, is, that at some period after the temple had been built, and before it had been much injured, the ground on which it stood gradually and slowly subsided until its pavement became about 4½ feet below the level of the sea.

63. There was probably in ancient times a channel communicating as there is at present, and thus the sea-water which entered became diluted by the water from the hot spring within the temple. Thus the hot spring supplied the calcareous matter, and the diluted sea-water was still fit for the existence of the Serpulæ.

64. It has already been remarked, that the lines at the lower edge of this incrustation do not give any indications of an uneven bottom; but as it does not, in the few places where it still remains, extend to the floor of the temple, this fact is not conclusive as to the temple not having been filled up to a certain extent previously to its deposit.

It is however certain that after its deposit, the temple must have been filled up to the depth of from 5 to 9 feet, a fact which is plainly indicated by the form of the lower edge of the great calcareous deposit.

Now the lowest stratum in the section adjacent to the temple, marked No. 6 in Plate II. and described at par. 41, has every appearance of a volcanic tuff: although I did not measure its height, I remember it was large compared to most of the others. It probably arose from an eruption of the Solfatara, and falling uniformly over the whole area of the temple, would leave a considerable elevation in the central part, the floor of which was already elevated $3\frac{1}{2}$ feet above the rest of the temple.

If this central part contained, as some have imagined, a circular temple with a marble roof, the weight of 5 or 6 feet of tuff might have broken it down, and thus have caused a still greater elevation in the centre.

65. The next fact given by the observations is the great incrustation. It is much harder and thicker than the preceding, and occurs (see par. 38) behind D 4—in the chamber C 8—in C C, to the west of the great entrance—and also on the standing columns, and on the fragments described in par. 8, 10, 15, 16, 18, 23, 25, 26, 27.

This incrustation cannot have arisen from sea-water, for the reason stated in par. 58. It may have arisen from the hot spring, and this is rendered highly probable from the following fact.

In that singular building called the Piscina mirabile, which is at a considerable distance from the sea, and which is supposed to have been used by the Romans as a reservoir for fresh water, there occurs an incrustation nearly similar in external characters.

Mr. Faraday in speaking of it says, "This is a chemical composition as like the last (that of the temple of Serapis) as possible; I do not find a word to alter. The state of aggregation is different and the successive deposits are not so evident: it is also more crystalline.

"Your first question, whether the first and second deposits (those of Serapis and the Piscina mirabile) are the same substances nearly in the same proportion, is already answered in the affirmative. Your second, of 'whether the combinations they contain are compatible with sea-water, or could they have been deposited in it?' requires a little more reservation: I cannot say that the carbonate of lime is incompatible with sea-water, or that it could not have been deposited from it. But I never heard of such a deposit from sea-water, nor can we now-a-days either naturally, or during the evaporation which goes on in salt-works, &c. &c. On the other hand, they represent perfectly such deposits as are taking place continually from waters holding carbonate of lime in solution by carbonic acid, and I cannot help thinking that such has been their source. In giving this opinion I am guided merely by the appearances of the deposits and their chemical characters, for I know nothing of the circumstances under which they occur, although twenty years ago I happened for a few hours to be at the temple of Serapis."

66. It should be noticed, that the portion of the incrustations attached to the standing columns and to the fallen fragments, although the same in chemical composition, is not quite so hard, and is in a different state of aggregation from that on the walls; also that no remains of Serpulæ or other sea shells have been noticed on it. The upper edge of this incrustation is level; the lower edge is irregular, as it would have been if the bottom of the temple had been filled up.

67. The conclusion from these facts is, that after the temple had subsided to a small extent its whole area was filled, either from a shower of volcanic ashes, or from some other cause, up to a certain height, apparently leaving the centre most filled up—that the same cause probably closed up the channel communicating with the sea—that in consequence of this, the water from the hot spring, having no outlet, filled the temple to such a height, that the waste from leakage and evaporation equalled the supply.

68. Admitting this explanation, the temple could have suffered little from decay previously to this event. Some of the marble panelling may have fallen down, as one of the specimens seems to prove. But the greater part of the columns must have been standing, because their fragments are surrounded by zones of various breadths arising from this incrustation.

69. From considering this fact, we are enabled to restore many of them to the positions which they must have occupied. Thus the fragment described in par. 8, and marked (4) on the plan and in the table, must have been a portion of one of the large columns standing on its base during the period this incrustation was forming, because—

	ft.	in.
Height of top of incrustation on column...........	6	4
Height to the base of the shaft of the large column ..	2	4
	8	8

The sum of these gives very nearly the average height of the top of this incrustation above the pavement of the temple, which was about 8 feet 10 inches or 9 feet.

70. Again, if we extract from the synopsis the two instances in which the lower portions of smaller Cipolino columns have marks of incrustation, we find from—

	ft.	in.
No. 15	3	11
No. 23	4	2
Average	4	0½
Add to this, height of the base, from No. 33........	1	4
Height of central part of temple, from No. 33	3	7
	8	11½

which is nearly the height of the great incrustation.

P 2

71. Again, the granite columns give the following height of the incrustation:—

	ft.	in.
From No. 25	7	3
From No. 26	7	7
From No. 27	7	2
Mean height	7	4
Add height of base	1	4
Height of great incrustation	8	8

These columns therefore could not have stood in the central elevated part of the area of the temple, because in that case the incrustation must then have been 3 feet 7 inches lower down on them.

72. If we compare in the same way the two portions of the columns of African breccia, we find—

	ft.	in.
No. 16, height of top incrustation	3	9
No. 18, height of top incrustation	2	8

Now the difference of 1 foot 1 inch in the height of the water-line is too large to attribute to any uncertainty in the measures, and leads me to believe that I must have entered in my note-book by mistake the word 'top' instead of 'bottom' of incrustation, when recording the fragment described in No. 18. If this were the case, then, adding the breadth of the incrustation which is 1 foot, we have for the top of it 3 feet 8 inches, which I shall adopt.

	ft.	in.
Hence No. 16, height of incrustation	3	9
No. 18, height of incrustation	3	8
Mean height	3	8½
Height of base	1	4
Height of elevated central part of the temple	3	7
	8	7½

which again is nearly the height of the top of the incrustation. It is however known that the columns of African breccia were part of the central temple.

73. There is, however, one circumstance which requires an explanation. The fragment described in par. 7 is covered with a calcareous deposit of the same nature as that which we are considering. It is the middle portion of a large Cipolino column, of which No. 8 is the base and No. 6 the top.

Now since the middle portion must have fallen into the lake formed by the hot spring (for it is incrusted all over), it is natural to inquire, why the top portion has escaped that fate, and is found perforated in all directions by the Modiolæ? The solution of this difficulty seems to be, that the top portion of the column fell on a part of the filling up of the temple which was above the reach of the lake formed by the hot spring, whilst the middle portion fell nearer the base of the column and into the lake; consequently, when the lake was filled up this fragment was covered up, and when the whole subsided into the sea, the part on the higher ground became immersed and perforated all over.

The fragment (par. 15) must have been standing on the central or elevated part of the temple when the great incrustation was formed, because—

	ft.	in.
Height of top of deposit from base	3	11
Height of base	1	4
Height of central part of temple	3	7
	8	10

which is the height of the great deposit. On the other hand, its top reaches 7 feet above the lowest perforations of the Modiolæ; for—

	ft.	in.
Height of fragment	12	6
Height of its base	1	4
Height of central part of temple	3	7
Height of fragment above floor of temple when standing	17	5
Lowest perforation	10	4
	7	1

It would appear, since 7 feet 1 inch of the height of this column must have been under water, that its upper part ought to have been perforated, which was not the case. It follows, therefore, either that, prior to the subsidence below the level of the sea, this central part of the temple was filled up to the depth of nearly 18 feet, whilst the surrounding part was not filled above 11 feet—an improbable supposition—or that after the great incrustation the temple must have been overthrown prior to its subsidence, and probably before the second filling up.

74. This is further confirmed by the fragment described in par. 24, which is of the same length. Being of African breccia it must have stood on the central part, and its top must have been at the same height above the floor of the temple as that of par. 15. It *is* perforated, and at the broken end, and therefore could *not* have been wholly covered up prior to the subsidence of the temple into the sea.

If it had been thrown down after that event, the whole length would have been perforated, which was not the case.

75. The next fact which presents itself is an appearance of disintegration on ten of the columns or fragments, which is not always accompanied with perforations of the Modiolæ. Whether this arose from a shower of hot ashes or from the subsequent irruption of the sea, or whether there are sufficient indications of its existence as distinct from the perforations, is perhaps still a matter of some doubt.

76. The next fact which presents itself in ascending from the floor of the temple, is, the remarkable perforations in the three columns that remain standing, which have fixed the attention of naturalists and geologists.

The Modiolæ which perforate rocks live at various depths below the surface of the sea, and although there are instances of marine animals inhabiting a mixture of sea- and fresh-water, yet they are comparatively rare. In the present instance we find three genera, which are very numerous—the Modiolæ, the Arcæ, which seem to have sheltered themselves in the untenanted abodes of the former genus, and the Serpulæ, which attached themselves to the inside of the shells of the Modiolæ, or to the sides of the cavities made by them.

77. The facts which have been adduced (par. 48 *et seq.*) to prove a subsidence of the adjacent land are conclusive on that point, and concur with the section immediately behind the temple, to show that at one period its pavement must have been considerably below the Mediterranean. But that section cannot be adduced as an argument, until we have refuted a theory which has been offered to explain the history of this temple.

It has been supposed that a great storm which partially destroyed the temple threw up a bar between it and the sea, and filled the area with sea-water containing the young of the several shell-fish which are found in the columns.

The objections to this theory are—that it supposes a salt lagoon to have existed for many years in a hot climate, with its surface 9 feet above the level of the adjacent sea, and without any supply of water; when evaporation must soon have dried it up, and the water from the hot spring could not have supplied it without leaving traces of another incrustation similar to those described as the dark deposit and the great incrustation; that the supposed lagoon must have existed in a cavity in a porous sandy soil, as is proved by the section close to the temple (par. 41)—and yet that a pressure of 9 feet of water did not cause such a reservoir to leak.

If it be urged that a lake has already been supposed to have existed in a former state of the temple, and that these objections are equally fatal to that lake, the answer is, that in the former instance there was a constant supply of water from the hot spring to replace the loss by evaporation and leakage—that the depth of this lake was much less—and that the deposit of carbonate of lime from the hot spring might have contributed to render its sandy bottom less pervious to water.

Either of these objections is fatal to the lagoon theory. When it is added, that this hypothesis is insufficient to explain the first incrustations without new suppositions—that it does not remove the necessity for a subsidence of the ground, which it was invented to supersede—that there are clear and unequivocal proofs of such changes of level in the immediate neighbourhood of the temple, and that the section close to it concurs in proving that the ground on which it stands was subject to those changes—it is quite unphilosophical to admit an hypothesis supported by no fact, and refuted by many.

It seems then that the temple subsided into the sea; but whether this happened slowly or at intervals, by repeated shocks of earthquakes, does not appear. Nearly at its lowest point there are indications of its having been stationary. For about 6 inches below the highest perforation of the Modiolæ the columns are corroded, as if that point had remained exposed for some time, alternately to the action of wind and water.

78. The next period in the history of the temple was its gradual elevation. Whether the deposit out of which it was dug covered it up before or after this event, is not perhaps distinctly evident. From the section behind the temple, I am induced to suppose that it preceded the elevation; and the chance of the columns not being overthrown by any sudden rising, would be considerably increased by the support they would derive from having more than one-half their height imbedded in earth.

79. The preceding conclusions involve no hypothesis, and may be considered as inferences fairly resulting from the specimens collected, from the facts observed on the spot, and from the historical evidence of changes which have happened in the neighbourhood of the temple. I shall now proceed to offer some conjectures relative to the causes of the successive changes in the level of the ground on which this temple stands—conjectures which I wish to be considered as entirely distinct from the former part of this communication.

On examining the country round Pozzuoli it is difficult to avoid the conclusion, that the action of heat is in some way or other the cause of the phænomena of the change of level of the temple. Its own hot spring, its immediate contiguity to the Solfatara, its nearness to the Monte Nuovo, the hot spring at the Baths of Nero on the opposite side of the bay of Baiæ, the boiling springs and ancient volcanos of Ischia on one side and Vesuvius on the other, are the most prominent of a multitude of facts which point to that conclusion.

The mode by which this heat operates is a question of greater difficulty, and in the absence of sufficient data, it may be enough to point out shortly some of its possible results.

80. It may be imagined that at a considerable depth below the surface a vast reservoir of melted lava exists, containing highly elastic matter imprisoned within it by the pressure of the superincumbent strata. The addition of matter supplying this elastic fluid, or the accession of heat, may increase the force, or on the other hand, the expansion or contraction of some portion of the superior strata may cause a fissure through which the melted lava may be forced up by the elastic fluid. In such circumstances, besides the earthquakes which will be caused by the rent, and the stream of lava which issues through it, the whole of the strata resting on the fluid lava will slowly subside. The cooling of the lava may fill up the rent and the strata again rise as before, until a renewal of the same cause reproduces a renewal of the same effect. It may here be remarked, that the expulsion of the immense quantity of gaseous matter, which some volcanos are known to throw out, may lower the temperature of the cauldron below, more effectually than the abstraction of the lava which is ejected from it.

81. Another view of the subject is, that there exists below the ground in the neighbourhood of Pozzuoli cavities containing water

or other condensed gases in a highly heated state—that any accession or diminution of heat, arising from the volcanic causes in operation in the neighbourhood, will increase or diminish the elasticity of these gases, and thus cause an elevation or subsidence in the strata above.

82. A different view however of the effect of heat may be taken, one which is well known, and which has in some instances been measured. The solid beds below the temple are themselves liable to expand by the action of heat, and to contract by its abstraction; rents and earthquakes, as well as elevations and depressions of the surface, may be the result of the partial application of this cause. It may perhaps be doubted whether sufficient effect can arise without imagining masses of immense thickness to have altered their temperature; a change which might have required longer time for its completion than the phænomena admit.

From a series of experiments upon the expansion of various stones by the application of heat, made by Mr. H. C. Bartlett, of the U. S. Engineers, under the direction of Col. Totten, and recorded in the American Journal of Science, vol. xxii. p. 136, it appears that for 1° of Fahrenheit's scale*—

Granite expands	·000004825
Marble	·000005668
Sandstone	·000009532

From these data the expansion of those substances has been calculated for various degrees of temperature, and for thicknesses varying from 1 to 500 miles. The table is given in the Appendix. From this it may be inferred, that if the strata below the temple and its immediate neighbourhood are equally expansible with sandstone, then a change of temperature of only 100° F. acting on a thickness of five miles would cause a change of level of above twenty-five feet—an alteration greater than any of the observed facts at the temple of Serapis require.

A similar change would be produced by supposing the temperature of a bed one mile thick raised 500° F.; and if the temperature of a bed of such matter 2600 feet thick were raised 1000°, its surface would be elevated by twenty-five feet.

* Other experiments have since been made by Mr. Adie, of which an account is given in vol. xiii. of the Trans. of the R. Soc. of Edinburgh. From this the following list of expansions are extracted:—

	Expands.
Roman Cement, per 1° Fahr.	·00000750
Sicilian White Marble	·00000613
Carrara Marble	·00000363
Sandstone from Craigleith Quarry	·00000652
Slate from Penrhyn, Wales	·00000576
Peterhead Red Granite	·00000498
Arbroath Pavement	·00000499
Caithness Pavement	·00000497
Greenstone from Ratho	·00000449
Aberdeen Grey Granite	·00000438
Best Stock Brick	·00000306
Fire Brick	·00000274
Black Marble, Galway	·00000247

(The Ninth Bridgewater Treatise, p. 223, 2nd edit., 1838.)

The difficulties of this theory are, that some part of the surface at the piers of Caligula's Bridge is at present raised above its former level, and other parts, as the temple of the Nymphs and of Neptune, are still below that level; whilst the temple of Serapis appears to have returned nearly to its former state. The answer to this is, that the thickness of the expanding beds may differ in different parts, or may have a different power of conducting heat—or it may be remarked, if the conducting power and the thickness be the same, the distance from the source of heat may be different, and consequently the full effects may have reached the piers of the bridge, and yet not have attained the other points.

Another objection is, that the columns of the temple are nearly vertical*, whilst the inclination of the strata, as proved by the perforations in the 6th and 12th piers of the bridge, shows an inclination which would be sensible. To this it may be replied, that during the transit of the wave of heat through the strata under the temple, the columns may have been slightly inclined and yet have retained their position, even if they had not been supported by being imbedded in the tuff and sand which then filled the temple. Or it may happen that the beds on which the temple stands are separated by faults or rents from their continuation under the other buildings; and if they be thus isolated, the effect of heating and cooling them would be to raise and lower the temple in a vertical position.

On the whole this explanation is the most tenable, because it is founded on facts—viz. that matter expands by heating; that great accessions of heat have at various times taken place in the neighbourhood of the temple; that it is sufficient to account for the phænomena by supposing a moderate depth of the beds below it heated to a degree which it is not unreasonable to presume must have taken place; that such changes of level would on the whole occur gradually, although they might be accompanied with earthquakes and occasionally by sudden changes of level—facts of which we have historical evidence as having happened on this spot.

83. In reflecting on the preceding explanation of the causes which produced the changes of level of the ground in the neighbourhood of Pozzuoli, I was led to consider whether they might not be extended to other instances, and whether there are not other natural causes, constantly exerting their influence, which, concurring with the known properties of matter, must necessarily produce those alterations of sea and land, those elevations of continents and mountains, and those vast cycles of which geology gives such incontrovertible proofs.

84. The small depth at which melted lava may exist below the surface of bad conductors of heat, had forcibly struck me in an expedition I made to Vesuvius during the interval between my visits to the temple of Serapis. Having descended into the great crater of Vesuvius to examine a little crater within it, which was then in a

* The late Capt. Basil Hall subsequently ascertained, by comparing these columns with their image reflected in the water, that they are very sensibly out of the perpendicular.

state of activity, throwing up pumice occasionally from 300 to 600 feet high, I was desirous of ascertaining the depth of the great crater. Accordingly, having taken the angles of certain points and measured, on the rough lava plain at its bottom, a base of 330 feet, I left a walking-stick fixed upright to mark its termination. After taking the angles at the opposite end I remeasured the base, and found it 331 feet; but on returning the walking-stick was in flames. In many of the crevices a foot or two in depth, the lava was red-hot. The bottom of the small crater in which the pasty semi-fluid lava was tossed about, was, I should think from memory, not more than fifty feet below the spot on which I stood. The depth of the plain at the bottom of the crater below the lowest part of its upper edge was, on the 3rd June 1828, about 505 feet.

I had been surprised at the small distance (two or three feet only) which separated the red-hot lava from the less heated surface on which I had been walking, and had carried on my trigonometrical operations, without experiencing much inconvenience from the heat. The view of the melted lava had however disappointed my expectations: instead of possessing fluidity, it ought rather to be described as a pasty viscous mass, having some degree of toughness, of an uneven surface, occasionally pushed up by a force from below which caused elevations that very slowly subsided, or more frequently were removed or interfered with by succeeding efforts of the same force.

85. The following explanation of the origin of the changes which have continually taken place in the forms and the levels of large portions of the earth's surface at many distant periods of time, and which appear still to continue their slow but certain progress, arose from the examination of the temple of Serapis, which has been detailed in the former part of this paper.

The theory rests upon the following principles:—

1st. That as we descend below the surface of the earth at any point, the temperature increases.

2nd. That solid rocks expand by being heated, but that clay and some other substances contract under the same circumstances.

3rd. That different rocks and strata conduct heat differently.

4th. That the earth radiates heat differently from different parts of its surface, according as it is covered with forests, with mountains, with deserts, or with water.

5th. That existing atmospheric agents and other causes are constantly changing the condition of the earth's surface, and that, assisted by the force of gravity, there is a continual transport of matter from a higher to a lower level.

The existence of the four latter causes has long been fully admitted: the only one on which any uncertainty rests is the first. All measures which have been made of the increase of the earth's heat as we descend below its surface concur in pointing out the fact, although, as might be expected, almost every case gives a different amount of descent for an elevation of temperature of one degree of Fahrenheit. In tracing out some of the consequences which necessarily result from the continued action of these five causes, it will be necessary to assume the truth of the first, although it is not necessary that we be acquainted with the law of its variation ; nor is it absolutely essential that we should suppose the heat to increase to such an extent, as to render the whole of the central parts of the earth fluid.

86. If we imagine at every point of the earth's surface a line drawn to its centre, then if a point be taken in any one line at a given temperature, there will be contiguous points of exactly the same temperature in all the adjacent lines ; and if we conceive a surface to pass through all these points, it will constitute a surface of uniform temperature, or an isothermal surface. This therefore will not be parallel to that of the earth, but will be irregular, descending more towards the centre of the earth, where it passes under deep oceans.

An increase of 1° of Fahrenheit's thermometer, for every fifty or sixty feet we penetrate below the earth's surface, seems nearly the average result of observations. If the rate continue, it is obvious that, at a small distance below the surface, we shall arrive at a heat which will keep all the substances with which we are acquainted in a state of fusion. Without however assuming the fluidity of the *central* nucleus—a question yet unsettled, and which rests on very inferior evidence* to that by which the principles here employed are supported—we may yet arrive at important conclusions ; and these may be applied to the case of central fluidity, according to the opinions of the several inquirers.

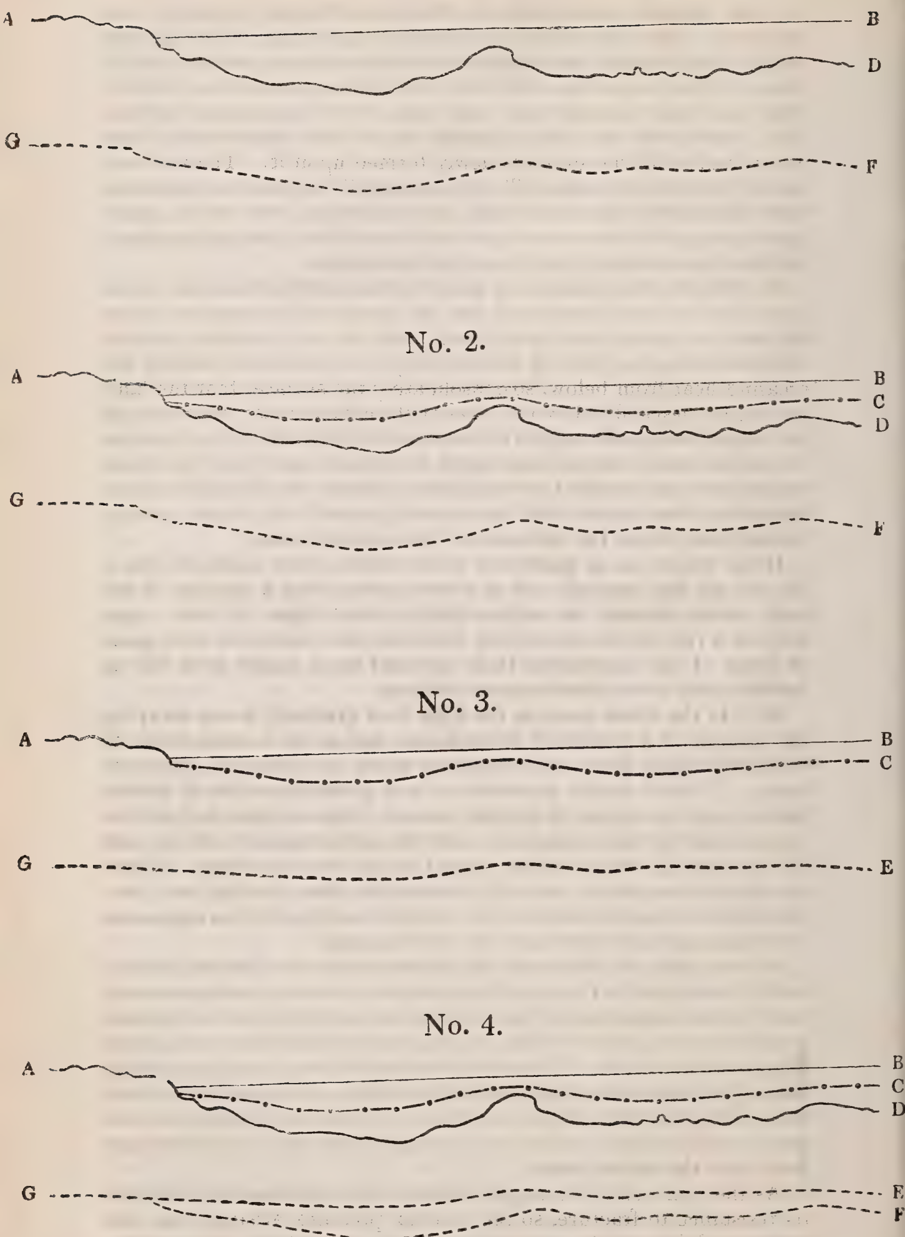
87. If we consider the temperature of any point—for example, G, situated two miles below the surface of an elevated table-land A, in the annexed woodcut fig. 4 ; and if we imagine a surface passing through all the points of equal temperature within the globe, then, as this surface passes under the adjacent ocean, which we may suppose, on an average, to be two miles deep, it is evident that the *surface of equal heat* will descend towards the earth's centre ; because, if it did not, we should have great heat nearly in contact with the bottom of the sea. In number one, B is the surface of the ocean ; A D the surface of the land, and of the bed of the ocean. The broken line G F is the isothermal line. Let us now suppose, by the continual wearing down of the continents and islands adjoining the ocean, that it becomes nearly filled up. The broken line C, in number two of the woodcut, indicates the new bottom. The former bottom of the ocean being now covered with a bad conductor of heat, instead of with a fluid which rapidly conveyed it away, the surface of uniform temperature will rise slowly but considerably, as is shown at G E, in number three. In number four, the first bed of the ocean A D, and its isothermal line G F, as well as the new bed, A C, of the ocean, and its corresponding isothermal line G E, are all shown at one view.

88. The newly-formed strata will be consolidated by the application of heat ; they may, perhaps, contract in bulk, and thus give space

* The reader will find this question fully discussed in the 32nd and 33rd chapters of Lyell's Principles of Geology, 7th edit.

Fig. 4.

No. 1.



N.B.—These woodcuts are stereotypes from *one* block, in the manner described p 266, Ninth Bridgewater Treatise.

for new deposits, which will, in their turn, become similarly consolidated. But the surface of uniform temperature below the bed of the ocean, cannot rise towards the earth's surface, without an increase in the temperature of all the beds of various rock on which it rests; and this increase must take place for a considerable depth. The consequence will be a gradual rise of the ancient bed of the ocean, and of all the deposits newly formed upon it. The shallowness of this altered ocean will, by exposing it to greater evaporation from the effect of the sun's heat, give increased force to the atmospheric causes still operating upon the inequalities of the solid surface, and tend more rapidly to fill up the depressions.

89. Possibly the conducting power of the heated rocks may be so slow, that its total effect may not be produced for centuries after the sea has given place to dry land; and we can conceive in such circumstances, the force of the sun's rays from without, and the increasing heat from below, so consolidating the surface, that the land may again descend below the level of the adjacent seas, even though its first bottom is still subject to the elevatory process. Thus, a series of shallow seas or large lakes might be formed; and these processes might even be repeated several times, before the full effect of the expansion from below had permanently raised the whole newly-formed land above the influence of the adjacent seas.

If the whole sea, or particular portions of it, were originally much deeper, as, for instance, ten or twenty miles, then a portion of the solid matter beneath its surface might, after a lapse of many ages, acquire a red, or even a melting heat, and the conversion into gases of some of the substances thus operated upon might give rise to earthquakes, or to subterranean volcanos.

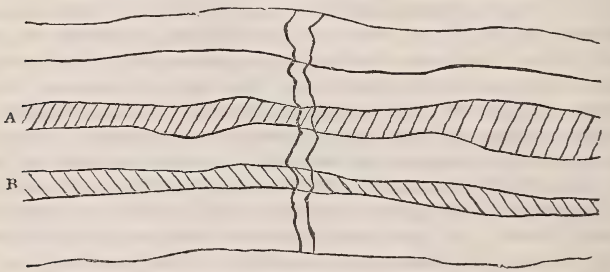
90. On the other hand, as the high land gradually wears away by the removal of a portion of its thickness, and as the cooling down of its surface takes place, its contraction might give place to enormous rents. If these cracks penetrate to any great reservoirs of melted matter, such as appear to subsist beneath volcanos, then they will be compressed by the contraction, and the melted matter will rise and fill the cracks, which, when cooled down, become dykes. Rents therefore or veins may arise by contraction from cooling, and proceed from the surface downwards; or they may result from expansive forces acting from below and proceed upwards.

If these rents do not reach the internal reservoir of melted matter, and if there exist in the neighbourhood any volcanic vents connected with it, the contraction of the upper strata may give rise to volcanic eruptions through those vents, which might be driven by such a force almost to any height. These eruptions may themselves diminish the heat of the beds immediately above the melting cauldron from which they arise; for the conversion of some of the fluid substances into gases, on the removal of the enormous pressure, will rapidly abstract heat from the melted mass.

As the removal of the upper surface of the high land will diminish its resistance to fracture, so the altered pressure arising from the removal of that weight, and its transfer to the bottom of the ocean, may determine the exit of the melted matter at the nearest points of weakest resistance.

91. Other consequences might arise from the different fusibility of the various strata deposited in the bed of the ocean. Let us imagine in the next woodcut (fig. 5), the two beds A and B to melt at a much lower temperature than those between which they intervene. It might happen, by the gradual rising of the isothermal surfaces, that one or both of these strata should be melted; and thus, supposing

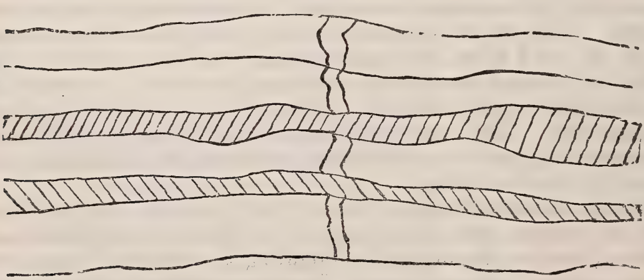
Fig. 5.



all the beds originally to have contained marine remains, we might, at a distant period, discover two interposed beds, without any trace of such remains, but presenting all the appearances of former fusion, resting on, separated by, and existing under, other beds of demonstrably marine formation.

If, during that former state of fusion, rents should have been formed through several of the strata, injection of the liquid matter might proceed from these melted beds, both upwards and downwards. If, on the contrary, older dykes had penetrated all the strata, it is possible to suppose such a degree of fusibility in the older dyke, or such chemical relation to the melted bed, that the portions of the dyke passing through that bed should be obliterated, whilst those that traverse the less fusible beds, protected from such action, should remain unaltered, as in the annexed cut (fig. 6).

Fig. 6.



92. Another consequence of this constant change in the position of the isothermal surfaces must be the development of thermo-electricity, which, acting on an immense scale, may determine the melting of some beds, or the combination of the melted masses of others, or cause the segregation of veins and crystals, in heated though not fluid portions of the strata exposed to its influence. Nor may the dykes themselves be without their use, either in keeping up the communication for the passage of electricity, if they are good conductors; or in separating the groups of strata which produce it, if they are bad conductors.

93. It is by no means necessary that these fused strata should be connected by dykes or other means with any cauldron of melted matter below; nor even that any large portion of the interior of the earth should be in a melted state. The mere advance of the isothermal surfaces may cause some more readily fusible strata to melt between its two adjacent more refractory companions. Two beds even—such, for example, as compact fluor and sulphate of lime—may each, when separated by intervening beds, have been submitted, by the passage of a highly heated isothermal surface, to intense heat without fusion: yet two exactly similar beds occurring higher up in the series, and perhaps not submitted to the same intense heat, may, if placed in immediate contact, by acting on each other as fluxes, become for ages a liquid fiery ocean, intercalated between strata regularly deposited from water.

94. The effects of this fusion of some intermediate strata may also be to alter the surface and dislocate all the beds above. If the matter expand by fusion, then elevations and cracks will ensue: if it contract into smaller compass on melting, then subsidences will occur; and in both cases, when a large extent of the earth's surface rests on a fluid bed contained in an irregular cavity, we may expect, from the difference of the weight above it at different points, that a system of irregular elevations and depressions will continue for a time to occur, until the conditions of equilibrium are fulfilled between the superincumbent weight and the fluid or semi-fluid and viscous mass.

This process will require time for its completion, and when accomplished, the surface above will remain undisturbed for ages.

It appears also that in case the intervening melted strata contract, the surface of the country above may be influenced by two or more causes. First, by the general elevation arising from the expansion of all the solid strata by heat, arising from the advance of the isothermal surface towards the surface of the earth. Secondly, by the depression arising from the melting of one or more of the intermediate beds. The joint action of these causes may produce many successive alternations of elevation and depression in the same portion of the earth's surface.

95. For the elucidation of this subject, it appears very important that experiments should be made on the effects of long-continued artificial heat in altering and obliterating the traces of organic remains existing in known rocks. It seems probable that, by a well-

planned series of such experiments, we might be enabled to trace the gradually disappearing structure of animal remains existing in rocks subjected to fire, into marks which, without such aid, seem utterly distinct from that origin; and that we might thus establish new alphabets with which to attempt the deciphering of some of the older rocks*.

96. It appears, therefore, that from changes continually going on, by the destruction of forests, the filling up of seas, and the wearing down of elevated lands, the heat radiated from the earth's surface varies considerably at different periods. In consequence of this variation, and also in consequence of the covering up of the bottoms of seas, by the detritus of the land, the *surfaces of equal temperature* within the earth are continually changing their form, and exposing thick beds near the exterior to alterations of temperature. The expansion and contraction of these strata, and, in some cases, their becoming fluid, may form rents and veins, produce earthquakes, determine volcanic eruptions, elevate continents, and possibly raise mountain chains.

The further consequences resulting from the working out of this theory would fill a volume, rather than a memoir. It may however be remarked, that whilst the principles on which it is founded are really existing causes, yet that the sufficiency of the theory for explaining all the phænomena can only be admitted when it shall have been shown that their power is fully adequate to produce all the observed effects.

Addition in 1847.

It appears from the preceding paper, that the joint action of certain existing and admitted causes must necessarily produce on the earth's surface a continual but usually slow change in the relative levels of the land and the water. Large tracts of its surface must be slowly subsiding through ages, whilst other portions must be rising irregularly at various rates: some, though perhaps few, may remain stationary.

It is a curious and an interesting fact, that this geological deduction, derived from pure reasoning, although suggested by the observations made on the temple of Serapis, which was first published in 1834, should soon after have received direct confirmation from an entirely opposite quarter.

Mr. Darwin, whose voyages and travels extended from 1826 to 1836, was gradually accumulating and arranging an immense collection of facts relating to the formation of coral and lagoon islands, as well as to the relative changes of level of land and water. In 1838

* Some experiments, with this object in view, were undertaken at the recommendation of the British Association (see Third Report, p. 479, and Fourth Report, p. 576), and portions of rock containing organic remains have already (1838) been exposed, for above five years, to the heat of the hearth of a blast furnace, at the Elsecar Iron Works in Yorkshire, through the permission of Earl Fitzwilliam, and at the Low Moor Works, by that of the proprietors.

Mr. Darwin published his views on those subjects, from which, amongst several other very important inferences, it resulted, that he had, from a large induction of facts, arrived at exactly the same conclusion as that which it has been the chief object of this paper to account for, from the action of known and existing causes.

APPENDIX.

No. 1. *Periods in the history of the Temple, founded on observation, or inferred from Geological and Physical evidences.*

1. Ancient mosaic pavement constructed 5 feet below the floor of the temple.
2. Dark incrustation, round the walls, formed previous to any filling up of the temple.
3. First filling up of the temple to the height of about 7 feet above the floor.
4. Period during which the great calcareous deposit was forming in the freshwater lake made by the hot spring.
5. Partial destruction of the temple.
6. Corrosion round several of the columns just above the calcareous deposit.
7. Second filling up to the height of about $10\frac{1}{2}$ feet.
8. Further destruction of the temple and subsidence below the level of the sea: perforations in the columns.
9. Third filling up to the height of from 20 to 35 feet above the floor of the temple.
10. Re-elevation of the temple above the present level of the sea.
11. Excavation of the temple in 1750.
12. Gradual subsidence of the temple between 1828 and 1845.

No. 2. *Dates of Historical facts connected with the Temple of Serapis.*

	B. C.
1. Colonization of Puteoli, according to Livy, lib. xxxiv. 24	194
2. Lex Parietis faciendi	105
3. Eruption of Vesuvius, destruction of Pompeii and Herculaneum	A. D. 79
4. Probable time of construction of the temples whose remains now exist, toward the end of the 2nd century.	
5. Eruption of Vesuvius	203
6. The temple adorned with precious marbles by Septimius Severus.............................. between 194 and	211

	A.D.
7. The temple adorned with precious marbles by Alexander Severus . . . . between 222 and	235
8. Valerius Maximus states that a bank was begun and finished, on the right side of the market, by throwing things into the sea, on account of the incursion of the storm	230
9. Pozzuoli ruined by Alaric	456
10. Eruption of Vesuvius	472
11. ———————	542
12. Pozzuoli ruined by Genseric	545
13. Eruption of Vesuvius	685
14. Pozzuoli ruined by Romualdo II. Duke of Benevento . .	715
15. Eruption of Vesuvius	993
16. ———————	1036
17. ———————	1043
18. ———————	1138
19. ———————	1139
20. Eruption of Solfatara	1198
21. Monte Epomeo, Ischia, active	1302
22. Eruption of Vesuvius	1306
23. Earthquake	1488
24. Eruption of Vesuvius	1500
25. Grant to the University of Pozzuoli of the land drying up from the sea	1503
26. Grant to the city of ground dried up (desiccatum) . .	1511
27. Monte Nuovo, Eruption of	1538
28. Eruption of Vesuvius	1631
29. ———————	1660
30. ———————	1682
31. ———————	1692
32. ———————	1701
33. ———————	1704
34. ———————	1712
35. ———————	1717
36. ———————	1730
37. ———————	1737
38. Temple of Serapis dug out	1750
39. Eruption of Vesuvius	1751
40. ———————	1754

No. 3. *Table showing the Expansion, in feet and decimal parts, of Granite from* 1 *to* 500 *miles thick, for various additions of temperature.*

Miles in thickness.	Degree of Fahrenheit's Scale.							
	1.	20.	50.	100.	200.	500.	1000.	3000.
1	·0255	·510	1·275	2·55	5·10	12·75	25·5	76·5
5	·1274	2·548	6·370	12·74	25·48	63·70	127·4	382·2
10	·2548	5·096	12·740	25·48	50·96	127·40	254·8	764·4
15	·3821	6·642	19·105	38·21	76·42	191·05	382·1	1146·3
20	·5095	10·190	25·475	50·95	101·90	254·75	509·5	1528·5
25	·6369	12·738	31·845	63·69	127·38	318·45	636·9	1910·7
30	·7642	15·286	38·215	76·43	152·86	382·15	764·3	2292·9
35	·8917	17·834	44·585	89·17	178·34	445·85	891·7	2675·1
40	1·0190	20·380	50·950	101·90	203·80	509·50	1019·0	3057·0
45	1·1464	22·928	57·320	114·64	229·28	573·20	1146·4	3439·2
50	1·2738	25·476	63·690	127·38	254·76	636·90	1273·8	3821·4
55	1·4012	28·024	70·060	140·12	280·24	700·60	1401·2	4203·6
60	1·5286	30·572	76·430	152·86	305·72	764·30	1528·6	4585·8
65	1·6559	33·118	82·795	165·59	331·18	827·95	1655·9	4967·7
70	1·7833	35·666	89·165	178·33	356·66	891·65	1783·3	5349·9
75	1·9107	38·214	95·535	191·07	382·14	955·35	1910·7	5732·1
80	2·0381	40·762	101·905	203·81	407·62	1019·05	2038·1	6114·3
85	2·1655	43·310	108·275	216·55	433·10	1082·75	2165·5	6496·5
90	2·2928	45·856	114·640	229·28	458·56	1146·40	2292·8	6878·4
100	2·5476	50·952	127·380	254·76	509·52	1273·80	2547·6	7642·8
200	5·0952	101·904	254·760	509·52	1019·04	2547·60	5095·2	15285·6
500	12·7380	254·760	636·900	1273·80	2547·60	6369·00	12738·0	38214·0

In order to employ this table for the expansion of marble under the same circumstances, increase the number found by the above table one-sixth. To find the expansion of sandstone, double the number found in the table for granite.

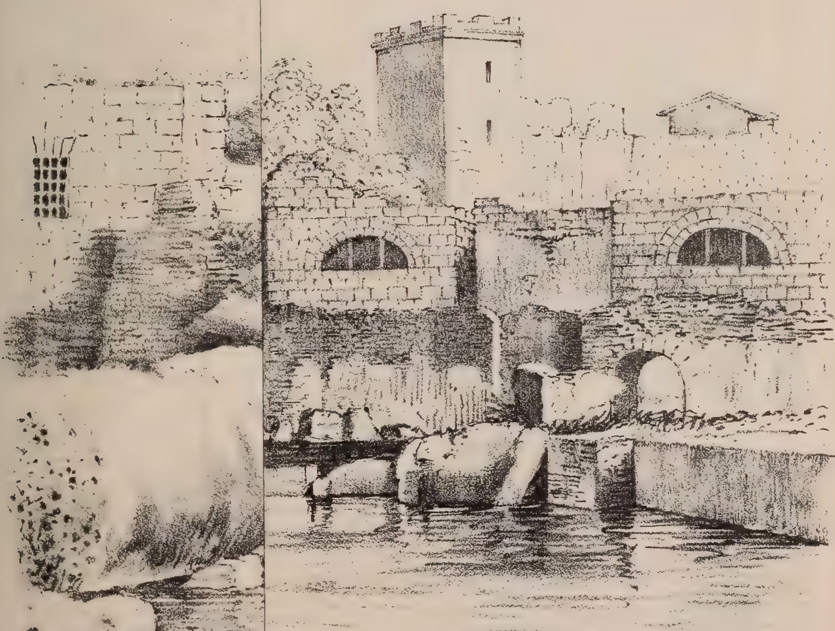
This table was computed by the Difference Engine from the first line, which was of course taken from experiment.

It will be observed that the numbers are always true to the last figure, a compensation made by the engine itself. As however the machine had not then been taught to print its computations, the accuracy of the table can only possess that of careful printing.

No. 4. *List of Shells determined by Professor E. Forbes.*

From below the Tuff of Monte Nuovo.

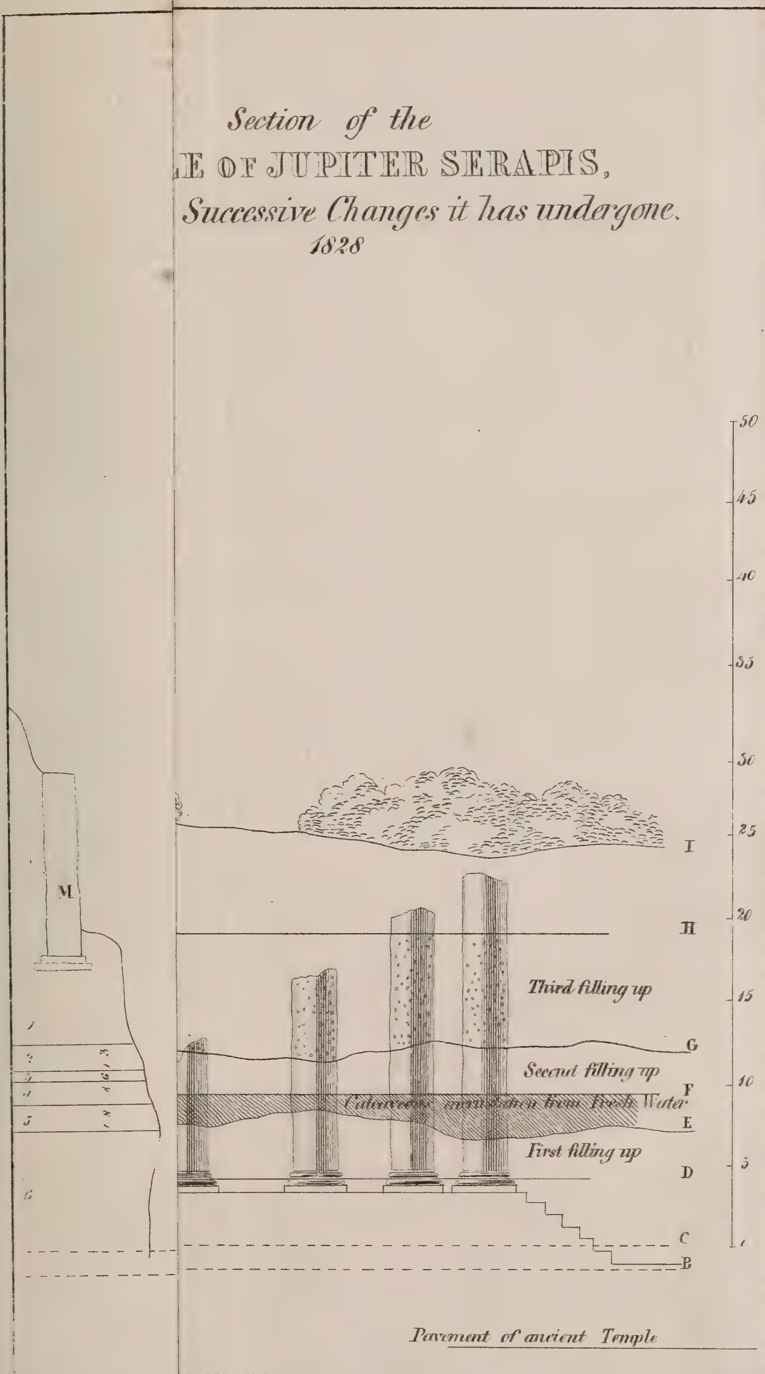
	Range in fathoms.	Remark.
Spondylus gadæropus	½—14.	The presence of the Haliotis along with Arca barbata and the Spondylus, indicates that these shells were imbedded *on a coast-line at water mark.* The others were washed up.
Arca barbata	0—4.	
Cardita sulcata	2—30.	
Venus verrucosa	0—40.	
Modiola tulipa	2—50.	
Haliotis lamellosa	littoral.	
Shells in cavities of the columns.		
Lithodomus lithophagus	littoral.	Indicate coast-line at water-mark *with certainty.*
Arca barbata	littoral—4.	
Vermetus sublamellatus?	littoral.	
Shells from holes in Tuff, 38 feet above the Mediterranean.		
Arca lactea	0—great depth.	Indicate a coast-line at water-mark.
—— barbata	littoral—4.	
Cast of Lithodomus	littoral.	
Shells from Strata near the Temple of Serapis.		
Conus mediterraneus	littoral—10.	The whole assemblage in this case indicates the line of water-mark, most of the species being such as live there, only mingled with those living immediately below it and washed up.
Bulla striata	under 1 fathom.	
Patella bonnardi	littoral.	
Fissurella neglecta	littoral.	
Trochus umbilicaris?	sublittoral.	
Scalaria lamellosa	near coast-line?	
Cerithium furcatum	littoral.	
—— vulgatum	5—40.	
Columbella rustica	0—55.	
Nassa variabilis	0—27.	
Vermetus gigas	sublittoral.	
Arca lactea	0—very deep.	
—— Noæ	littoral and deep.	
—— barbata	littoral.	
Cardita sulcata	7—30.	
—— trapezia	0—95.	
Chama gryphoides	0—50.	
Lucina divaricata	?	
—— pecten	0—16.	
Venus fragilis	littoral.	
—— aurea	littoral—10.	
—— geographica	5—15.	
—— verrucosa	littoral—40.	
Mesodesma donacella	littoral.	



Reeve Brothers, Lithographers

Reeve Brothers, Lithographers

TEMPLE OF JUPITER SERAPIS.



Edward J. Anson, Ju

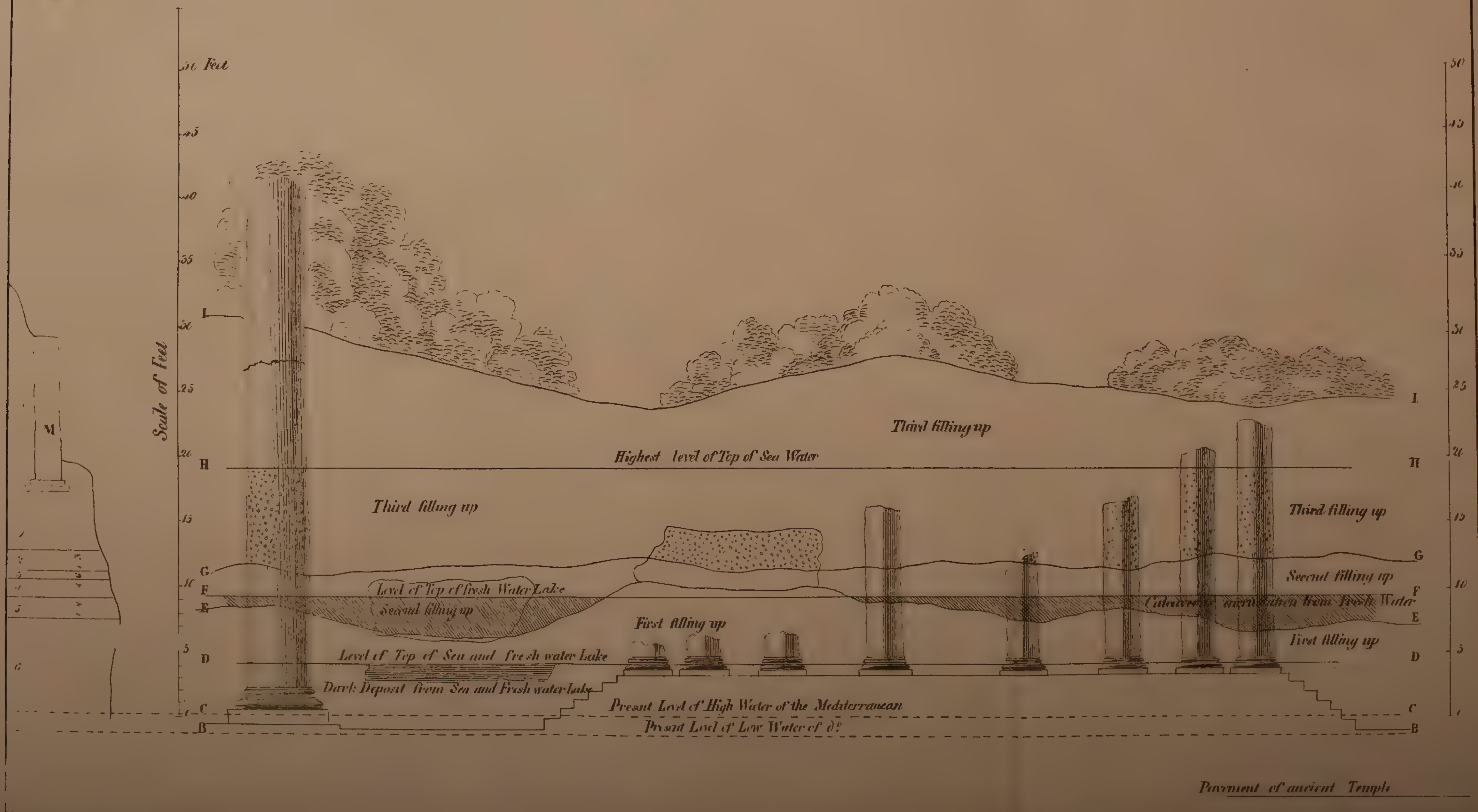
Reeve, Brothers, Lithographers.

Section of the

TEMPLE OF JUPITER SERAPIS,

Shewing the Successive Changes it has undergone.

1828



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No. 5. *Description of the Plates.*

Plate I.— *View of the Temple of Serapis.*

I am indebted to the kindness of Mr. Edward I. Anson, Jun., for this excellent representation of the temple. It was taken by means of the Camera Lucida in 1836, and may, I believe, be relied upon even to the minutest details.

Plate II.—*Section of the Temple of Serapis, showing the changes it has undergone.*

I deduced this section from a series of measures made at the temple in June 1828, in company with my friend Mr. Head. Several days were occupied, and some important questions were discussed on the spot. Mr. Head also entered into the antiquarian questions, which, if they had been admissible into these transactions, would have added greatly to the interest of the story of the temple of Serapis.

	Paragraphs where referred to.
A At bottom on right-hand pavement of ancient temple	43, 55
BB Line of low water of the Mediterranean, June 1828	
CC Line of high water ditto	
DD Level of the top of mixed sea and fresh-water lake	34, 35, 36
Dark deposit below that line....................	56 to 64
EE Irregular line representing the first filling up of the temple....................................	64, 67
This filling up reaches from the bottom to EE.	
FF Level of the top of fresh-water lake	37, 64
GG Irregular line of second filling up. The other boundary of this filling up is EE.	
HH Highest level attained by the sea	77
I I Irregular surface of the soil out of which the temple was dug in 1750.	

I I and GG are the two boundaries of the third filling up.

The sketch of the bank and wall M on the left side is accurate where measures are given, but in other respects it must not be considered as rigidly correct.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

November 5th to December 31st, 1846.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

Agricultural Magazine, for December.
Athenæum Journal. Parts 226, 227 and 228.
Calcutta Journal of Natural History. Nos. 17 to 24.
Chemical Society, Memoirs and Proceedings. Part 19.
Institution of Civil Engineers, Annual Address, 1846.
Leeds Philosophical Society, Twenty-sixth Annual Report.
Philosophical Magazine. Nos. 196 and 197. *From R. Taylor, Esq., F.G.S.*
Royal Society, Philosophical Transactions. Parts 1, 2 and 3, 1846.
———, Proceedings. Nos. 62 to 65.
St. Petersburg, Mémoires de l'Académie Impériale des Sciences de. 6me Série, vols. i. to vii.
———, Bulletin de la Classe Physico-Mathématique. Vols. i. to iv.
Yorkshire, Geological and Polytechnic Society of the West Riding of, Reports of the Proceedings, 1844–45.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names in italics presented by Authors.

Agassiz, L. Iconographie des Coquilles Tertiaires.
——— Nomenclator Zoologicus. Fas. v. and vi.

Ansted, D. T. Facts and Suggestions concerning the Economic Geology of India (I. Coal-fields of India).

Burr, Thomas. Remarks on the Geology and Mineralogy of South Australia.

Dunker, Wilhelm und H. v. Meyer. Monographie der Norddeutschen Wealdenbildung.

Gillis, Lieut. J. M. Astronomical Observations made at Washington, 1838; and Magnetical and Meteorological Observations.

Gumprecht, T. E. Ueber einige geognostische Verhältnisse des Grossherzogthums Posen und der ihm angränzenden Landstriche.

——— Zur geognostischen Kenntniss von Pommern.

Mantell, G. A. On the Fossil remains of Foraminifera in the Chalk and Flint of the S.E. of England.

Reeve, Lovell. Conchologia Iconica. Monographs of the Genera Monoceros, Purpura, Ricinula, Haliotis, Mangelia, Ranella, Pollicipes, Pleurotoma, Phorus, Murex, Isocardia, Harpa, Cypræa, Cypricardia and Cardita.

——— Elements of Conchology. Parts 4, 5 and 6.

Rose, Gustav. Ueber das Krystallisationssystem des Quarzes.

Sismonda, Angelo. Notizie e schiarimenti sulla Constituzione delle Alpi Piemontesi.

Sismonda, Eugenio. Descrizione dei Pesci e dei Crostacei Fossili nel Piemonte.

Spratt, Lieut. T. A. B. and Prof. E. Forbes. Travels in Lycia, Milyas, and the Cibyratis. 2 vols.

Volborth, Alexander von. Ueber die Russischen Sphæroniten.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

JANUARY 6, 1847.

[Continued from No. 10.]

3. *On the Neighbourhood of* BOMBAY, *and certain beds containing Fossil Frogs.* By G. T. CLARK, Esq., C.E. *Communicated by the* Very Rev. the Dean of Westminster.

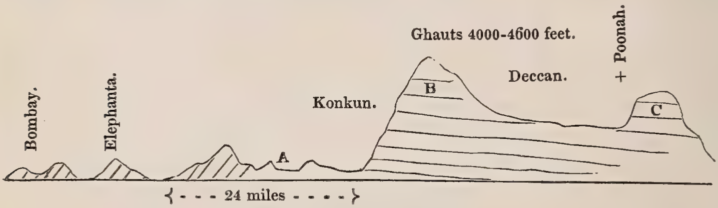
THE island of Bombay is composed of five or six bands of trap rock, chiefly greenstone and amygdaloid, conformable, and dipping west at about 10° or 15°, and separated by beds that have every appearance of being of sedimentary origin, though there is no actual proof of the fact. The highest and most western of these beds have been laid open in some engineering operations, and in these the fossils sent to the Society have been found.

The batrachian beds are a mass of blue rock, weathering into a shale not unlike ordinary coal shale, and containing what I have no doubt will turn out to be vegetable impressions. The upper beds are interstratified with thin seams of sandstone and argillaceous rock, and over the whole is a mantle of basalt which cannot have been less than 70 feet thick. This basalt has in parts caused imperfect fusion of the fossil beds, obliterating their stratification and superimposing something of its own columnar, or at least prismatic structure.

These fossils were discovered, a few days ago, by Dr. Leith of the Bombay Service, and as he is an acute and diligent observer and well-acquainted with his subject, I think, before very long, these beds will be thoroughly investigated.

I am preparing an account of the geology of the island, but it is so closely connected with that of the main land, that I am loath to say much upon the one until I am better acquainted with the details of the other.

I have however succeeded, in the course of the past year, in establishing some rather interesting facts relating to the trap district, and a sketch of these I propose, at the risk of becoming very tedious, to relate.



From this section it appears that the Ghauts are a step or scarp, rather than a regular mountain range. Upon the scarp, however, are many hills, commonly the abrupt ends of long ranges which traverse the Deccan E. and W. for from 50 to 300 miles. (B) is such a mountain.

The Deccan rocks are traps, chiefly greenstone and amygdaloid, capped with basalt. Their dip is very slight, and not discernible upon distances of less than a mile or two. It is however easterly, and this is shown by the occurrence of a peculiar bed near the top of the Ghaut mountains, and low down on the outlying mountain (C) above Poonah. After extending from two to three hundred miles eastward or inland, the trap is found to overlie gneiss and other metamorphic, as well as some later rocks.

The rocks of Bombay and the western margin of the Konkun, all dip west and at a much higher angle. This led me to suppose that their origin would be in the centre of the anticlinal, and to seek it, not as some have done in the interior of the peninsula, but in the middle of the Konkun; and here, at (A), I found a broad band of very well-marked craters, extending nearly N. and S., parallel therefore to the Ghauts, and (which is important to any general theory of India) ranging with the Laccadive and Maldive band of islands.

Lateral bands of volcanos seem to have been here and there given off for short distances, producing bays in the general outline of the Ghauts, of which the most remarkable is that nearly E. of Bombay, towards Jooneer. Basaltic dykes are numerous, parallel both to the main and subordinate bands.

The aspect of these volcanos shows that they have been submarine, and have been covered up by other igneous rocks; in fact, that they were the nuclei of more lofty volcanos, now in great part removed.

It would be tedious to enumerate the evidences, but the history of the matter seems to be as follows:—The original peninsula was metamorphic, raised and supported by granites of various ages, and covered up partially by the diamond sandstones and argillaceous limestones, the whole being traversed by greenstone dykes.

Next, the whole mass being still below the sea, a line of volcanic vents seems to have burst forth along the western coast; all the eastern ejections from these rolled, at a very moderate dip, over the older rocks, while the western ejections descended at once into the deep sea.

As the accumulation proceeded the volcanic region gained elevation, and finally reached a height of at least 5000 feet above the present sea-level, or perhaps it would be more correct to say above the beds now forming the sea-shore. The later eruptive period produced basalt, beds of which mantle the western coast and cap the Ghauts. This basalt seems to have flowed out rather in long coulées than in sheets, and to have formed the mountain ridges which run eastwards from the crest of the Ghauts.

After this came a period of basaltic dykes. These seem to have closed the scene, for they traverse the craters as well as the adjacent rocks, and though confined for the most part to the crater region, they lie along and parallel to it, and seem to have been injected, not from the individual craters, but from some deeper-seated action affecting the whole.

Many of these dykes are above fifty feet thick, are highly columnar, and extend for many miles; they are seldom found east of the Ghauts, but they cleave the highest mountains upon them.

Denuding forces seem next to have come into action. The whole surface of the Deccan presents evidences of the action, I think the gradual action, of water. The rocks being undisturbed the water cut its way slowly, but it did *cut* its way, cutting through rather than lifting up the beds. All the Deccan valleys are valleys of excavation, and I have seen no trace of any thing like an extensive fault; in fact I do not think I have seen a fault at all.

In the volcanic region the case is wholly different. The water was admitted, through the craters and the dykes, which are fissured and everywhere loose, at once into the interior of the mass, and the result has been the removal, with some exceptions (which remain as evidences), of the whole of the upper 5000 or 6000 feet of volcanic matter. The waters have not *cut* the rocks as in the Deccan, but have *dissected them out* neatly; and the valleys, except near the sea, are not water-worn, but are evidently formed by the meeting of lava streams, often actually meeting at a sharp angle, and sometimes such valleys are partially filled up by a third stream. The rocks are commonly hard, and the water-flow has often been unable even to efface the sort of ripple-mark that is so common in lava streams.

I believe the distinction between the Konkun and the Deccan (and therefore the Ghauts) to be due entirely to the loose structure of the former and the dense undisturbed structure of the latter, and, in the absence of anything like a great line of fault, it is difficult to account for the Ghauts in any other manner. The Konkun is in fact a great valley of elevation, the line of the volcanos being its anticlinal line.

Mr. Malcolmson and others have established the age of certain beds connected with the eastern margin of the trap. Dr. Leith's discovery bids fair to determine the age, on the western margin, of the beds above the regular trap and below the basalt capping.

Professor Orlebar is of opinion that he has discovered a sort of intercalary volcano, below this basalt, in Salsette.

I have collected a great number of specimens, and I hope, during the next eight months, when I shall be under canvas, to add to them, and so far to arrange them as to render them worth the acceptance of the Society, when perhaps some competent geologist may be induced to take the matter up.

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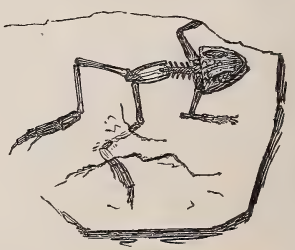
4. *On the* BATRACHOLITES, *indicative of a small species of* FROG (Rana pusilla, *Ow.*). *Addendum to the Communication from* G. T. Clark, Esq., Bombay. By Professor OWEN, F.G.S.

THE portions of shale transmitted by Mr. Clark contain delicate, but for the most part distinct, traces of the, generally, entire skeleton of small anourous *Batrachia*; the osseous substance is black, as if charred.

The number of vertebræ, atlas and sacrum inclusive, is nine: the caudal vertebræ are fused into a long, slender cylindrical style, as in most anourous *Batrachia*.

Fig. 1.

Fig. 2.



In the specimen (fig. 1) which lies on its back, the posterior convexity of the vertebral bodies is shown.

The short, subcylindrical and very slightly expanded lateral or transverse processes of the sacrum, and the absence of ribs or their rudiments in the dorsal vertebræ, with the proportional expanse of the skull and length of the hind-legs, show the specimens to belong to the family of Frogs (*Ranidæ*).

There are seven abdominal vertebræ, with long and subequal transverse processes, that of the second (third vertebra including the atlas) being the longest. The humerus is cylindrical, not expanded as in

Cystignathus. The head is a little larger relatively than in *Rana temporaria, R. esculenta*, or *Hyla viridis*; and still larger, therefore, than in the Toads and Natterjacks (*Bufonidæ*), or than in the *Pipa*: the expansion of the sacrum removes the genus *Pipa* and the *Bombinatores* from that of the present fossils. The following are admeasurements of the more perfect specimens:—

	In.	Lines.
Length from front part of head to symphysis pubis...	0	6½
Ib. of the head	0	2¾
Ib. of the dorsal vertebral series	0	2¾
Ib. of os innominatum..................................	0	2½
Ib. of femur..	0	2¾
Ib. of anchylosed tibia and fibula.....................	0	2¾
Ib. of tarsus..	0	1¼
Ib. of whole foot	0	4½
Ib. of whole anterior limb..............................	0	4

All the specimens belong to individuals which had completed their metamorphosis, and they are similar to one another in size; they may have belonged either to a not quite full-grown brood, or to an unusually small species, of *Rana*.

They conform in all respects as closely to the typical organization of the Frogs of the present day, as do the fossils discovered by Goldfuss in the tertiary lignites of the Siebengebirge, and referred by him to *Rana diluviana*; but the Bombay batracholites differ not only in their smaller size, but also in their proportionally larger skulls.

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5. *Extract from* Mr. Conybeare's *Report on the Country between the Summit of the Malsej Ghaut and the Gungathuree, dated Bombay, Oct.* 1846. *Communicated by* W. J. Hamilton, Esq., M.P., Sec. G.S.

Numerous spurs everywhere extend from the Sahadry range to the eastward, and the distance to which they extend is proportionate to the importance of the streams which run between them. The ranges which separate the smaller class of tributaries soon cease; those which intervene between the rivers which result from the junction of such tributaries have a greater extent, and the ranges which form the watersheds dividing the great river systems, sometimes extend 200 or 300 miles into the interior.

To the latter class belongs the range forming the northern boundary of the valley at the head of the Malsej Ghaut; that valley is the most northern of the river system of the Kristna, and the waters of the Kristnawuttee, which rise in it near the crest of the Ghaut, reach the main trunk by flowing successively along the Kokree, the Goor and the Beema; the precipitous range which bounds and hedges in this valley on the north is the southernmost member of a hilly tract thirty miles in depth, which separates the Kristnawuttee from the level plains of the Gunga or Godavery, and in which rise the most southern affluents of the latter river.

No eligible opportunity occurs for traversing this range and thereby entering the Bramanwarree hills, until the Alleh Khind is reached about twenty-two miles E. of the Malsej. A few miles beyond this point the southernmost range becomes almost impracticable, expanding into broken table-land, and barring all further progress to the east, by pushing out towards the south the branch which forms the watershed between the Beema and the Seena.

The trap formation in this district consists of an alternation of hard and soft beds of great thickness, and remarkable for their uniform horizontality. The hill ranges, which include in their height several such alternations, present a peculiar streaked appearance, the hard beds usually having bare mural escarpments blackened by the weather, while the softer beds, decomposing at an angle of about 45°, are covered by rich vegetation. The strata are undisturbed and almost horizontal; the surface of the country is generally conformable to them, and remarkably free from considerable undulations.

As the mechanical structure of all trap rocks depends principally on the particular circumstances under which they have cooled, it is not surprising that such structure should vary exceedingly in short distances even in the same stratum, although the predominant character of the bed does not disappear.

The line between Koobee and the Gungathuree will always rest either on a stratum of amygdaloidal rock, or on the bed of gravel lying immediately beneath it.

The latter stratum is from 50 to 90 feet in thickness, and is (for a member of the trap formation) remarkably uniform in character: it is of a whitish grey-colour, and in structure something between gravel and marl; it frequently contains thin beds of friable, spongy-looking amygdaloid, and everywhere abounds in nodules of *chunam*. It is well developed along the Kristnawuttee, between Murr and Dingora, and also between Peepulgaom and Ootoor; to the north of Alleh it forms the bed of the Mool, and the mountain torrents descending to that river from the Bramanwaree hills, have hollowed out deep chasms in it, whenever they descend to its level.

The amygdaloid which rests on this bed, varies exceedingly in colour, structure and hardness; in some places it is as soft and friable as marl, in others as hard as columnar basalt. It is sometimes thin-bedded and fissured in all directions, and at others rises in perpendicular and solid escarpments to the height of 200 feet.

Of these varieties the friable marly beds are the rarest; the hardest sorts appear to be generally either of very limited thickness or much fissured in all directions. The beds of moderate thickness frequently resemble lias in appearance, but are generally softer and coarser-grained. The highest and most compact-looking escarpments are often as soft as freestone.

On this bed of amygdaloid rests the nodular basalt (basalt *en boules*); the nodules that compose it vary from one pound to several tons in weight; they are very hard, generally spherical, and enveloped in thin, grey, friable concentric coats like those of an onion; they are imbedded in a *matrix* resembling the soft bed already described. The nodules may therefore be easily separated by a crowbar and rolled away.

On ascending this formation the nodules become closer and closer, and at last the matrix disappears altogether; the nodules compress each other into hexagonal prisms, and the rock finally passes into columnar or compact basalt.

In the lower beds of gravel and amygdaloid, dykes of columnar basalt are of frequent occurrence; but these seldom require blasting, as the columns, or rather prismoids that compose them, are always small, jointed and easily separated. These dykes occasion little disturbance in the strata they traverse.

Between Alleh and the Peera river three ranges of hills intervene, all of them spurs, stretching out from Hurreechunderghur, and consisting of the above-described amygdaloid rocks overlying the lower gravel, as already mentioned.

Of these three ranges, the first separates the river Kokree from the Kristna; the second, which is really a branch of the first, separates the Kristna from the Mool; and the third separates the Mool from the Peera river.

The left bank of the river Mool is much disturbed by spurs of the third range; and along the right bank is a series of rocky bluffs, between which and the prolongation of the first range, intervenes a wide tract of deep gravel cut up by chasms in all directions.

Below this the river Mool runs through the Gung Peer pass four miles in length; here a narrow strip of gravel ground, cut up into numerous small ridges and hollows by the watercourses descending from the western bank of the ravine, and averaging 300 yards in width, intervenes between the left bank of the river and the hills of the third range, forming the western boundary of the pass.

The table-land which forms the usual summit of the third range, corresponds in level with that of the first range, with which it appears to have been originally connected.

January 20, 1847.

William Thomas Collings, Esq. was elected a Fellow of the Society.

The following communications were read:—

1. *On the Wave of Translation in connexion with the Northern Drift.* By W. Whewell, D.D., F.G.S.

The great geological problem of the "Northern Drift" has been attacked in various ways; and the diffusion of Scandinavian rocks and northern detritus over a vast area in the northern part of Europe has been ascribed to various kinds of natural machinery. Of late, a large part of this operation has been attributed to "Waves of Translation," produced by the sudden upheaval of the bottom or shore of the sea. This view is advocated in the 'Geology of Russia' by Sir Roderick Murchison. There are some very simple numerical calculations which belong to this subject, and which may throw some light on the probability of such a theory. These calculations must necessarily be hypothetical as to their quantities, but as to their quantities only;

and even these will be capable of correction by a more careful survey of the facts. For the mathematical doctrine on which they proceed is rigorously true, and does not depend upon any hypothetical view of the structure of the masses which we have to deal with. Mr. Scott Russell tells us that the wave of translation may be regarded as a mechanical agent for the transmission of power, as complete and perfect as the lever or the inclined plane. Assuming this property of the wave of translation as a basis, I shall point out some of the results of its operation in the case now to be considered.

It has been stated to the Geological Society, that, by supposing the sudden elevation of a submarine district, there is no difficulty in accounting for a current of twenty-five or thirty miles an hour at the bottom of the sea, as a consequence of the "wave of translation." In making this assertion, I think it has not been sufficiently considered that what is thus called a "current," is really a *transient* motion for each point of the bottom of the water. The great wave is *solitary*: the fluid *before* and *behind* it is *at rest*; and the particles move *only while* the wave is passing over them. Therefore the effect of such a wave upon loose materials immersed in the fluid would be only one of two:—*either* it would carry a *single* mass along with it, giving to it its own velocity,—*or* it would give a *transient* motion to a series of masses in succession, as it passed over each, moving each but a small distance. A single wave of translation cannot explain the situation of a long line of masses *each* of which is moved through a *great* distance.

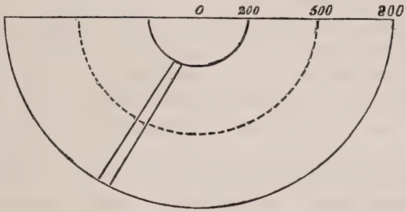
If indeed we suppose a *series* of waves of translation each produced by a sudden elevation, or by some other paroxysmal action, we may obtain a greater effect. In the operation of such a *battery*, each shock would be transmitted through the water by means of the wave, and would do its measured work; and by accumulating such processes, any amount of result may be mathematically accounted for.

In whatever manner we frame the hypothesis in order to account for the "Northern Drift," the same mathematical equality, between the work done and the force exerted, will hold, as if the effect had been produced by any other mechanical power:—whether the waves be one or many, great or small. And as the amount of the work done in transporting the northern drift from its parent rocks (supposing their place known) to its present position, may be calculated upon assumed numerical bases, we may test the theory of the wave of translation, by thus calculating the amount of sudden elevation which it necessarily supposes. The numbers which I shall assume may be grossly erroneous; but the result being attained, can easily be corrected by altering it in proportion to the alteration which ought to be made in any of the numerical elements.

In the 'Geology of Russia' it is stated that the northern drift occupies a space 2000 miles long and 400 to 800 miles wide. If all the materials were derived from one centre, we might, as a general approximate view, suppose the area to be circular, with a radius of 800 miles; or rather, semicircular, the northern half being for the most part cut off. But if we suppose this semicircle of 1600 miles diameter to be extended to a length of 2000, by taking the *Scandina-*

vian chain for the source of diffusion instead of a *single centre,* the distance travelled by each mass will be the same as in the supposed circle, which we may therefore make the basis of calculation.

Within the circle of 800 miles radius, I will take an inner circle of 200 miles radius, and I will consider the drift as occupying only the annular space between these two circles.



The *mean* distance from the centre of the annulus lies along a circle of which the radius is 500 miles. I will first consider places at this mean distance.

I must necessarily make some supposition about the mass of the materials which compose the drift. Let it be supposed that, at this mean distance from the centre of diffusion, every square mile, on an average, contains as much drift as would cover it entirely to the depth of one hundredth of a foot. This is equivalent to supposing that there is on each mile, a patch of drift, one-tenth of a mile square and one foot deep; or a ridge or "trainée" of drift, one-tenth of a mile long, one-hundredth of a mile broad, and ten feet deep. It is easy to see that the supposition might be put in innumerable other forms; and by comparing these with many observed facts, some average result might perhaps be obtained.

Supposing this result to be, as I have said, that on every mile there is an average depth of one hundredth of a foot, I shall, for the sake of easy calculation, call this $\frac{1}{500,000}$ of a mile (instead of $\frac{1}{528,000}$). And thus, on every square mile of ground, at the mean distance from the origin, there is $\frac{1}{500,000}$ of a cubic mile of drift.

I will suppose the mean specific gravity of this material to be three times that of water. When the materials are immersed in water, the effective gravity will therefore be twice that of water.

The horizontal force which it requires to move a body along a surface on which it rests, depends on the form of the body, its texture and that of the surface, and other circumstances: but I think we may suppose that it would require a force and pressure of at least one-fourth the weight of the mass moved, to propel rocks and loose materials along the bottom of the sea.

This being assumed, it will require a force (pressure) equal to the weight of half a cubic foot of water to move a cubic foot of drift; and so, for any other quantities. And to move $\frac{1}{500,000}$ of a cubic mile of drift, will require the weight of $\frac{1}{1,000,000}$ of a mile of water, acting as a pressure.

Now this mass of drift, which is found on an average mile at the mean distance, has travelled 500 miles from the centre. And the labouring force which has carried it through this space, in whatever way it has acted, must be equivalent to the product of the moving pressure and the space through which it has acted; that is, it must be equivalent to the weight of $\frac{1}{1,000,000}$ of a mile of water, multiplied into 500 miles.

This is the same as $\frac{1}{2000}$ of a mile of water, multiplied into one mile; or one mile of water multiplied into $\frac{1}{2000}$ of a mile of elevation.

That is, one cubic mile of water rising through $\frac{1}{2000}$ of a mile (or about $2\frac{1}{2}$ feet) would supply the power necessary to carry the drift which occupies one average mile at the mean distance from the centre of distribution.

Instead of one cubic mile of water, we may take a square of ten miles, $\frac{1}{100}$ of a mile deep; and this mass, rising through $\frac{1}{2000}$ of a mile, will produce the effect now spoken of.

Taking any radius drawn from the centre of the annulus, the part of this radius which lies on the annulus is 600 miles. On each of these 600 miles, we suppose drift to rest. Each portion of drift has travelled a different distance from the centre. But at each different distance from the centre, there may be a different quantity of drift upon the average; the quantity probably decreasing as we recede from the centre. Let us suppose, for the sake of calculation, that the quantity diminishes exactly *in proportion* as the distance increases; so that at the distance of 200 and 800 miles, the quantities on a square mile are as four and one respectively.

On this supposition, the labouring force requisite to carry the drift which lies on each square mile of the same radial line, would be the same. It would take the same labouring force to carry $\frac{1}{1,000,000}$ of a mile through 500 miles (the mean radius) as to carry $\frac{1}{400,000}$ through 200 miles to the inner edge of the annular space; or $\frac{1}{1,600,000}$ through 800 miles, to the outer edge of the annulus. In each case, the amount of force requisite would be, as before, the weight of $\frac{1}{2000}$ of a mile of water, raised through one mile.

Here the labouring force requisite to carry the drift to the whole of the 600 miles which lie along this radius, would be $\frac{6}{20}$ or $\frac{3}{10}$, of a mile of water raised through one mile ($600 \times \frac{1}{2000} = \frac{6}{20} = \frac{3}{10}$).

Now taking the whole semi-annulus, the length of the mean semi-circle, of which the radius is 500 miles, is about 1500 miles.

Hence if we suppose the radial tracts a mile wide just spoken of to make up the semi-annulus, the force requisite to distribute the whole mass of drift will be $1500 \times \frac{3}{10}$, or 450 cubic miles of water raised through one mile.

Now though these radial tracks do not make up the annulus, being too broad within the mean distance and too narrow beyond it, this excess and defect balance each other; and therefore we arrive at the conclusion that 450 cubic miles of water raised a mile high would produce an effect equivalent to the dispersion of the whole body of northern drift.

But we may put this result in a shape more readily conceivable. It is equivalent to 4500 cubic miles of water raised through a space of $\frac{1}{10}$ of a mile; or again, to a body of water 45,000 miles in surface and $\frac{1}{10}$ of a mile deep, raised through $\frac{1}{10}$ of a mile. If then we suppose a sea-bottom 450 miles long and 100 miles broad, which is $\frac{1}{10}$ of a mile below the surface of the water, to be raised to the surface by paroxysmal action, we shall have the force which we require for the distribution of the northern drift, on the numerical assumptions which have been made. And this is true, whether we suppose the elevation to have taken place at once, or by repeated operations, so long as they are paroxysmal. We shall have the requisite force, for instance, if we suppose this area to be elevated by ten jerks of 50 feet each, fifty jerks of 10 feet each, or by the same 500 feet any how divided into sudden movements. And as we diminish the area elevated, we must increase the total amount of elevation in the same proportion, so as to retain the same ultimate product of water paroxysmally elevated through a certain space. In all these cases, we shall have a machinery, which, operating through waves of translation, will produce the requisite effect. And if any of our data be held to be erroneous;—the area occupied;—the amount of matter in the drift;—the amount of friction or tenacity to be overcome in propelling it;—the law of its diminution in quantity as we recede from the centre of distribution;—the final result will have to be proportionally diminished or augmented.

It may be asked whether, since the paroxysmal elevation may thus be reduced into successive smaller elevations, the same result would not follow if it were so reduced as to become, not paroxysmal, but gradual, and even insensible: for, it may be said, mechanical power retains its amount however much it be thus distributed through time, and divested of the character of extraordinary violence. And to this I reply, that no action except such as is of a paroxysmal character could produce the effect. This impossibility depends upon the nature of the effect to be produced. The friction of the bottom which supports the drifted materials, and the tenacity of the masses, are to be overcome: and the peculiarity of such resisting forces is this;—that except the force which acts be sufficient to overcome these resistances, it produces no effect, and is altogether lost. If we push at a mass resting on the ground, with a force insufficient to move it, the force which we exert is wasted, and disappears from all calculations which suffer force to be preserved and transferred into the change produced. A very small elevation, even if sudden, would produce a wave of translation which would pass over all the large masses, and leave them unstirred; and the wave would disappear without producing any such effects as we are here endeavouring to account for.

And thus, the great mass of northern drift, inasmuch as no considerable part of its transfer can be accounted for by any minute causes or languid operations of water, is an irresistible evidence of paroxysmal action; and of action in a scale which may be judged of from the conclusion at which we have arrived:—an elevation of 45,000 square miles of sea-bottom through 500 feet. And this conclusion is equally certain, whether or not we suppose the machinery employed in the distribution of this mass from the centre to be waves of translation. For the proposition that the labouring force expended in the transit of this mass of materials must be equal to the force exerted, and that this force must be exerted in such portions as, at every step, to overcome the friction and tenacity of the masses of rock, shingle, and other detritus moved, is equally true, whatever be the machinery employed. As no gradual or minute action could move the masses in question through a yard of space, no accumulation of such action, through any amount of time, could distribute the masses through the great distances which the northern drift has traversed, and spread them over the vast spaces which that formation occupies. The distribution of the northern drift belongs to a period when other causes operated than those which are now in action.

Postscript.

Perhaps it may throw some light upon the subject to remark that a wave of translation differs little from a "debacle" according to the notions of earlier speculators. A wave of translation is a *debacle* conceived according to the more exact notions to which modern science has led. Or rather, since a *debacle* was generally conceived as a vast torrent sweeping over the land, arising from the emergence of a submarine area, or some such cause, we may say that a *wave of translation,* in such cases as we have considered, is *a debacle travelling along the sea* after it has been shot off the land.

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2. A notice of a new Clinometer, presented to the Society by R. Grantham, Esq., was then read; for which he received the thanks of the Society, and the Instrument was ordered to be deposited in the Museum.

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3. *On the Slow Transmission of Heat through loosely coherent Clay and Sand.* By James Nasmyth, Esq. *Communicated in a letter to* Leonard Horner, Esq., P.G.S.

When I lately had the pleasure to see you at the foundry, on drawing your attention to what appeared to me a remarkable example of the low capability of mineral substances for conducting heat, I was much gratified to find that you agreed with me in considering that the instance in question had an important bearing on several interesting geological questions, especially those relating to the theory of the central heat of the earth.

At your request I have much pleasure in sending you a statement of the instance in question, under the impression that it may chance to prove of some interest as an illustration of what may yet exist in respect to the state of the interior of the globe, as regards its high temperature.

The instance in question, you will remember, was that of a large plate-iron pot, containing eleven tons of white-hot melted cast-iron—a temperature so high as to be quite beyond all thermometric certainty, but well-known to be the highest intensity of furnace heat, being quite equal to that of welding hot iron.

This vast mass of white-hot melted cast-iron, you will remember, stood in the pot for upwards of twenty minutes, and but for a thin coating of clay and sand of about half an inch thick, would have soon melted the bottom and sides of the pot.

This half-inch thickness of mineral substance, however, was quite sufficient to prevent the conduction of the heat to the exterior; so completely so, that after this vast mass of hot iron had remained for upwards of twenty minutes in the pot, you could place your hand on the side of the vessel without feeling any inconvenient degree of heat; and, as I mentioned to you, so slowly and imperfectly does this thin lining of half an inch of clay and sand permit the heat to pass outwards, that the entire mass might rest there till it became cool ere the outside of the pot would have reached a temperature high enough to carbonize wood in contact with it, the radiation from the outside carrying away the heat as *fast* as the *slow* conducting power of the clay and sand lining transmits it.

So striking an instance of the low conducting power of such substances is not frequently met with, and it appears to me that it is calculated to remove some of the doubts occasionally expressed respecting facts which indicate a high temperature in the interior of the earth. If half an inch of mineral matter thus intercepts the communication of so high a temperature as that of a mass of eleven tons of white-hot cast-iron, what may not two or three hundred miles of similar substances effect, in preventing the central heat of the earth from developing its action beyond a very moderate extent towards the surface? If this reasoning be correct, it tends to show that there may exist below the crust of the earth, a mass of fluid molten matter which at depths of two or three hundred miles may have a temperature transcending all our ideas of high heat, the only indications of which, at the surface, are afforded by volcanos, hot springs, and that regular increase of temperature as we descend towards the interior found in deep mines, or by deep borings.

There are many other instances of this nature which I could bring forward, as exhibiting the remarkable non-conducting powers of clay; many such examples are every day before the eyes of our manufacturers who have to do with furnaces where intense heat is employed. The fire-brick lining of such furnaces is only from 4½ to 9 inches thick, and yet while the heat within is as high as our furnace powers will carry it, the hand can be placed outside without suffering any inconvenience.

February 3, 1847.

A paper 'On the London Clay,' by Joseph Prestwich, Jun., Esq., F.G.S., was read.

[The publication of this paper is postponed by the author's desire, in order that it may be printed together with another paper on the Bagshot sands subsequently read.]

February 24, 1847.

John Craig, Esq., Glasgow, was elected a Fellow of the Society.

The following communications were read :—

1. *On recent Depressions in the Land.* By James Smith, Esq., of Jordan-hill, F.G.S.

The human period may be subdivided into the present, or that in which geological events are subjected to our own observation; the historical, or that in which they have been observed and recorded; and the antiquarian, in which, although we cannot assign a date to them, we can prove from human remains or works of art that they must have taken place since the earth was inhabited by man.

Having recently observed proofs of movements of depression in each of these periods, I proceed to notice them in their retrograde order.

When I visited Pozzuoli in 1819, the floor of the temple of Serapis was dry, but I remarked that the channels cut across it for the purpose of draining the waters of the thermal spring which rises within its precincts were nearly filled with sea-water, with a sensible current flowing inwards, or from the sea; when I returned in 1845, I found that the high-water mark stood at 28 inches above the pavement, exhibiting a rise of about an inch yearly.

As there is a rise and fall of tide of nearly 10 inches within the building, and as I have no means of knowing the state of the tide at my first visit, I cannot speak with certainty as to the exact change of level which had taken place during the interval between my observations; I am however satisfied that it could not be much more or less than one inch yearly.

Professor Forbes of Edinburgh visited the temple in 1826, and Mr. Babbage in 1828; and as both of these gentlemen took notice of the state of the tide, and have favoured me with the record of their observations taken at the time, I am enabled to compare them with my own, and find that the differences agree very nearly with what I have above stated.

Professor Forbes found the depth of water at full tide about 12 inches, which is 16 inches below my measurement made eighteen years and a half afterwards.

Mr. Babbage, who made a section of the building, has marked the high-water level about 2 inches below the top of the plinth, or lowest member of the base of the columns, which is about 14 inches below that observed by me seventeen years afterwards.

Professor Forbes again visited the temple in 1843, when he noticed the height at which the surface stood at the base of the columns; and as I also measured the depth at the same spot, I find that our measures agree as nearly as possible. He says, that when they were taken "the level was lower than usual, being very calm, yet the water rose above the first roll of the pillar" (the TORUS), *i. e.* about 20 inches above the floor. He adds, "there appears to be much more water than when I saw it in 1826."

He does not mention the state of the tide, but his observation must have been made within half an hour of high water, as the date was 9th Dec. 1843, and the hour between 10 and 11 A.M.; but it was high water in the Bay of Naples upon that day about eleven, being two days after full moon; the time of high water at Naples being 9^h 23^m at full and change*.

In order to enable future observers to estimate the annual rate of depression with more accuracy than I have been able to do, I have to mention that when I made my measurements there was no disturbing cause to affect the mean level of the sea in the Bay of Naples.

The winds for some time previously had been light and variable, and at the time in question (11th May, 1845, at 7 A.M.) it was so calm that the oscillations of the surface did not exceed 2 inches on the pier of Pozzuoli. The observations were taken exactly at low water, for when engaged in examining the tunnel by which the water within the building communicates with the sea, I noticed the first of the flood entering it; at that time the water stood 1½ inch above the square plinth, or lowest member of the base of the southernmost of the three pillars, and 9½ inches above the step upon which they rest: hence it must have stood 11 or 12 inches above the plinth at high water.

I think it right to state that my conclusions, respecting the annual

* As the state of the tide is an essential element in all calculations respecting the rate of change of level, it is necessary that it should be stated, or at least that the date and hour of the day be given, to furnish the means of making the necessary correction of the observed depths. The *establishment* of the Port of Naples, as given by Signor Nobile in the 'Rendiconti dell'Academia delle Scienze di Napoli,' is as follows:—High water at full and change of the moon 9 hours 23 minutes; rise and fall of the tide 378 millimetres (14·8 inches). Within the temple of Serapis the rise and fall is certainly not so much; I found the marks of the preceding tide 10 inches above low water; Cav. Nicollini states it to be nine-tenths of a (Neapolitan) palm or 9½ inches; he also notices that the time of the turn of the tide is well-marked (ben distinto) in the outlet; I can confirm this by my own observation.

The mean level of the Mediterranean is of course affected by the winds. In looking over Cav. Nicollini's observations, I find that the difference between any two consecutive tides rarely amounts to 100 millimetres or 4 inches; and only upon one occasion is it so much as 131 or 5·17 inches; it appears, however, that he omitted to record unusual elevations caused by the "buttature" or swell on the outside.

From the open form of the Bay of Naples, the sea-level must soon recover its equilibrium, hence observations made in calm weather cannot be much affected by this disturbing cause.

rate of change of level, differ considerably from those of Cavalier Nicollini, who has made a series of observations on the depth of the water between the years 1822 and 1838. They prove the important fact, that a gradual change of level is taking place; but according to his calculations it is only at the rate of seven millimetres, or less than one-third of an inch annually.

Upon examining his tables, however, I find that though the entries repeatedly descend to zero on the scale of his hydrometer, they never go below it; and on the other hand, he rejects all the high numbers, confining his data to the three lowest of each year, from which he infers that the amount of rise in these sixteen years was only 112 millimetres, or about $4\frac{1}{4}$ inches, which, divided by sixteen, the total number of years of observation, gives the above-mentioned result. It is obvious that the mean rate which he arrives at by this mode of calculation must be too small; this however does not diminish the value of his observations, and I regret I cannot avail myself of them in the present comparison, because I am unable to discover the relative height of his low-water mark with the bases of the columns, or even with the level of the floor.

In consequence of an accident to his hydrometer, he has erected a new one which gives the depth at high water above the floor (sopra del piano). This, in January 1838, was half a metre, or about 20 inches, being about 8 inches below my observation made seven years and a half afterwards, agreeing very nearly with the rate deduced from the observations made by Professor Forbes, Mr. Babbage and myself.

It appears to me that this depression has been going on for many years, probably since 1538, the date of the last paroxysmal elevation, according to the contemporary accounts published by Sir William Hamilton, and mentioned by Mr. Lyell in his account of the building.

In 'La Vera Antichita di Pozzuoli,' printed at Rome, 1652, there is a bird's-eye view of this locality, in which the three columns are represented standing in the garden of a villa at a considerable distance from the sea, and between it and the building are seen two churches, Santa Maria Gratiarum and Jesu Maria; and in the 'Guida di Pozzuoli,' 1709, the columns are thus noticed: "Nell giardino oggi di Alessandra Flauto si vedono tre colonne maravigliose tutti di un pezzo." The whole of the intervening space with its buildings has disappeared, and there are two sea-walls standing in the sea parallel to the present one, built to protect the road; one of them is, if I recollect right, 20 or 30 feet from the shore, and the other about double the distance.

The church of Madonna del Assunto is now surrounded by the sea and connected with the land by a causeway, which it has been found necessary to raise, and the surface of the water is level with the floor of the building.

The road from Naples along shore was being raised at the time I visited it, and from every thing I could learn upon the spot from the old people, a gradual subsidence has been going on for many years.

The following appears to be the history of the changes in the relative levels of sea and land, which have taken place subsequent to the erection of the building, at which time the ground must have stood at a higher level than it does at present.

1. The first movement of which we have evidence is that of gradual depression; this is proved by the false floor which has been placed several feet above the original one. The same process has been necessary in the causeway which connects the church of La Madonna del Assunto with the shore; the sea having washed away a portion of the pavement, an older one is exhibited about two feet below.

2. This has been followed by a period of stationary level, during which the columns were perforated by lithodomous mollusks.

3. A gradual movement of elevation: this is proved by grants made to the University of Pozzuoli in 1501 and 1503, of the land which the sea was leaving dry (il terreno che il mare andava lasciando in secco), as noticed by Cav. Nicollini.

4. The paroxysmal elevation in 1538 described in the contemporary accounts.

5. Lastly, a gradual subsidence, which is still going on at the rate of about one inch yearly.

The next series of proofs of recent depression belongs to the historical period. The phænomenon of submerged forests is nowhere more largely developed than on the coasts of Britanny, Normandy and the Channel Islands; the great rise of tide, amounting in some places to fifty feet, and the flatness of the shores over which it ebbs and flows, in some places not less than seven miles, afford opportunities for observation probably nowhere else to be found.

The chief peculiarities which distinguish this forest are, first—

The freshness of the wood. When exposed, the wood does not differ from that of other submerged forests in respect of decay; such was the case with what I observed in the Bay of St. Ouen in Jersey; but Col. Le Couteur, who lives in that neighbourhood, showed me the stem of an oak, which had been laid bare by a heavy gale, in the most perfect state of preservation. In a communication to the Agricultural Society of Jersey, he thus describes it:—"After the gale, which had greatly denuded the sands, I had the good fortune to see the stem of one of these ancient oaks: the trunk stood four feet above the peaty soil on which it was firmly rooted; its diameter was about three feet. * * * * * It was still heart of oak."

I observed at low water, on the shore between Granville and Avranches, stems of oak in the attitude of growth in a similar state of preservation.

According to the Abbé Manet these ancient stems are locally termed *Coerons*, and in some places *l'anaillons*; the wood is used for economical purposes, such as beams in the roofs of houses, furniture, in which its hardness and dark colour give it the polish of ebony, and for espaliers, "qui resistent long temps aux injures de l'air et qui portent avec eux leur peinture," p. 63.

The next peculiarity which distinguishes these forests is, that they contain the ruins of ancient buildings and works of art. I cannot speak as to this from my own observation, but the Abbé Manet has brought forward a great mass of evidence proving their occurrence on the French coast; and Falle, the historian of Jersey, states, that there are buildings in the submerged forest of St. Ouen. I can, however, give the authority of Capt. Martin White, R.N., who has executed, under the directions of the Admiralty, an elaborate survey of this part of the French coast. He informs me that on a shoal, which is named in the French charts "La Parisienne," he has brought up with the lead fragments of brick and tile, and is quite satisfied that it has been formed by the ruins of an ancient building. He has also seen, under water, lines running along the bottom evidently artificial, and which are probably the same as those mentioned by Borlase in his account of the Scilly Isles*, which are locally called 'hedges,' *i.e.* ancient stone walls, which, he says, "are frequently seen upon the shifting of the sands in the firths between the islands." The same author also mentions a straight-lined ridge, like a causeway, running across the old town creek in St. Mary's, which is now never above water.

Another peculiarity of this forest is the great vertical range through which it can be observed. The tide rises and falls, as already noticed, in the Bay of Cancale, about fifty feet; and Capt. White informs me he has seen, as far as the eye can penetrate below the surface at low water, stumps of trees *in situ* beneath the sea, with the roots shooting out in every direction. He has observed this phænomenon both on the coasts of France and Jersey. These trees could not be less than sixty feet below high water.

The most important point connected with this forest, however, is the precision with which the date of the submergence can be ascertained.

The account given by ecclesiastical historians and metrical chroniclers is as follows:—About the beginning of the eighth century St. Aubert, Bishop of Avranches, founded a church in honour of the Archangel Michael, upon the mount which now bears his name, which was then surrounded by a forest, and was more than two leagues distant from the sea. Being anxious to procure some relics of the patron saint, he sent two priests to Mount Garganus, in the south of Italy, for a portion of a red cloak which the archangel had left when he visited that place, and of the marble of the altar upon which he appeared. During their absence, according to the Père de Moustier, in

* Borlase's account of the Scilly Islands contains many proofs that they have been subjected to a movement of depression during the human period. If they are the same as the Cassiterides mentioned by Strabo, and there is no other group to which his description can apply, it is quite evident that a great depression must have taken place since he wrote. The traditional account of the loss of land between Scilly and Cornwall is well known; it was first mentioned by Camden, but he treated it as a mere fable, "nescio qua fabula." His translator, Bishop Hudson, mentions a report, that at the Seven Stones, rocks between Scilly and the mainland, *fragments of windows* had been brought up by the hooks of the fishermen. Capt. White, who has also surveyed this part of the English Channel, states, that the summit of one of these rocks was evidently levelled by art, and that he brought up with the lead, amongst other remains of art, a *fragment of the leaden astragal of a window*.

his 'Neustria Pia,' "Deo permittente mare sylvam quantumque esset superavit et prostravit, replevitque arena locos Monti Tombelino adjacentes; nuntii autem reversi 16 Octobris* saltus arena refertos adeo mirati sunt ut novum orbem se ingressos putaverunt."

The Abbé De la Rue, in his 'Essai Historique sur les Bardes,' (vol. ii. p. 303,) quotes an ancient poem by Guillaume de Saint-Pair, a monk in the monastery of Mont St. Michel who flourished in the twelfth century, who says, that what was then sand was formerly a forest:—

"Ceu qui or est mer et areine
En icels tems est forest pleine
De mainte riche venaison
Mais ore il noet li poisson.
* * * *
En le forest avait un mont," &c.

But in monkish historians and metrical chronicles we are naturally apprehensive of finding legends for history—in explanation of appearances, the origin of which is unknown.

Professor De Hericher of Avranches, in his work entitled 'Avranchin Monumentale et Historique,' quotes certain ancient MSS. preserved in the public library in that town, which belonged to the Benedictine Abbey of Mont St. Michel, but were dispersed at the revolution, which give an account of the sudden eruption of the sea by which the ancient forest was submerged. I availed myself of the opportunity which a visit to that place afforded me of examining them.

The volume No. 34 contains several works in different hands, but all of great antiquity. The one alluded to by M. De Hericher, which he considers, from its palæography, to have been written in the ninth century, has for its title, "Incipit revelatio Ecclesiæ Sancti Michaelis in monte qui dicitur Tumba in occiduis partibus sub Childeberto Rege Francorum, Auberto Episcopo."

The account contained in it is as follows:—"Qui primum locus, sicut a veracibus cognoscere potuimus narratoribus, opacissima claudebatur silva longe ab oceano ut estimatur æstu millibus distans sex, abditissima præbens latibula ferarum.

* * *

"Mare quod longe distabat paulatim assurgens omnem silvæ illius magnitudinem virtute complanavit, et in arenæ suæ formam cuncta redegit.

* * *

"Quasi novum ingressi sunt orbem quam primum veprium densitate reliquerant."

M. De Hericher, unwilling to admit an actual change of level, supposes that the distance, "ab oceano æstu," refers to low water, and as Mont St. Michel is six miles from it, concludes that no change has taken place; but the account of its having been surrounded by wood leaves no room for such a supposition.

* In corroboration of the season (October), the Abbé Manet states that certain places are remarkable for the number of well-preserved acorns and nuts which are found in them (p. 53.).

According to Père de Moustier, the return of the messengers took place 16th Oct. 709. This date agrees with that assigned to the event by the metrical chronicle quoted by the Abbé De la Rue, who observes, "Ces révolutions durent avoir lieu suivant le poëte sous l'épiscopat de St. Aubert et sous le règne de Childebert," vol. ii. p. 303.

The Abbé Manet states, that during the great gale of 9th Jan. 1735, the violence of the sea "sur les grèves du Mont Saint Michel fit sortir des sables une quantité prodigieuse de ces billes qu'on y trouva *presque toutes couchées du nord au sud*," p. 53. This is exactly the position in which the sea, rushing in to fill up a sudden depression, would lay the stems, as the bay of Mont St. Michel or Cancale is open to the north.

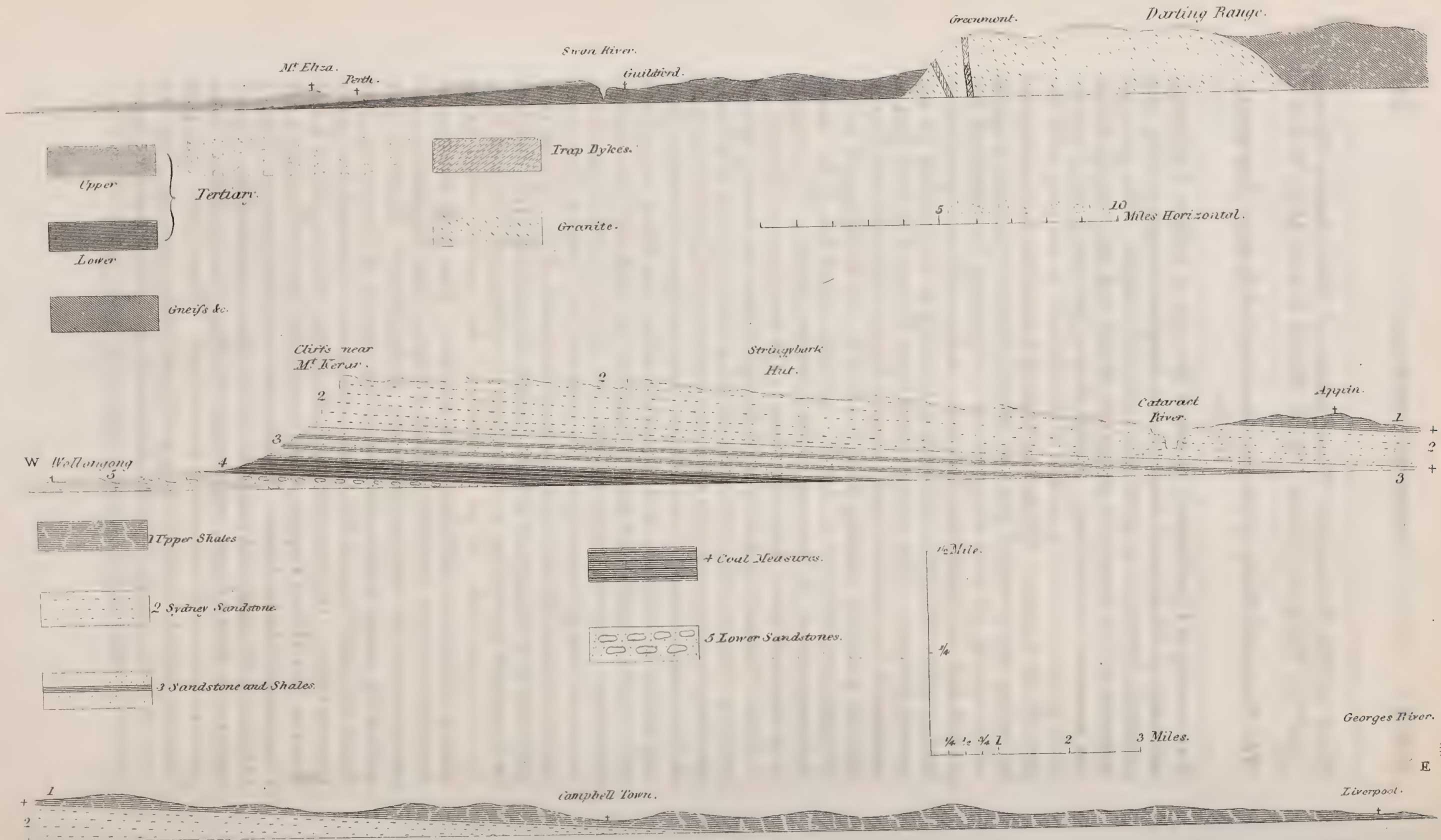
The last proof of recent submergence which I have to offer belongs to the antiquarian division of the human period; it occurs in the islands of Malta and Gozo.

A great part of the surface of the island of Malta is composed of a soft stone (miocene tertiary); across it may be observed the tracks of wheels, about 4 feet apart and very deeply marked on the rocks, the depth being rarely less than 18 inches. They cross the island in every direction, but have no connexion with any of the existing lines of communication, neither is there any tradition concerning them. On the south side of Malta they terminate in the mural escarpments which skirt that part of the coast. At the east end, at a place called St. George, in the Bay of Marsa Sirocco, I observed them passing under the sea as far as my eye could reach. On this occasion the water was turbid from the quantity of sea-weed which had been blown into the bay; but Bres, a Maltese author, in his 'Malta Antica Illustrata,' states that they can be observed at the bottom of the sea, as far as the eye can reach in the clearest weather. He also mentions that they occur at the west end of Malta, and on the opposite part of Gozo (p. 59). As he has not indicated the precise locality, I searched for the tracks in vain at the west end of the island. Mr. St. John of Valetta informs me, that he has observed these tracks on Filfolo, a detached rock which lies about a mile distant from Malta.

At St. Paul's Bay, on the north-west side of the island, there is a narrow channel separating the small island of Selmoon from the main land of Malta. Across this channel, at the depth of 10 or 12 feet, may be seen a vertical escarpment of about the same height, causing a sudden change in the depth of water of about two fathoms. This is evidently an ancient sea-cliff, indicating a period of stationary level anterior to the present; but this must have been preceded by another movement of depression, also within the human period, for this difference of height would not account for the continuity of Malta, Gozo and Filfolo, which the occurrence of these tracks, in each of them, seems to indicate.

The occurrence of the fossil elephant in Gozo, formerly noticed*, probably belongs to a much more remote period.

* Proceedings of the Geological Society, June 1846.



Cs Wallis. Sculpt

Notes on the Palæozoic Formations *of* New South Wales *and* Van Diemen's Land. By J. Beete Jukes, M.A., F.G.S.

The Palæozoic Rocks of the neighbourhood of Sydney, New South Wales.

The county of Cumberland, in which the city of Sydney is situated, and parts of the adjacent counties, are composed almost entirely of a palæozoic formation of great thickness and extent. The principal materials of this formation are certain shales and sandstones, with a few associated beds of coal. In the close of the year 1845 I made a short excursion across a portion of this district, in company with the Rev. W. B. Clarke. We carried with us a mountain barometer, and by taking the means of the two sets of observations made in going and returning, got such an approximate estimate of the heights of the ground and the thickness of the rocks, as to enable us to construct a section with a sufficient approach to accuracy to be relied on for my present purpose. This section runs from Liverpool (a town just at the head of the tidal waters of George's River, which falls into Botany Bay) by a slightly winding line, first S.S.W. for about twenty miles, through Campbelltown to Appin, and then about S.S.E. for about eighteen miles to Wollongong in the Illawarra district. Wollongong is on the coast about forty-five miles to the northward of Sydney.

From Paramatta by Liverpool to Campbelltown the country is low, gently undulating, and composed (Pl. VII.) almost entirely of (No .1) black and brown shales, with a few thin interstratified beds of sandstone in their lower portion. From Campbelltown to Appin the country rises into bolder undulations, and on approaching the latter town thick beds of (No. 2) sandstone show themselves, creeping out from beneath the shales. Beyond Appin nothing but this thick-bedded sandstone was to be seen for many miles, the ravine of the Cataract river showing precipices 200 feet high entirely composed of it. It rose very gradually in a wide gently sloping plateau, furrowed in every direction by innumerable winding and precipitous ravines, and covered by a forest of gum-trees, till on approaching the coast it ended in an abrupt escarpment 1200 feet above the sea. This bold escarpment stretches from the sea-cliffs of Bulli obliquely into the country, and sweeps round the valley of Illawarra, uniting towards the south with some lofty ranges which come out of the interior of the country, and which are, according to Mr. Clarke, composed of volcanic and other igneous rocks. In descending this escarpment between Mount Kerar and the Hat Hill of Captain Cook, we get the lower beds coming out from beneath the sandstone. These consisted of alternations of (No. 3) thick beds of shales and sandstone, with some conglomerate, (No. 4) shales with beds of coal, and lastly, of (No. 5) some beds of compact sandstone with calcareous concretions. These latter beds rose from the foot of the hills into a gently undulating country about the town of Wollongong. To the southward these latter rocks were cut off by a strong band of igneous rocks, principally greenstones, forming a tract of country two or three miles wide, to the southward of which again were other sandstones of a dull red colour; but our time did not permit of our working out their relations with any approach to accuracy. I will now briefly describe this section in an ascending order, and glance at the extension of the rocks over the adjoining district, and at the position in which they now repose.

5. The lowest group of rocks, the Wollongong sandstones, are commonly thick-bedded, fine-grained, and either dark grey or reddish brown. They are often slightly calcareous, and contain many concretionary calcareous nodules, from two inches to two feet in diameter, which when broken open commonly disclose a fossil shell. Beds two or three feet in thickness often exhibit concentric bands of colour, or sections of spheroidal coats, and the rock has more or less a tendency to decompose along these coloured coats. This concretionary structure in one place exhibited itself on a much larger scale. A portion of the beds, twenty feet high by thirty feet long, and consisting of six or eight beds, exposed in the face of a cliff, showed on each side the coloured edges of concentric coats enveloping the whole mass. The lines of lamination of the beds passed through the enveloping coats without alteration. The coats were not more than a foot thick altogether, and peeled off as they decomposed, leaving the mass described above as a solid nucleus.

These Wollongong sandstones contained a few fragments of fossil wood and shells and corals, identified by our Curator Mr. Sowerby.

Fossils of Wollongong.

Stenopora crinita.
Producta rugata.
Spirifer subradiatus.
—— Stokesii.
—— avicula.
Pachydomus carinatus.
Pachydomus ovalis (*P. globosus*, Morris, not Sowerby).
Orthonota, sp. nov.
Pleurotomaria Strzeleckiana.
Bellerophon contractus, *MSS.*, sp. nov.

At Wollongong these beds dipped to the N. and N.N.W. at a slight angle, and in following them along the coast in that direction, as we rose on to the higher beds and approached the coal, the sandstone became charged with great quantities of fossil wood. In the level sheets of rock left by the tide at low water, great fragments of black fossil wood, with smaller chips scattered about, were exposed in the lighter-coloured sandstones, with their edges rounded and worn, and having been evidently drift-wood before they were enclosed in the rock. So like were they to common drift-wood on a beach, that I could hardly help fancying them so, until their hard siliceous substance and the difficulty of extracting them from the sandstones proved the contrary. The total thickness of these sandstones, as seen by us, was about 300 or 400 feet.

4. The coal-measures that show themselves in the cliffs, on the north part of the Illawarra district, are but very insignificant, the total thickness of the whole beds containing the coal not exceeding 200 feet. The actual thickness of the coal-seams themselves we did not ascertain, but from all we saw and heard of them, they must be but

unimportant beds in an economic point of view. Abundance of black silicified wood strewed the road where it crossed these coal-measures, and I have no doubt whole trees might be extracted with comparatively little cost and trouble.

3. Of the alternations of shales and sandstones above the coal, I can say nothing more, than that Mr. Clarke recognized them as resembling beds he knew in the valley of the Hunter, to the northward, which had the same position with regard to the coal. They were about 400 feet in thickness.

2. The thick mass of sandstone above them was called by Mr. Clarke provisionally "the Sydney sandstone." It consists of very thick beds of white and light yellow sandstones, in some places fine-grained, at others coarse, and containing small quartz pebbles. Lithologically it resembles the millstone-grit and the sandstones of the lower coal-measures of the north of England. Its beds are parted occasionally by thin bands of shale and contain no organic remains, so far as is known. Its thickness is fully 700 or 800 feet.

1. The upper shales contain a few small fragmentary vegetable impressions and bits of leaves, and I believe also some fossil fish. Their thickness must be at least 300 feet, but may be much more. The most conspicuous member of this series in the country around Sydney is No. 2, the Sydney sandstone. The districts composed of it are always rocky and barren, with a level or gently sloping outline when viewed from a distance, but when traversed are found to be eaten into or furrowed in every direction by innumerable ravines. These have almost invariably steep if not perpendicular sides, with projecting and overhanging ledges of rock. They are narrow in proportion to their length and depth, the latter often very great, and when the sandstone rises any height above the sea, becomes enormous*. The same character still continues however even below the sea-level, as it is this which gives their peculiar form to the harbours of Port Jackson and Broken Bay, with their many long winding narrow arms bounded by precipitous rocky cliffs.

The upper shales, as might be expected, form a country with very different characters, namely gently undulating plains and round-topped lumpish hills. This is shown in all the district between Paramatta and Emu Plains, Windsor and Campbelltown.

In a good physical map, such as Sir T. Mitchell's map of New South Wales, these characters become so distinctly marked, as to enable us to give at once a rough approximation to the boundary of the countries occupied by the two kinds of rock.

By this aid and by the description given me by the Rev. W. B. Clarke, joined to my own cursory observations, I am enabled to state that the country lying between Campbelltown, Paramatta, Windsor, and the Nepean River, forms a flat basin, being composed of the upper shales, from beneath which the Sydney sandstone rises out in

* See Mr. Darwin's description of two of the most celebrated valleys of this kind on the slope of the Blue Mountains (Darwin's Journal). Mrs. Meredith also describes them in her account of New South Wales.

every direction. To the westward this sandstone rises with a gradual slope high onto the range of the Blue Mountains, with the inferior rocks and the coal-measures exposed in the depth of some of its gullies. To the north it rises into a widely-spread rocky district, from beneath which come out the coal-beds now worked at Newcastle on the river Hunter. To the south, as already described, it rises into the sandstone ranges, the escarpment of which overlooks the Illawarra district, the inferior coal-measures being again exposed below it. Towards the east it rises with a very gradual slope, but before it has attained any considerable elevation is cut off by the sea, which, as before explained, has penetrated into its winding gullies in this portion and formed the harbours of Port Jackson and Broken Bay.

The city of Sydney stands, I believe, just on the uppermost beds of the Sydney sandstone, near the passage of that mass of rock into the upper shales. Considerable beds of shale are indeed to be seen around the town, resting on and interstratified with the sandstones. If this be correct, the beds of coal are about 1100 or 1200 feet below the city of Sydney, and still deeper at the town of Paramatta and in the central portion of the county of Cumberland.

The series of rocks now described are by no means set forth as representing the whole palæozoic formations of New South Wales. There are very probably higher beds than the upper shales here mentioned, as there are certainly much lower beds than the Wollongong sandstones. The limestones of the Yass country will probably be found to be below the whole of the rocks mentioned in this paper.

As a general observation, I would remark on the perfect conformability of the whole series of rocks here described and their gradual transition from one into the other. They evidently form part of one great and continuously deposited formation.

From a collection transmitted by Mr. Clarke to the Woodwardian museum of Cambridge, I have been permitted, by the kindness of Professor Sedgwick, to select the following fossils in addition to those already mentioned. They come chiefly from the valley of the Hunter; the vegetable remains from the coal-measures at Newcastle; but I do not know the precise geological or geographical locality of the other fossils.

Plants.

Glossopteris Browniana.
Vertebraria indica.
Pecopteris australis.
Phyllotheca australis.

Animals.

Favosites gothlandica.
One species of Crinoides, apparently related to Platycrinus.
A form belonging to the Radiata, and resembling an Echinoderm.
A small Trilobite.
Two new species of Spirifer.
Two species of Leptæna.
A Terebratula.
A Eurydesma.
An Inoceramus.
A Pleurotomaria.
And a Conularia.

2. *On the south-eastern portion of Tasmania.*

The two principal rock-masses of the south-eastern portion of Tasmania are a very massive rudely columnar greenstone, and the sandstone of the palæozoic formation. The igneous rocks vary from a crystalline dark greenstone, through fine-grained basalts, to a coarse cellular trap or scoriaceous lava-like pumice. The sandstones contain interstratified beds of clay, shale and loose sand, as also of limestone and coal.

From the want of a good physical map on a sufficiently large scale, and of time for a detailed examination of the country, I am unable to draw any section of any portion of Tasmania, or even to give an accurate and positive description of the order of superposition of the stratified rocks, or of their relations with the igneous rocks.

The interior of the country is rugged and broken, with many ranges of hills running in various directions, and the coast-line is indented by a multitude of bays, harbours and channels penetrating into the land with much irregularity. To the difficulty thus arising from the external features of the country, is added that resulting from great complexity in its internal structure. The sedimentary and the igneous rocks are so interlaced and entangled one with the other, and their apparent relations at the surface so different in different localities, that nothing but a careful and minute survey, laid down on maps of a large scale, will ever be able thoroughly to elucidate them.

A. *The Valley of the Derwent River.*

Along the S.W. side of the valley of the Derwent runs a bold range of flat-topped hills, of which one of the principal promontories is Mount Wellington, rising immediately behind Hobarton to a height of 4200 feet above the sea. The upper portion of this range is composed of massive greenstone, often forming rude columns of great size, frequently as much as ten feet in diameter. The lower slope of this range, and much of the country forming the opposite side of the valley, is composed of the palæozoic rocks. These lie generally in a nearly horizontal position, and I believe *abut horizontally against the greenstones*; but as I never found a clear section near the junction of the two, I cannot positively say that they do not pass under them, —that the greenstones of the hill-tops are not a thick capping resting on the palæozoic formation. In ascending Mount Wellington from Hobarton we first pass over a great thickness of white and yellow sandstones nearly horizontal; above these are shales and thin beds of limestone, likewise horizontal; over which again other sandstones are found. These rocks occur to a height of 2500 feet above the sea, and apparently form a solid mass of that thickness at least. Above this point greenstone alone is to be seen, forming a mass 1700 feet thick at least. Its total thickness depends of course on the undecided question, of whether it be a capping to the palæozoic rocks, or what I believe is much more probable, a solid mass with the sedimentary beds resting against its sides.

Both the sandstones and limestones are quarried at several points.

At Mr. Hull's limestone quarries at Tolosa, about four miles from Hobarton, I found dark grey limestone, sometimes compact, sometimes finely laminated, with fragments of shells and corals. The beds of limestone were about two feet thick, and in one place were some beds of soft brown sandstone interstratified with thin beds of limestone. These sandstones were scarcely consolidated, and fell to pieces on being taken from the quarry. They often contained fossil shells, both Spiriferi and Productæ, quite perfect in appearance, but so much decomposed as not to bear extraction, falling into white powdery fibrous carbonate of lime. I procured from other parts of these quarries the following fossils:—

Fossils from Mr. Hull's Quarries.

Corals.

Stenopora Tasmaniensis.	Fenestella internata.
—— informis.	—— fossula?
Fenestella ampla.	Caryophyllæa.

Mollusks.

Producta rugata.	Spirifer Stokesii.
—— brachythærus.	—— Vespertilio.
Spirifer subradiatus.	—— avicula.
—— Darwinii.	Pecten squamuliferus.
—— Tasmaniensis.	—— Limæformis.

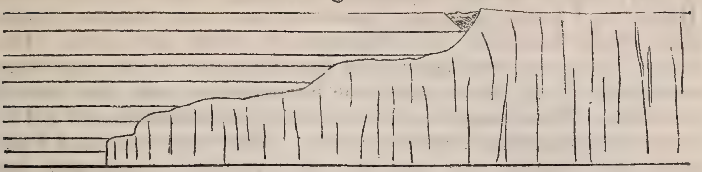
A few miles above New Norfolk, the banks of the Derwent showed cliffs consisting of alternations of sandstone with black and brown shales, producing a precise resemblance to parts of the English coal-measures. Much fossil wood, apparently parts of large trees, lay in these rocks.

Similar rocks to these were frequently observed in the cuttings of the road-side as far as Oatlands in the centre of the island, and they almost invariably lay in positions so nearly approaching horizontality, that their dip was not appreciable to the eye. Still their continuity did not appear to extend unbroken over any large district, as not only were dykes and other masses of intrusive trap rocks frequent, but solid ridges of crystalline greenstone often intervened, and evidently cut off one portion of the palæozoic rocks from the other.

In the immediate vicinity of Hobarton there were places, as near Stoke, and at the mouth of the valley of Risdon, where the palæozoic rocks had evidently been tilted up and altered by masses of trap rock, which could be traced to have a perfect passage from compact tabular or amorphous basalt into hills of solid crystalline greenstone.

In other places quarries were opened in sandstones of the palæozoic age, forming small patches either embosomed in greenstone, or resting upon it. About a mile from a place called Ralph's Bay Neck, on the S.E. side of North Bay, I found a cliff where the sandstones were shown clearly to be posterior to the igneous rock. In this case a dark, rudely columnar trap rock ended in a succession of small cliffs and terraces in one direction, upon which terraces and against which little cliffs rested the sandstone perfectly undisturbed, and evidently in the position in which it had been originally deposited.

Fig. 1.



A parallel instance was observed in the cliffs a little to the eastward of the entrance of Port Arthur.

It appears then that there are masses of greenstone both of more ancient and more modern date than the palæozoic rocks.

At Macquarrie Plains, about ten miles above New Norfolk, there is a large exhibition of igneous rock, which from its cellular character seems certainly to have flowed as lava in the open air. It forms a mass of considerable thickness, as shown in the brooks and ravines, and appears to have been gradually accumulated by successive accessions of melted matter. I infer this from the fact of its including fossil trees, apparently in the position of growth, which seem to have been enveloped while living in the lava.

There are two small patches of tertiary travertinous limestones: one mentioned by Mr. Darwin, and found in the outskirts of Hobarton, where it appears to have been tilted by the intrusion of an adjacent mass of trap; another in a little cove called James's Bay about three miles above Hobarton, on the opposite side of the Derwent. It rests here nearly horizontally, and is but little elevated above the level of the sea. A Helix and a Bulimus, and the leaves and portions of the stems of several plants, have been found in each locality.

Fossils from James's Bay.

Plants, unnamed: one figured by Morris.
Helix.
Bulimus.

There are very thick masses of gravel, consisting of pebbles as large as the fist, accumulated on the sides of the Derwent River at some places, and Count Strzelecki mentions great accumulations of loose sand from beneath which he procured a large Cypræa. This was at Newton, a short distance from Hobarton.

B. *Norfolk Bay and Tasman's Peninsula.*

The principal mass of Tasman's Peninsula appears to be columnar greenstone, forming the highest and most rugged of its hills, and the gigantic perpendicular cliffs of Cape Pillar and Cape Raoul and the intermediate shores round the entrance to Port Arthur. Just to the eastward of the mouth of that harbour, a mass of the sandstone of the palæozoic formation, a quarter of a mile across and 200 feet high, may be seen resting against these perpendicular cliffs of columnar greenstone with its beds quite horizontal and apparently unaltered.

Point Puer, one of the projections inside the port, is composed of a white compact, rather argillaceous sandstone, which among others contains the following fossils:—

Fossils from Point Puer.

Producta rugata.	Pterinea macroptera.
Spirifer subradiatus.	Orthonota compressa.
—— crassicostatus, *MSS.*, sp. n.	Allorisma, *n.s.*
—— Stokesii.	Pachydomus carinatus.
—— Vespertilio.	Pecten squamuliferus.

Eagle Hawk Neck, the connecting link of Tasman's and Forrester's Peninsulas, is one of the celebrities of Tasmania, on account of the peculiar jointed structure of its rocks, forming what is called "the tessellated pavement." The rock is a very hard, brittle, fine-grained and compact grey sandstone or gritstone, lying in a horizontal position. It occasionally contains pebbles of granite, porphyry, or quartz rock.

The rocks abound in fossils, especially at the south point of Pirates' Bay. Among others I collected fine specimens of the following:—

Fossils from Eagle Hawk Neck.

Fenestella internata.	Spirifer subradiatus.
Producta rugata.	—— Vespertilio.
Spirifer crebristriatus.	Platychisma Oculus ?
—— Darwinii.	Pachydomus carinatus.
—— avicula.	

On the opposite side of Norfolk Bay is a small peninsula about three miles across, in which is a large convict-station called The Mines. The mass of this piece of land consists of sandstone with some trap, but immediately at the back of the station is a small colliery. A bed of coal of slight thickness and extent is here worked. The following was the shaft-section as given me by the overseer:—

	Yards.
"Ironstone" (a fine-grained trap rock) ..	20
Sandstone	20
Sandstone and shale..................	10
Coal	1½

This coal, which in the deepest part is about seven or eight feet thick, rises pretty rapidly in every direction from that point, and as it rises, it thins out to about two feet. It thus forms a small basin, not half a mile across, and its outcrop is everywhere covered by beds of loose sand. A little beyond its outcrop on the sea-shore was the following section:—

	Yards.
Trap (in small prismatic pieces)	7
Sandstone, formed of grains of some trap rock..	18
Sandstone, soft and rather shaly	6
Shale and bind	2
Coal	0½

Near this spot they had bored to a farther depth of nearly 100 yards and passed through one twenty-inch coal; but the rest of the mass was almost entirely sandstone. I got from these coal-measures fossil plants, among which were *Pecopteris Australis*, a Sphenopteris and a Zeugophyllites.

There are other places in Tasmania where coal is worked, but they are chiefly detached and isolated spots separated by greenstone ridges one from the other. I was not able to visit any other of these localities, but I should fear that the beds of coal in Tasmania are comparatively insignificant in an economic point of view, that the true coal-measures of the country have no great thickness, and that the seams of coal contained in them are but partial, thickening and thinning out perhaps along the same horizontal lines, and thus forming limited cakes rather than regular and persistent beds.

C. *East Coast of Tasmania.*

Rocks of the palæozoic formation, chiefly sandstones, are found at various points of the eastern coast, but greatly broken and obscured by the usual greenstone ranges and local exhibitions of other trap rocks. In Maria Island are limestone quarries which I did not visit, but from which I procured fossils, among which were some of the large Pachydomi, of precisely the same species as those from Wollongong in New South Wales.

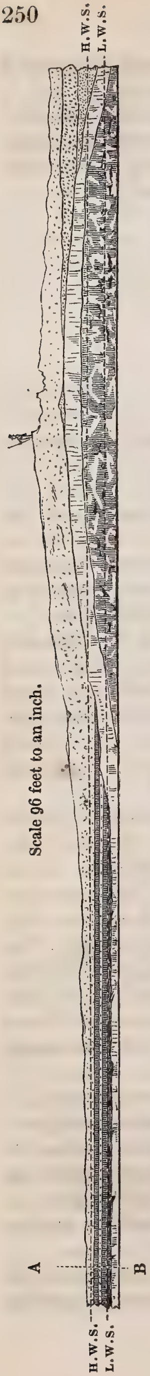
At Spring Vale, about ten miles above Great Swan Port, is a patch of palæozoic rocks, not more than a mile or two in extent, forming a low gently undulating ground surrounded by hills of igneous rock. No section is exhibited, but blocks of the rock protrude through the soil. It is a fine compact quartz rock, charged with the usual fossils of the formation in great abundance. The rock reminded me strongly of the quartz rock of the Lickey Hill. The fossils of this locality were—

Fossils from Spring Vale.

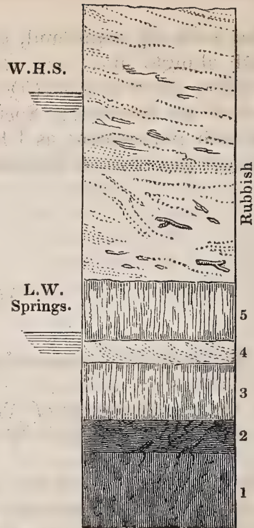
Fenestella ampla.	Spirifer Stokesii.
Producta rugata ?	—— crassicostatus, sp. nov.
Spirifer radiatus.	—— three others.
—— Darwinii.	Stem of a Crinoidal animal.
—— Tasmaniensis.	

On a Section exposed by the excavation at the New Steam Basin, in PORTSMOUTH DOCK-YARD. By Capt. JAMES, Royal Engineers, M.R.I.A. F.G.S. &c.

THE principal fact which this section exhibits is one with which every geologist is familiar. Almost every writer who has examined any extent of our sea-coasts has alluded to submarine forests, and pointed to them as a proof of the subsidence of the land within a comparatively recent period, and I should hardly have thought it worth while to present this section to the Geological Society, if it did not exhibit the facts in a much clearer manner than usually occurs. I may however observe, that I have myself seen the remains of forests, not only along the coasts of England in localities which have been described, but also in many places along the coast of Ireland which I believe have not been previously noticed, as in the counties of



Wicklow, Wexford and Waterford, and at Ballycotten, Kinsale and Castletown-bearhaven, in the county of Cork. These observations indicate that the subsidence in these islands was general as regards the southern portion of their areas*.



The substratum of the section described is the upper portion of the London clay (1); which is here very fossiliferous and dips to the north, or towards the chalk ridge at Hilsea. This however is merely an undulation of the strata, as all the lower beds are brought up in succession before we arrive at the chalk, and the red plastic clay from Stamshaw, about a mile to the north, is used for making the dams water-tight, a purpose for which, from its weight and tenacity, it is admirably adapted.

Resting on the London clay is the forest (2) with the roots of trees *in situ*, at a depth of 16½ (in another place 29) feet below high-water. It dips towards the north and the inner part of the harbour. Similar remains may also be seen at low-water on the sea-coast outside the harbour, between South-Sea Castle and Lump's Fort; but I had not the means of ascertaining in either case, to what depth below the level of the sea the forest extends.

Amongst the peaty matter which is 2 feet thick in the same stratum with the trees, we find the *Lacuna Montaguei* indicating the presence of very shallow salt water and the growth of the *Zostera marina* on which that mollusk feeds. Over this peat is (3) a blue clay 4 feet thick similar to the present estuary mud, and containing the common shells now found in the harbour. Above this clay there is a bed of shingle (4), which seems to indicate that the sea at some subsequent period had broken into the estuary. One can well imagine how the low land along this coast may have been subject to such accidents: indeed if a violent gale or any other cause should carry away the narrow neck of shingle connecting Black House

* The Preventive Service men along the coast near Hastings get their principal supply of fire-wood out of the submarine forests in that neighbourhood at low spring tides.

Fort with the main land, the mud of Haslar Creek would be covered with shingle in a very similar manner. Above the shingle bed is another layer of clay (5) forming the bed of the present estuary. I shall not trouble the Society with any observations which the study of such phænomena as I have now described might suggest, as this subject has been so frequently and so recently discussed.

March 10, 1847.

The following communications were read :—

1. *On the Structure of* Trinucleus, *with Remarks on the Species.* By J. W. Salter, F.G.S., A.L.S.

Having met with some unexpected results during a study of the Trilobites, more especially with regard to the genus *Trinucleus*, so eminently characteristic of the *Lower Silurian* and *Cambrian* deposits, I wish to offer a few observations on some changes now necessary in nomenclature, and also on the structural peculiarities arrived at.

It is to classical feeling we owe the name of this genus, for Llhwyd's *Trinucleus*, published in the 'Philosophical Transactions' so far back as 1698, meant no more than the general term *Trilobite*, and could not, except by courtesy, set aside the name *Cryptolithus*, first proposed, with characters, by Green. Sir R. I. Murchison has revived the old and far more expressive name, and all subsequent European naturalists have adopted it.

The genus can hardly be confounded with any other—the peculiar perforated border and the small number of segments in the body, together forming an animal dissimilar from all related genera. Thus the genus *Harpes*, which has a broad punctate border, has numerous body-segments and a minute tail; while *Ampyx*, another close ally, though similar in the body, wants entirely the ornamented margin. The absence of eyes in the most common species has been supposed generic, and it may be so, for we only have a prominent tubercle in their place in the *Tr. seticornis*, which probably has only minute scattered lenses upon it; at all events vision seems not to be essential to this curiously constructed animal. Ampyx is equally destitute.

The facial suture,—stated by Lovën to surround the whole head,—has been detected by Emmerich and myself in its normal position: it may be seen in good specimens, but only on the under surface of the head, and not continuously. Its course is obliquely upwards from the eye tubercle (in one species) to the upper end of the glabella, where it appears to terminate in a solitary deep perforation, similar to those which surround the head (fig. 1, *a a* to *b b*).

The glabella, in good specimens, has an obscure furrow at the base on each side, independent of the conspicuous one which separates the neck-segment in all Trilobites; the latter segment in our genus is armed with a spine.

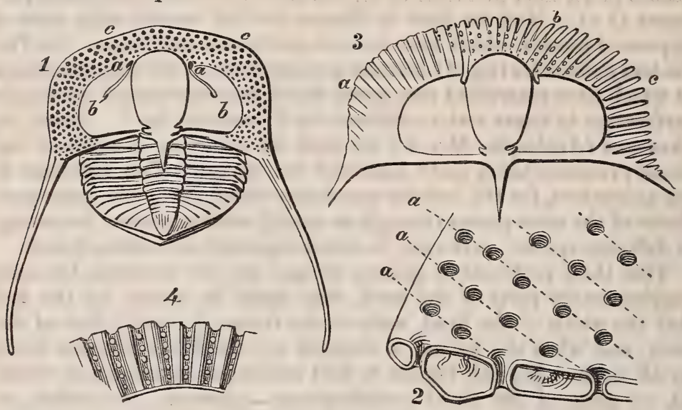


Fig. 1. *Trinucleus ornatus.*
2. Do. magnified fringe.
3. Hypothetical development of the fringe.
4. Fringe of *T. fimbriatus.*

The body-rings are six, very flat, and capable only of bending or doubling, not of rolling up as in Calymene—a character of considerable importance, inasmuch as it has relation to the connecting membranes and articular surfaces of the crust: species capable of rolling into a ball requiring large articular surfaces on the segments to enable them to move freely on each other; and a fulcrum, as centre of motion, on the side pieces of each segment, is generally placed about one-third of the distance from the axis:—in Trinucleus the rudimentary fulcrum is quite at the extremity of the segment, and apparently useless.

The tail, generally smooth, has a deflected border, but not, as far as observed, a striated internal fold, so common in higher forms of Trilobites.

The peculiar perforate border is the most interesting part of these animals, and I propose to examine it critically.

The puncta are almost always arranged in radiating rows, three, four, or more holes in each row, and these being at equal distances they form concentric lines. In *T. granulatus,* two of these rows are separated by a furrow from the rest; in *T. seticornis,* three are distinct from the remaining two or three, by the front rows being sunk in a deep concentric furrow. Other modifications take place: in *T. fimbriatus,* the two front rows are turned downwards; lastly, in *T. ornatus*—for by that name we must call *T. Caractaci*—the dots occur most frequently in quincunx order—*i. e.* the radiant rows appear zigzag, and not direct (fig. 2): this appearance is due to the great obliquity of the rays (2, *a a*). I wish to call attention to this, because I consider it enables us to understand the nature of the enigmatical puncta.

If we suppose a head furnished with a produced membranous margin (fig. 5) instead of a perforate one, we shall get at the explanation by supposing the membrane to collapse at regular intervals, become plicate (5 *a*), then perforate (5 *b*), and lastly, separate into linear processes (5 *c*). Now we have in Harpes the flat border, with rows of impressed puncta, which have not yet perforated the fringe. In *Trinucleus fimbriatus* (fig. 4), we have a plicate border, the thin interstices of which have contracted into pores, which is a step beyond the simple perforation in linear series exhibited by *T. ornatus*, fig. 1. Lastly, in *Ceraurus* (Acidaspis, *Murch.*) we have the structure completed, the linear processes being quite separated into spines. This structure is not anomalous, for the cellular membrane which forms the inner peristome of the moss passes through an exactly similar course, becoming, in different species, perforate, in others separated into distinct teeth.

That these perforate or spinous fringes are not essential, but only supplementary parts of the head, may easily be shown, by the fact that the width of the head, without the fringe, is exactly that of the body, and when the animal is doubled up, the fringe projects freely on all sides. We still require to find anomalous specimens in which all, or some of the above modifications,—plication, perforation, or partially cleft borders,—may be exhibited together, in order to demonstrate the supposed origin of the structure.

I now wish to call attention to the species best known to students, the *T. Caractaci*, which the author of the 'Silurian System' has taken so much pains to illustrate. And I am sure all naturalists will regret that its classical name must give way to a much older one, by which it has been long known on the continent, *T. ornatus*, Sternberg, described by him in his account of the Prague Museum, 1833. It is not a little singular that foreigners should have adopted the name of Sir Roderick Murchison, without perceiving from his figures that their species was the one he represented.

The great difficulty of obtaining rare foreign books or specimens is a sufficient reason for the name given in the 'Silurian System,' as it was for the naturalists of the day being unwilling to undertake the description of the *Trilobites* of that work, and for this labour being added to Sir Roderick Murchison's other tasks; and if our well-known English fossils have to forego their present names, we are in no worse position than our botanists, whose species have been so frequently forenamed on the continent. We may hope for the future that a free interchange of specimens will prevent more of this evil. I would not have said so much, were it not that the *T. Caractaci* is known as widely as the 'Silurian System,' and even Burmeister, in his late grand work, describes both species without perceiving their identity. A good series of Bohemian Trilobites, now in the possession of the Geol. Survey of Great Britain, has enabled me to set the matter right, and shows too that Barrande has given to our fossil still another name, *T. Goldfussii*. The *T. Bigsbii* and *T. tessellatus* of American naturalists, and *T. elongatus* and *T. latus* of Portlock, all belong to the same species, which may be thus characterized:—

TRIN. ORNATUS.

Syn. *T. ornatus*, Sternb. Verh. Ges. Mus. Prag. 1833, fig. 2 *a*; Burm. (Transl. by Ray Soc.) 58.

Trinucleus tessellatus, Green, Mon. 73.
T. Bigsbii, ib. p. 76.
T. Caractaci, Murch. S. S. pl. 23. fig. 1; Portl. Geol. Rep. pl. 1 B. fig. 3, 4, 5 [and also 6]; Burm. (Ray Ed.) pl. 1. fig. 1.
T. elongatus, Portl. *l. c.* fig. 7.
T. latus, ib. fig. 10 to 14.
T. Goldfussii, Barrande*, Tril. et Sil. Syst. Bohem. p. 31 (1846).

Spec. Char.—Outline subquadrate; glabella obovate, not much narrower below; fringe broad, flat, produced in front and angular at the sides, with about four or five rows of large puncta, not in regular radii; cheeks about equal to the glabella, rounded posteriorly, with puncta beneath them; spines as long as the entire body, directed outwards, incurved at their extremities; body and tail together as long as glabella; the first of six narrow rings; the axis more than half as broad as the pleuræ; tail very short, triangular; the axis three- or four-ribbed, and but slightly convex towards the end, where the sides are a little depressed; about three lateral furrows.

I know four distinct varieties:—

α. *Sternbergii*, Salter; puncta close-set, four rows in front; glabella broad, gibbous.
Syn. *T. ornatus*, Sternberg; Barrande*.
β. *Caractaci*; puncta rather distant, often quincunx, three or four rows in front; glabella broad, gibbous.
Syn. *T. Caractaci*, Murch.; Burm.
T. Goldfussii, Barrande*.
T. tessellatus, Green.
γ. *elongatus*; puncta in sunk radii in front; glabella and whole axis elongate narrow.
Syn. *T. elongatus*, Portl.
δ. *favus*, Salter; head transverse-rectangular, puncta in outer angles enlarged like honeycomb, border narrow, glabella rather narrow and long.

These four varieties differ considerably in the prolongation of the external angles of the head and the size and shape of the pores, but in all essential characteristics they agree; in the uniform flat, not bent or divided border, the triangular few-ribbed tail, and the direction of the spines.

I know of but five species:—
T. ornatus, Sternberg: see above.
T. seticornis, Hisinger.
T. granulatus, Wahl. *T. Lloydii*, Murch.
T. fimbriatus, Murch.
T. radiatus, Murch.

The latter species appears to me a good one and quite distinct. Burmeister reduces it under *T. ornatus*, Sternb. I have carefully examined the originals.

* Barrande, in a supplement just published, has transposed these names; but this only confirms my view, as I am now sure that the Bohemian fossils in our collections are the same as Sternberg's figure.—J. W. S., June 1847.

2. *Letter from* J. G. Anthony *to* C. Lyell, Esq., V.P.G.S., May 6, 1846, "*On an Impression of the Soft Parts of an Orthoceras.*"

Cincinnati, May 1, 1846.

Dear Sir,—In accordance with the wish expressed by you a short time since, that I should communicate to you some account of the Orthoceratites found in the marlite near Cincinnati, I have thrown together a few brief notes which may perhaps serve as the basis of a paper on the subject.

The blue limestone formation, of which the marlite above alluded to is a member, was formerly supposed to represent the Trenton limestone of the "New York system," but further examination has proved its identity with the "Hudson River group." In the State of New York, where it is widely developed, it consists mainly of argillaceous deposits; but in this section it is quite calcareous, and is composed of alternate layers of a hard fossiliferous limestone and shale, or as it is frequently termed *marlite*, interstratified and lying horizontally. The thickness of the blue limestone at Cincinnati is about 450 feet. Quarries have for many years been opened in this deposit for the purpose of procuring the hard limestone for building and for paving our streets. In the removal of the stone for these purposes, many beautifully preserved remains of the "Aborigines of Creation" have been brought to light, and a greater number have been discovered on the hill-sides, where the refuse of the quarries has lain long enough exposed to the action of frosts and washings of heavy rains.

The layers of which the blue limestone formation is composed are by no means uniform in thickness, the hard stone varying in this respect from one inch to eighteen, and the soft shale from six inches to many feet. Numerous species of fossil shells, Trilobites, Crinoidea, &c., are distributed throughout the entire deposit, the same species generally occurring at various elevations, though it often happens that a certain species may be abundant at certain points and be comparatively rare or even entirely wanting at others.

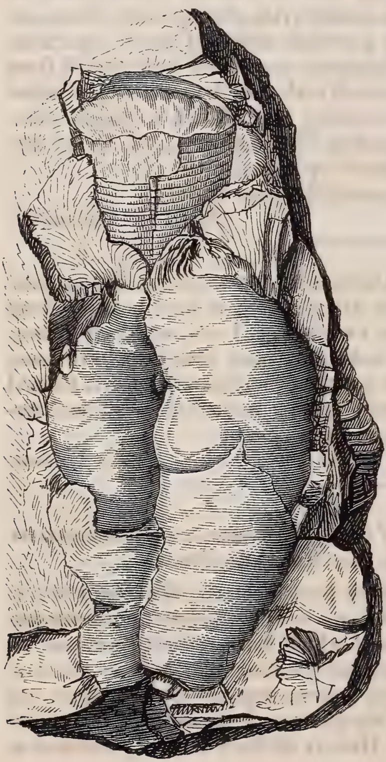
In the spring of 1842 a quarry was opened on the side of the hill, where the Cincinnati Astronomical Observatory has since been erected. In the progress of the work, a deposit of the marlite was reached of an unusual thickness; this occurred at a point about 200 feet above low-water mark of the Ohio river. This stratum was of a peculiarly fine, soft nature, admirably adapted to preserve the more delicate parts of the imbedded fossils; and its consistence was such, that it could easily be cut with a knife and the superfluous marl removed from around the fossils, so as to exhibit them in the best possible manner. This matrix afterwards became quite hard in drying, but was always liable to disintegration by moisture, so that fossils could only be preserved in it by protecting the surface with a coat of varnish or glue. This point in the deposit was unusually rich in the fossils commonly found in the blue limestone. These remains consisted of

Calymene Senaria.	Triarthrus Beckii.
Asaphus, one species.	Isoteles megistos.
Trinucleus Caractaci?	Bellerophon bilobatus.

Cystolites ornatus.	Orthis, several species,
Strophomena sericea.	(testudinaria? striatula? &c.)
—— nasuta?	Atrypa.
—— ?	Lingula, one species.
Orthoceras, more than one species.	Delthyris.
Trochus —— ?	Encrini.
Pterinea carinata.	Graptolites, two species.
Cypricardia angustifrons.	And an abundant variety of corals
—— ovata.	of several genera and species.
Orbicula —— ?	

Some of the above were remarkably well preserved in the marl, which is here almost entirely an argillaceous deposit. The Trinucleus, which at other elevations is seen only with its singularly-formed buckler, so highly ornamented, was here found attached to its posterior ribs, and with delicately sharp spinous projections from each end of the buckler nearly an inch in length. *Triarthrus Beckii*, which in the lower part of the deposit has generally presented a head merely, or the ribs unconnected with a head, was here completely perfect. Lingulæ were in nearly every instance found, *not* parallel with the strata, but standing up, as if they had been entombed while growing in their usual position, and so quietly as not to disturb or throw them down. Calymene were seldom found rolled up, or distorted in any way, and a dozen were sometimes seen on one side of a slab of marl four or five inches square, all beautifully spread out as if intended for cabinet specimens by nature herself. The *Isoteles megistos* exhibited both spinous terminations of the shield well-defined. Graptolites were in the greatest abundance, and one species was peculiarly delicate and hair-like; in short, all were preserved in primæval perfection, untouched by the corroding tooth of Time.

Fig. 1.



The most interesting of all were the Orthocerata, which were frequently of unusual size, measuring over three feet in length; they all appeared more or less compressed as if by the weight of the superimposed strata, and their diameter when thus flattened was frequently over six inches. The surface was often coated with a black substance, like paint; where this was removed, it appeared rough, almost like shagreen. My attention was however particularly drawn towards the smaller specimens, each of which was enveloped in a sac (fig. 1), an appearance which I had never before noticed in connexion with these remains. This sac was of an oval form, about twice the diameter of the enclosed Orthoceratite, enveloped its whole length, was like it flattened, and had a longitudinal depression through its entire length. Upon seeing it, the idea was at once suggested that here was a solution of the question, never before determined, with regard to the form and texture of the body of the Orthoceratite. Though very widely distributed through various strata, yet the soft parts have been so completely destroyed by time and circumstances, that no discovery of them had been hitherto made, by which even a surmise could be formed of the organization of the animal. The straight chambers and siphuncular apparatus of the Orthocera were common enough, but conjecture was at fault while endeavouring to form a correct idea of the associated body. Indeed I have heard it asserted by some, that the parts usually seen, with perhaps the addition of some kind of a head, constituted its whole organization. From the present discovery we may reasonably suppose they were furnished with a fleshy body, like the Sepia of the present day and its kindred cephalopods, or perhaps like the Belemnite of the antediluvian creation with its accompanying ink-bag. If they were provided with this latter apparatus, might not the black coating so common upon them be a deposit from that dark liquor? I leave however all such speculations to those better acquainted with the subject, contenting myself with a simple statement of the circumstances attending the discovery, and of the impressions which that discovery made upon my mind.

I am, very respectfully, your friend,

John G. Anthony.

Having compared, when at Cincinnati, the three specimens, portions of which are conjectured by Mr. Anthony to have possibly some reference to the soft parts of the Orthoceras, I saw so much resemblance in them all, that I could not but suspect that they have some connexion with the fossil, and are not of a concretionary nature, formed by mud collecting round the shell. Other undoubted casts and impressions in the same clay confirmed the opinion.

C. Lyell.

February 1847.

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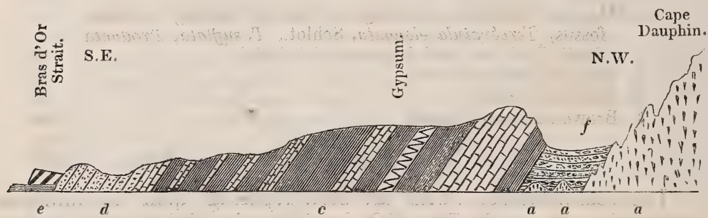
3. *On the Gypsiferous Strata of* Cape Dauphin, *in the* Island of Cape Breton. By Mr. Richard Brown.

Previously to Mr. Lyell's visit to Nova Scotia in the year 1843, it was generally supposed that the marls and sandstones containing those remarkable beds of gypsum, which have recently occupied so much attention, were both in age and position analogous to the new red sandstone of Europe. Such indeed was my own opinion (as stated in an imperfect outline of the geological structure of this island which appeared in Haliburton's 'History of Nova Scotia,' published in

1829), founded chiefly upon the occurrence of gypsum and brine springs in a formation bearing considerable resemblance in lithological character to the new red sandstone, without any reference whatever to its fossils, which at that period had not been examined by competent observers.

Mr. Lyell, in a paper on this subject read before the Society in 1843, and more recently in his 'Travels in America,' has clearly shown, from their proximity to the older rocks, the great disturbances which (compared with the coal-measures) they have undergone, and more particularly from their characteristic fossils, that the gypsiferous strata of Nova Scotia and Cape Breton are the representatives of the lower beds of the carboniferous limestone of Europe; but hitherto I am not aware that any decided example of the superposition of the millstone grit and coal-measures has been observed. It affords me therefore much satisfaction to be able to furnish a section of the strata forming a lofty cliff at Cape Dauphin, the western boundary of the Sydney coal-field, where the carboniferous limestone and associated marls containing gypsum, with the millstone grit lying conformably thereon, are brought up to the surface within a very limited horizontal space, by the protrusion of the granitic ridge of St. Ann's, as represented in the annexed cut.



f. The newer conglomerate.
e. The coal-measures.
d. The millstone grit.
c. Carboniferous limestone, shales and marls containing gypsum.
*b**. The old conglomerate.
a. The red granite.

The following is a section of the strata in detail, from the millstone grit across the carboniferous limestone and associated beds, to the granite, in the descending order, the measurements being taken at right angles to the planes of stratification.

	Thickness in feet.
31. †Millstone grit	200
30. Finely laminated grey shales with thin bands of limestone	110
29. Slaty sandstones with traces of plants	10
28. Blue and grey shales, with some thin beds of nodular limestone	120
27. Strong sparry limestone	6
26. Soft crumbling marls	90

* This conglomerate is seen in the section on page 260, to which the above references also apply.

† The coal-measures (*e*) are not seen in actual contact with the millstone grit at Cape Dauphin, having been abraded by the heavy surf continually beating upon this exposed point, but they overlie it in a more sheltered situation about half a mile higher up the Strait.

		Thickness in feet.
25.	Strong limestone	18
24.	Brown sandstone	12
23.	Red shales	33
22.	Blue shales	8
21.	Strong limestone, lower beds slaty, containing fossils, *Producta Lyelli*, De Verneuil, and Encrinus, same species as that found by Mr. Lyell on the Shubenacadie river and on the East River Pictou, No. 46, 'Lyell's Travels,' vol. ii. p. 222	17
20.	Mottled red and green marls	24
19.	Intermingled sandstones and limestones	22
18.	Blue shale	6
17.	Red shale	8
16.	Strong limestone	5
15.	Mixed grey and brown shales	12
14.	Concretionary limestone	4
13.	Soft blue clay	3
12.	Slaty limestone in layers 1 to 2 inches thick	47
11.	Soft blue marl, with pieces of gypsum intermingled near the bottom	32
10.	Gypsum	8
9.	Soft green marl	3
8.	Marl containing layers of limestone	28
7.	Coarse limestone and shales	44
6.	Crumbling porous limestone	50
5.	Calcareous breccia, containing partially worn fragments of red granite	24
4.	Mass of limestone, showing no lines of bedding (contains fossils, *Terebratula elongata*, Schlot., *T. sufflata*, *Producta Lyelli*, De Vern., and fragment of Avicula)	60
3.	Compact slaty limestone	6
2.	Soft brown shale	6
1.	Brown and purple marls	40
	Total......	1056

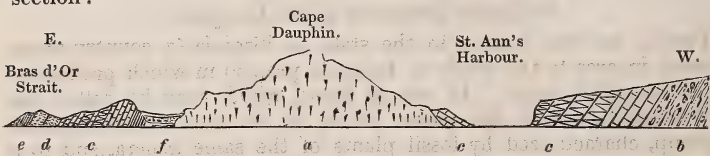
The coal-measures which are seen reposing upon the millstone grit half a mile up the Bras d'Or Strait consist of alternating beds of shale and sandstone, the former predominating, and containing a few traces only of coal plants.

The millstone grit of the Sydney coal-field, which attains a thickness of 2000 feet in some places, does not here exceed 200 feet; it nevertheless preserves the characteristic features of the formation, the lower beds being coarse and pebbly, with few traces of coal plants; the upper, fine-grained sandstones abounding in impressions of Calamites, Lepidodendron and Sigillaria, of which the last are by far the most numerous.

The only beds of limestone in which I found any fossils were Nos. 4 and 21. In the first of these they are very abundant, being disseminated through the whole mass of limestone, 60 feet in depth, although apparently confined to a very limited number of species. The separation of this immense bed of limestone from the underlying stratum No. 3 is very distinct, but upwards it passes gradually into the overlying bed No. 5; throughout its whole thickness there is not the slightest trace of lines of stratification.

No. 5 is a soft crumbling conglomerate of small pebbles of quartz rock, clay-slate and red granite, united by a calcareous base. The granite pebbles are much larger than the others, and also more angular, showing that although this series of beds were ultimately raised to their present position by the upheaval of the granite ridge, there must have existed at the time of their formation hills of similar granite at no great distance.

The thickness of the bed of gypsum No. 10 cannot be very clearly ascertained, as it lies between beds of soft green and blue marl; its minimum thickness must be 8 feet, since large masses of gypsum from 6 to 8 feet square have fallen from the cliff. This is probably the highest bed of gypsum in the formation; the lower beds associated with limestones, marls and shales, reposing upon the old conglomerate (*b*), being developed in great thickness at St. Ann's, on the opposite slope of the granitic nucleus, as shown in the following section:—



The conglomerate (*f*) in this and the preceding section, which caps the protruding granitic rocks at Cape Dauphin, and abuts against the outcropping purple and brown marls No. 1, is evidently of more modern date than the conglomerate (*b*); being, so far as I could ascertain, composed of angular and half-worn fragments of hard brown shale, red granite and quartz rock, cemented imperfectly by ferruginous sand; it also dips to the north-east at an angle of 10°, whilst the limestone and shales dip S. 80° E. at an angle of 58°. I must add, however, that a heavy surf rolling in upon the narrow beach, and occasionally dashing its spray up against the cliff of conglomerate, prevented me from examining this part of the section so carefully as I could have desired.

The old conglomerate (*b*), composed of large rounded pebbles of flinty slate, clay-slate, quartz rock, and masses of a still older conglomerate, is found in five cases out of six underlying the gypsiferous strata of Cape Breton wherever continuous sections can be obtained.

In conclusion I may observe, that I have never been able to find any traces of organic remains in the gypsum in this neighbourhood, but Professor Johnson of Philadelphia informed me that he found fossil shells in thin bands of gypsum alternating with limestones at Plaister Cove in the Gut of Canso, about three months ago.

April 14, 1847.

Henry F. Hallam, Esq., and Thomas Ottrey Rayner, M.D., were elected Fellows of the Society.

The following communications were then read:—

1. *On the Structure and Probable Age of the* COAL-FIELD *of the* JAMES RIVER, *near* RICHMOND, VIRGINIA. By CHARLES LYELL, Esq., V.P.G.S.

Contents :—

Geological Structure of the Coal-field.

THERE are two regions in the state of Virginia (a country about equal in area to the whole of England proper) in which productive coal-measures occur. In one of these, which may be called the Western Coal-field, the strata belong to the ancient carboniferous group, characterized by fossil plants of the same genera, and to a great extent the same species, as those found in the ancient coal-measures of Europe. These strata form an integral part of the system of rocks constituting the Appalachian chain, and have been disturbed by the same movements, and subsequently exposed to the same denuding action. Another coal-field, wholly disconnected from the above in its geographical and geological relations, is found to the east of the Appalachian mountains, in the middle of that granitic region sometimes called the Atlantic Slope. This district of granite, gneiss, hornblende, schist, and other hypogene rocks, intervenes between the palæozoic rocks of the Alleghanies and the low country bordering the Atlantic, which is composed of cretaceous and tertiary deposits. In consequence of the isolated position of these eastern coal-beds, the lowest of which rest immediately on the fundamental granite, while the uppermost are not covered by any overlying fossiliferous formations, we have scarcely any means of determining their relative age, except by the characters of their included organic remains. The study of these induced Prof. W. B. Rogers, in his memoir published in 1842 (Trans. of American Geologists, p. 298), to declare his opinion that this coal was of newer date than that of the Appalachians, and was about the age of the oolite, a conclusion which, after a careful examination of the evidence on the spot, and of all the organic remains which I could collect, appears to me to come very near the truth. The only doubt that can be entertained on the subject in the present state of our knowledge is, whether we should refer the strata to the triassic or oolitic period; and if we incline with Prof. W. B. Rogers to the latter opinion, these rocks must then be considered as the only ones hitherto known in all Canada and the United States, which have been proved by their organic remains to be of contemporaneous origin with the oolitic or jurassic formation of Europe.

Before I discuss the question of the relative age of the strata, I shall proceed to describe briefly the geographical extent, position, and geological structure of the coal-field. The tract of country occupied by the crystalline or hypogene rocks which runs parallel to the Alleghany mountains, and on their eastern side, is in this part of Virginia about seventy miles broad; in the midst of this space the coal-field occurs in a depression of the granitic and other hypogene rocks on which the coal rests, and by which it is surrounded along its outcrop. The length of the coal-field from north to south is about twenty-six miles, and its breadth varies from four to twelve miles. It extends over portions of six counties, from Amelia the most southern, through parts of Chesterfield, Powhatan, Henrico, Goochland and Hanover. The James River flows through the middle of it, about fifteen miles from its northern extremity, while the Appomattox River traverses it near its southern borders; on its eastern side it is distant about thirteen miles from the city of Richmond, the capital of the State of Virginia: it occupies an elliptical area, the beds lying in a trough, the lowest of them usually highly inclined where they crop out along the margin of the basin, while the strata higher in the series, which appear in the central parts of the basin, are very nearly horizontal. The general strike is about N.N.E. and S.S.W., while that of the nearest ridges of the Appalachian chain is about N.E. and S.W.

A great portion of these coal-measures consists of quartzose sandstone and coarse grit, some of the beds in the lower part of the series resembling granite or syenite, being entirely composed of the detritus of the neighbouring granitic and syenitic rocks. Dark carbonaceous shales and clays, occasionally charged with iron ores, abound in the proximity of the coal seams, and numerous impressions of plants, chiefly ferns and Zamites, are met with in shales, together with flattened and prostrate stems of Calamites and Equisetum. These last however, the Calamites and Equisetum, are very commonly met with in a vertical position, more or less compressed perpendicularly. That the greater number of Calamites standing erect in the beds above and between the seams or beds of coal which I saw at points many miles distant from each other, have grown in the places where they are now buried in sand and mud, I entertain no doubt. This fact would imply the gradual accumulation of the coal-measures during a slow and repeated subsidence of the whole region*.

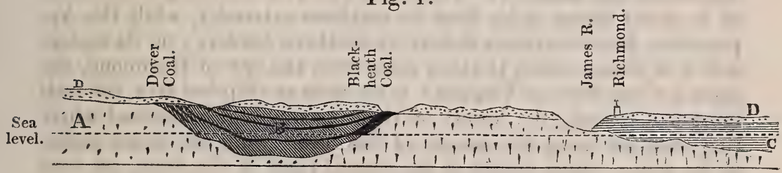
The coal-seams have hitherto been all found at or near the bottom of the series, and the plants in beds below or between them, or immediately overlying. One or two species of shells (Posidonomya?) also occur in the same part of the series, at a small height above the coal-seams, and above these a great number of fossil fish chiefly referable to two nearly allied species of a genus very distinct from any ichthyolite

* It is worthy of remark, that the *Equisetum columnare*, the same species as that found in the Virginian coal-field, also occurs in an upright position, and extends over a wide area in those oolitic strata near Whitby in Yorkshire, which are supposed, from the general evidence of the fossil plants, to be the equivalents in age of these secondary coal-measures of America.

hitherto discovered elsewhere. Above these fossiliferous beds, which probably never exceed 400 or 500 feet in thickness, a great succession of grits, sandstone and shales, of unknown depth, occur. They have yielded no coal, nor as yet any organic remains, and no speculator has been bold enough to sink a shaft through them, as it is feared that toward the central parts of the basin they might have to pass through 2000 or 2500 feet of sterile measures before reaching the fundamental coal-seams.

Section showing the Geological Position of the James River, or East Virginian Coal-Field.

Fig. 1.



A. Granite, gneiss, &c. B. Coal-measures.
C. Tertiary strata. D. Drift or *ancient alluvium*.

The annexed ideal section (1) will show the manner in which I suppose the coal-field to be placed in a hollow in the granitic rocks, the whole country having suffered by great denudation, and the surface having been planed off almost uniformly, and at the same time overspread by a deep covering of gravel and red and yellow clay, concealing the subjacent formation from view, so that the structure of the region could not be made out without difficulty but for the artificial excavations. It will be seen by the section that the tertiary strata appear at Richmond, about thirteen miles from the eastern outcrop of the coal, and they continue to occupy the lower country between that city and the Atlantic.

It has been stated, that the only beds of coal hitherto discovered lie in the lower part of the coal-measures, and that consequently they crop out all round the margin of the basin. As the dip is usually at a considerable angle, vertical shafts from 400 to 800 feet deep are required to reach the coal at the distance of a few hundred yards inside the edge of the basin; it is only therefore along a very narrow band of country that the coal comes up to the surface naturally, and even here it is for the most part buried under superficial red and yellow clay with sand and gravel, the whole often 30 or 40 feet thick. I saw no erratic blocks or far-transported materials in the detritus, but it is so continuous as to conceal the junction of the carboniferous and granitic rocks, and I felt some curiosity to learn how the existence of coal in such a country had been originally suspected. It appears that in Chesterfield, the county where the richest seams occur, the coal enters very largely into the composition of the overlying gravel and sand, and at the old Blackheath pits, which were first worked between the years 1785 and 1790, a fallen tree displayed fragments of coal in the soil adhering to its roots, which led to excavations, and the discovery, at the depth of a few yards, of a rich bed of bituminous coal, no less than 30 feet thick, of excellent quality. Being so near the surface, it was for a time worked with great profit; but very exaggerated notions were formed, both here and in the vicinity, of the real thickness of the main seam, due allowance not being made at first for the dip of the beds through which the shafts passed down obliquely to the planes of stratification. In the valley of a small tributary of the James River, about two miles north of Blackheath, I saw, exposed in a natural section of drift, a bed of rubbly coal, which might easily have betrayed the existence of the seam from the waste of which it had been derived.

It has been usually stated in reports on this coal-field, that north of the James River the coal is divided into two or three seams, while to the south of the same river it forms one huge seam from 30 to 40 feet thick. Such however is not the case, the coal being almost everywhere separated into three distinct beds, and sometimes more, and this division being observable quite as much in the southern as in the northern half of the trough. The uppermost seam is almost always the most important. Thus in the Clover-hill pits, near the Appomattox River, towards the southern extremity of the basin, I found five seams of coal, all as usual at the margin of the basin. Here, about 160 feet of grit and shale intervene between the lowest of the five seams and the fundamental granite and hornblende schist. Of this section I shall have to say more in the sequel. In all the localities I visited, the thickest bed of coal or the main seam is the uppermost, except at Clover-hill just mentioned, where a thin layer of coal is met with still higher; but it is not continuous for any distance. Along the western margin of the basin at Dover, for example, I observed the same division of the coal into two or more seams; nor am I aware of any place, except Blackheath and the adjoining parts of Chesterfield county, where all the seams appear united as it were into one, of unusual strength, from 30 to 40 feet thick,—to explain which we may perhaps adopt the theory of Mr. Bowman, and suppose the vegetation to which the coal is due to have grown uninterruptedly in this spot, while elsewhere it was frequently arrested for a time in its progress by subsidence, which submerged certain areas and permitted the deposition of mud and sand to take place upon the materials of the future coal. This unity however of the coal-seam in the Blackheath region is of small extent, and even in the purest mass there occur thin intercalated layers of shale and sandstone with pyrites, to separate which from the coal costs the miner no small labour. These "partings" of sedimentary matter, which in some spots swell out rapidly from a few inches to a thickness of several feet, or even yards, make the great seam of Blackheath much less of an *exceptional* case in a geological point of view than might at first be supposed. The inconsiderable distance to which the undivided state of the seam extends, is shown by the section obtained only a quarter of a mile to the south of Blackheath in the Midlothian pits, where a shaft sunk to the depth of 774 feet passed through the undermentioned beds.

Section at the Midlothian Pit, half a mile south of Blackheath, on the eastern outcrop of the Coal.

	Feet.	Inches.
Sandstone and shale	570	0
Slate with Calamites	1	6
Sandstone and shale	43	10
Sandstone with Calamites	8	0
Sandstone and slaty shale	48	0
Slate and long vegetable stems	2	6
Sandstone	6	6
Slate with Calamites, numerous	5	6
Sandstone	14	0
Black rock (carbonaceous?)	13	0
Slate	5	0
Main coal	36	0
Sandstone, not laminated	5	0
Slate	4	0
Coal	1	0
Slate	3	0
Sandstone or grit	7	0
	773	10

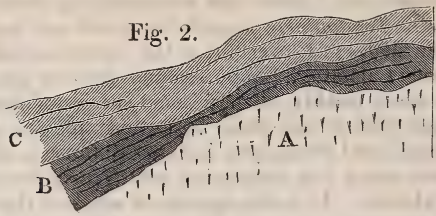
Granite, depth unknown.

It will be seen that here, within a quarter of a mile of the Blackheath pit, there are two seams of coal—one, the uppermost, more than 30 feet thick, and the other separated from it by 9 feet of intervening shale and sandstone about one foot thick; this lowest seam being within four feet of the fundamental granite, and parted from it by beds of grit and shale. Some deduction must be made from all the estimated thicknesses of the beds as above stated, the inclinations of the beds cut through by the vertical shaft being at an angle of 20°. After making this deduction, however, the magnitude and persistency of this seam, from 30 to 40 feet in thickness, consisting of as pure a mass of rich bituminous coal as can perhaps be found in the world, even in the old carboniferous formations, are truly remarkable, especially when we take into account its geological age. I was indeed not a little surprised when I first arrived at Blackheath and descended a shaft 800 feet deep, to find myself in a chamber more than 40 feet high, caused by the removal of the coal. Timber props of great strength are required to support the roof, and although the use of wood is lavish here as everywhere in the United States, the props are seen to bend under the incumbent weight. The great seam in some places at Blackheath is seen actually to touch the fundamental granite, or is parted from it only by an inch or two of shale. The unevenness of the granite floor is extremely great, as represented in the annexed drawing, Fig. 2*; and the manner in which, in these *troubles* as they are called, the coal is squeezed out at one point and made to swell and thicken at another, B, must be referred to movements of the rocks

* For this and several other documents relating to this coal-field, and for numerous organic remains, I am indebted to the kindness and exertions of my friend Mr. A. F. D. Gifford, under whose superintendence I found the Blackheath mines. I have also to acknowledge the liberality of Dr. Samuel H. Royal of Blackheath, who presented me with fossil fish, and plants of great rarity and beauty.

Junction of Coal and Granite, Blackheath Mines.

Fig. 2.



C. Sandstone and shale. B. Coal. A. Granite.

and the forcing of the granite against the coal, the distinct layers of which are often cut off abruptly one after the other by the granite in contact. The dips of the strata of coal in the neighbourhood of these sudden thickenings and swellings of the seams vary from 20° to 70°, and at one point attained an angle of 84°. Polished surfaces or *slicken-sides,* with their planes turned in various directions, also bear testimony to the sliding and friction which the beds have undergone. Some of the alleged varieties in the thickness of the great seam at short distances may be explained by sudden changes in the angle of dip, which, as before stated, might cause an exaggerated estimate wherever an inclined stratum is cut through vertically in vertical shafts; but it appears that where the coal is nearly horizontal, it often is far from uniform in strength at points a few hundred yards apart. The beds which I actually observed at Blackheath and the neighbourhood varied in their inclination from 8° to 42°, the dip being always westerly.

The great uncertainty of the depths at which the coal can be won in sinking shafts at known distances from the natural outcrop or from previous workings, proves the irregularity of the dip, and implies in some places sudden flexures, or more probably vertical faults. An example of one of these occurs in comparing the sections exposed in the Creek and White Chimney pits. A shaft at the former or Creek mine being sunk 400 feet deep to the main seam, the coal was followed for 15 yards westward in the direction of the dip at an angle of 20°. The White Chimney or Old Midlothian shaft was then sunk 500 yards westward of the former, and the same great bed of coal, with the granite below it, was entered at the depth of 360 feet. If the dip of about one in three continued westward, in this instance, an upthrow of more than 100 yards would be required to account for the position of the coal so near the surface in the more westerly pit.

About five miles north of the Midlothian shaft last mentioned, at Duval's pit, which is also on the eastern outcrop, the coal-measures are seen near the granite to be arranged in a small trough extending only a few hundred yards east and west. At this place there are three beds of coal, which in the deepest part of the small basin are only 200 feet from the surface. Again, at the northern extremity of the whole coal-field, at the Deep-run pits, there is another example of a small basin only a mile and a half in its longest diameter, from N.N.E. to S.S.W., and half a mile in breadth. The coal there is similar in quality to that of Blackheath, and I found the accompanying shales full of that splendid fern, the *Tæniopteris magnifolia*, spread out between the laminæ, as in the shales of Clover-hill at the southern end of the coal-field. The same Calamites, Equisetum and Zamites also occur there, and in nearly every locality, though some species of ferns have only as yet been met with at one place, as for example the *Filicites fimbriatus* (Bunbury) and *Pecopteris bullata* (Bunbury), which I found at the Deep-run mines just mentioned, and *Neuropteris linnææfolia* found at Blackheath. It is the opinion of some of the miners, that where several seams of coal occur, they would form, if united, a single seam, about equal in the aggregate to the average thickness of the great single bed of coal in the Blackheath region; but it seemed to me that the strength of the beds in most of the workings would never approach in importance the single main seam in the Blackheath and Midlothian pits—and here also the seam is sometimes no less than 30 feet thick where other beds of coal intervene between it and the granite. This may be seen about two miles north of the Engine pit, at the place where the coal was first obtained in 1785, in the valley of a small tributary of the James River. The main seam is there 30 feet thick at its outcrop, and in the coal-measures separating it from the granite, consisting of grit and shale 200 feet thick, are seen two beds of coal, the uppermost three feet and the lowest about one foot thick.

It was before stated (page 263), that there have been no borings for coal in the central parts of the coal-field; the only section I could obtain of the beds far from the margin of the basin is that afforded by the cuttings along the Richmond and Lynchbury canal, and these are only a few yards in depth. The beds here consist of shale and quartzose grit, one undivided stratum of which, ten feet thick, was very conspicuous.

Wherever I observed these strata closely, their dip was about 10° south-east; but on reaching the western outcrop of the coal at Dover, only three-quarters of a mile from where the beds are so slightly inclined on the canal, I found the coal-measures dipping at an angle of no less than 50° east, or opposite to that prevailing at Blackheath on the other side of the trough. The seams of coal at Dover correspond very closely at their outcrop near the granite with those before mentioned, where the western dip prevails, the main seam at Dover being 16 feet thick, and there being two other thinner ones below. Only a mile or two south of the open shaft at Dover, where I saw the beds dipping at an angle of 50°, I observed the strata near the granite to be almost horizontal. The same may be said of the strata three miles south of the Powhatan pits, near their junction with the crystalline rocks on the eastern outcrop. I was told also of instances of the strata dipping towards the granite, as for example three miles south-east of the Midlothian pits before mentioned. In short, the disturbances have been so great, that although the general structure of the coal-field is that of a basin or trough, as before stated, the deviations from this form are numerous.

Organic Structure and Mineral Composition of the Coal.

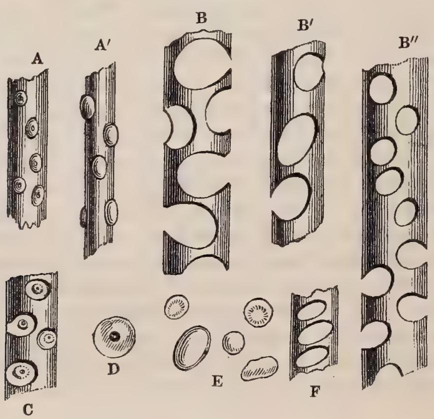
The coal of Eastern Virginia, although derived from a different vegetation from that of the ancient carboniferous period, resembles very closely the older coal in structure, appearance and composition. That of the Blackheath mine has usually a highly resinous lustre and conchoidal fracture, and always contains at least as large a proportion of gaseous or volatile ingredients (hydrogen, oxygen and nitrogen) as the coal of the palæozoic rocks of the United States.

The coal is also divided into horizontal layers of slight thickness parallel to the planes of stratification, as in the older kind of coal. Sometimes these layers consist alternately of highly crystalline and resinous coal with a bright lustre, and of other portions exactly resembling charcoal in appearance. The same is observed in some of our Welsh coal, where the charcoal is called "mother coal."

My friend Dr. Hooker has had the kindness to examine for me some specimens of this Virginian charcoal, which I procured at the Blackheath mines, and others from those of Clover-hill before alluded to, and he finds vegetable structure in both, but appearing in each locality to belong to a different species of plant. At first he thought they might be referable to ferns, but abandoned that opinion from the total absence of cellular and scalariform tissues. The prominent glands of the fibres are much more minute than the glands of coniferous tissue, whilst the large perforated tubes are foreign to that order. They depart still more widely from Zamia, and do not indeed present any obvious affinity with any existing natural order. "Both are very opake, much crushed, and so fragile that it is difficult to obtain fragments fit for microscopic investigation. They principally consist of a mass of parallel fibres or elongated cells, amongst which occur very large tubes whose walls are pierced with circular, or longitudinally or transversely elongated holes, either scattered or placed very close together.

Vegetable Structure of Mineral Charcoal from Clover-hill Mines, Virginia.

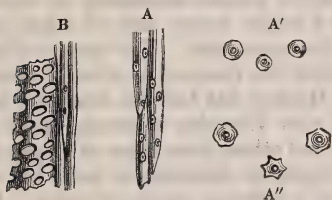
Fig. 3.



"In this (Fig. 3.) the fibres (A) are larger in diameter, covered with prominent dots or glands, each often having a dark spot in the centre. The perforations in the tubes (B) are often filled up with circular discs (as at C), which have a central dark spot (D), or are transparent throughout (E). The perforations of some of the tubes are so closely placed and so much elongated transversely (F), that the tube resembles the scalariform ducts of a fern.

Blackheath Specimen (*Creek Mines*).

Fig. 4.



"The fibres of this specimen, fig. 4. (A), are smaller and more closely packed, covered with more numerous prominent dots or glands; the latter have almost uniformly a central spot (A′), are extremely minute, very caducous, and are often star-shaped (A″), or of various outline. The tubes are very rarely seen, and have many series of generally transversely elongated perforations (B)."

Next to the ferns, the most abundant vegetable remains in the coal-measures under consideration are two species of Calamites and the *Equisetum columnare*, especially the former, and the bark of the Calamites is usually converted into coal. It is therefore natural to conjecture, that the thin layers resembling charcoal may have been derived from Calamites, a plant of which the botanical structure is still unknown. Dr. Hooker, in reply to this suggestion, tells me that some fossil charcoal in the Museum of the Geological Society, from the English coal formation, supposed to be derived from Calamites, is very like that of the Virginia coal above described.

The cities of New York and Philadelphia have for many years supplied themselves with coal from the Blackheath mines, for the manufacture of gas for lighting their streets and houses. The annual quantity taken by Philadelphia alone has of late years amounted to 10,000 tons. It will appear from the annexed table of analyses of specimens of coal, which Mr. P. H. Henry has had the kindness to make for me, that the proportion of volatile ingredients—hydrogen, nitrogen and oxygen—in this newer coal of the James River comes exceedingly close to that found in the older coal of America, which it so much resembles in aspect and structure. The specimen from Tuscaloosa in Alabama was from the old coal formation described by me in the Journal of this Society for 1846, vol. ii. page 278, in which are found precisely the same plants as in the coal of the Appalachians, of Nova Scotia, and of the north of England. The other three specimens, from

Analysis of American Coals and Coke, dried at 250° Fahr. Moisture 1 to $1\frac{1}{2}$ per cent.

	Coal and Coke of the Newer Coal-field of Eastern Virginia.				Ancient Coal of Alabama.
	Coal, Clover-hill.	Coal, Blackheath.	Coal, Deep-run.	Coke—Townes and Powell's.	Coal, Tuscaloosa.
Carbon	76·49	80·38	82·90	86·54	80·96
Hydrogen ...	5·23	4·08	4·77	4·23	5·13
Oxygen and Nitrogen	8·41	6·19	5·97	4·53	7·83
Ash............	9·87	9·35	6·36	4·70	6·08
	100·00	100·00	100·00	100·00	100·00

Clover-hill, Blackheath, and the Deep-run mines respectively, represent the southern, middle, and northern parts of the coal-field treated of in this memoir. On comparing this analysis of the Clover-hill coal as here given, with Dr. Percy's analysis of the older coal from Pomeroy on the Ohio (see this Journal, vol. i. p. 199, May 1844), we cannot but be struck with the identity of the results, as far as relates to the proportions of carbon and hydrogen. Thus the ancient coal of Pomeroy gave, carbon 76·70, hydrogen 5·67, in which it will be seen that the figures are the same, except the decimals, as in the analysis of the newer coal from Clover-hill. Nearly the same remarks are applicable when we compare the Blackheath coal and that of Tuscaloosa in the annexed table.

That there should be a disengagement of inflammable gas from this coal, containing so much volatile matter, was to be expected; accordingly, in spite of the usual precautions taken to prevent accidents, several fatal explosions have occurred; one of these happened at Blackheath in the old pit in 1839, by which forty-five negroes and two white overseers lost their lives. They were killed, not by choke damp, but by the combustion of carburetted hydrogen, attributed by the miners to the spontaneous ignition of coal mixed with decomposing pyrites. The most approved methods of ventilating the mines had been introduced, but another terrible accident occurred so late as the year 1844, at the depth of more than 900 feet, at Blackheath, occasioned by the leaking out of gas from some deserted works, which had been ineffectually dammed off from the new galleries.

On Beds of Coke and Altered Coal, and the Action of Intrusive Igneous Rocks.

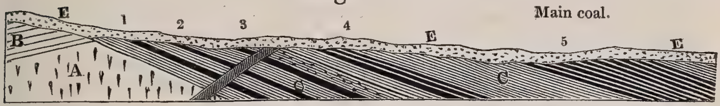
Although rocks of volcanic origin do not form a prominent feature in the geological structure of this coal-field, as they do in the region of the new red sandstone of Connecticut and New Jersey, they are not wanting, and I shall next describe the manner of their interference with the strata and the changes they cause at and near their contact.

At the southern extremity of the coal-field at Clover-hill before alluded to, four miles north of the Appomattox River on "Johnson's

Tract," a dike of greenstone is seen about 20 feet thick, running W. 10° S.; the coal-measures crop out here near the granite at various angles between 10° and 45°. Near the locality last mentioned, I obtained at the Beaver mine a section passing through five seams of coal: see Section Fig. 5. The fundamental rocks consisted of granite

Section at Clover-hill, Virginia.

Fig. 5.



A. Granite.
B. Hornblende schist.
C. Coal-measures.
D. Dike of greenstone.
E. Drift, or ancient alluvium.
C′. 10 feet stratum of sandstone.
1, 2, 3. First, second, and third coal-seams.
4. Four foot coal.
5. Main seam of coal, 10 to 12 feet thick.

and hornblende schist, on which repose coal-measures, chiefly of white sandstone and shale 500 feet thick with three seams of coal, the uppermost of which was cut through by the dike of greenstone, the coal, as the miners expressed it, having been burnt up by it and altered into a kind of coke. On the altered coal No. 3 rests a solid undivided stratum of sandstone 10 feet thick, and on this a seam of coal 4 feet thick, to which succeeds slaty shale 30 feet thick, and on this rests the fifth seam or main coal, 10 to 12 feet thick. Then follow strata of sandstone, shale and other rocks without coal for a thickness of about 160 feet, exposed continuously. The next point to the north where I saw greenstone in connexion with the coal-measures was in Sallé's Tract, within a mile-and-a-half of the James River and near the United States' Arsenal, about sixteen miles north of Clover-hill pits last mentioned. In this region some of the coal is affected and more or less deprived of its bituminous qualities, although not in contact with the igneous rock, which however I traced to within 120 feet of the altered coal, and it may approach much nearer.

Not far from the same locality, in "Burfoot's Tract," about three-quarters of a mile from the Arsenal on the James River, the principal coal-seam was described to me as damaged by the near approach to it of the whin and a kind of coke produced. The mass of trap was visible, a greenstone of the ordinary character 28 feet thick, and near it a brecciated rock of hardened shale varied by patches of carbonaceous matter resembling impure coke in appearance. The locality, like all the others, is near the junction of the coal-measures and the granite. Before visiting the Richmond or East Virginia coal-field, I had been asked by some geologists, whether it was not a singular phænomenon that some upper beds of coal had been deprived of all their volatile matter, while others below remained perfectly unaltered and bituminous? The explanation appears to be simply this: that the greenstone, although intrusive, has often here, as is so common elsewhere, made its way between the strata like a conformable deposit, and has driven out the gaseous matter from the upper coal, while its influence has often not extended to lower seams. In fact, at Duval's and farther north, at Townes and Powell's pits, the trap overlies the coal, and forms a bed having the same dip as the coal-bearing strata.

At the first-mentioned of the above places (Duval's pit, on the south bank of the James River), a shaft, open at the time of my visit, had passed through—first, 105 feet of sandstone and shale, then the greenstone reduced to a thickness of 6 feet and parallel to the strata. Below the trap, strata 25 feet thick, similar to those above, were met with, and then the main seam of coal 10 feet thick, of which the quality was not affected as in some adjacent mines, owing probably to the thinness of the greenstone and the interposition of the other rocks. Below the coal the miners entered black slaty rocks 35 feet thick with numerous prostrate and upright Calamites, and then reached a second bed of coal 3 feet thick of excellent quality resting on other carbonaceous slates with Calamites. Next came the bottom coal 6 feet thick, also unchanged: some other thin partings of coal between this bed and the fundamental granite, show how various are the modifications under which the seams of coal present themselves,—a diversity probably connected with the variations in the amount of the subsidence to which the erect position of the Calamites observed at intervals over so wide an area clearly points.

Coke of Townes and Powell's Pits.

The most remarkable example of natural coke met with in this or any other coal-field known to me, occurs at Townes and Powell's pits at Edge-hill, a locality between five and six miles north of the James River and ten north of Blackheath, being also on the eastern outcrop of the basin and within 500 yards of the granite. A large quantity of coke, used for furnaces and other economical purposes, is here extracted from a bed about 8 feet thick, below which at greater depth are two beds of imperfect coal. The measures passed through above the 8-feet-bed of coke are 110 feet thick, including a conformable bed of blue basalt 16 feet thick. The shale immediately below the trap was white for 11 feet, and then 25 feet of dark leafy shale succeeded, below which came the bed of coke resting on white shale, and lower down coal-measures with two seams of inferior coal, each about 4 or 5 feet thick. The shale, 47 feet thick, interposed between the basalt and the coke, exhibits so many polished surfaces or slickensides, and is so much jointed and cracked, and in some places disturbed and tilted (in one area of 12 feet the beds being vertical), that we may probably attribute the change from coal to coke, not so much to the heating agency of the intrusive basalt, as to its mechanical effect in breaking up the integrity of the beds, and rendering them permeable to water, or the gases of decomposing coal. In some places in the same district where the upper part of a seam is coke, the lower is coal, and there is sometimes a gradation from the one to the other, and sometimes, I was told, a somewhat abrupt separation. The general dip of the strata in this locality is W.S.W. Calamites are abundant in the beds associated with the coke.

I observed that some of the basalt of the neighbourhood assumed a very regular concretionary and spheroidal structure on exposure to the air. About 200 yards north of the great coke-pit, the trap, 14 feet thick, is found within 26 feet of the surface. At the distance of about two miles south of Townes and Powell's, at Crouch's pits, 300 feet deep, where no trap occurs, the coal is bituminous and unchanged.

Analysis of the Coke.—It will be seen by the table before given (p. 270), that Mr. P. H. Henry, who has very carefully analysed this coke, finds it to contain, carbon 86·54, hydrogen 4·23, oxygen and nitrogen 4·53, ash 4·70. He informs me that, according to Mr. Regnault, Welsh anthracite contains only 3·3 per cent. of hydrogen, and it appears in the paper before cited (Quart. Journ. Geol. Soc. vol. i. p. 199), that Dr. Percy found only 2·45 per cent. of hydrogen in the Pennsylvanian anthracite, which I submitted to his examination, from the Mauch Chunk mines. In the Frostburg coal (see same paper), the total quantity of volatile ingredients (hydrogen, oxygen and nitrogen) does not greatly exceed that detected in the coke of Edge-hill, or Townes and Powell's, although the latter is so much less inflammable.

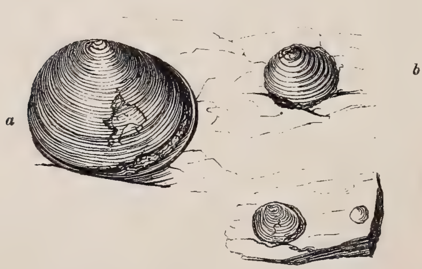
Mr. Mitchell, in his 'Geology of North Carolina' (1842), p. 133, observes, that the theory of the fluviatile origin of the sandstone of North Carolina (which, like that of East Virginia, contains coal) is open to this objection: "That it takes no account of the trap, which is not only imbedded in it, but traverses the sandstone in a thousand different directions. The same trap (he adds) is not met with in the slates and granite which lie adjacent to the sandstone, and the area of a river or estuary could not have been liable throughout its whole extent in length and breadth to injections and eruptions of trap, whilst nothing of the kind occurred upon its banks." The same might be said of the red sandstone districts of the valley of the Connecticut and of New Jersey, for there also we no sooner pass the limits of the sedimentary strata and enter on the hypogene region, than all the conspicuous masses of trap cease to show themselves. But the explanation of this phænomenon has probably occurred to the mind of every experienced geologist. The same greenstone which alters the coal at Clover-hill, above alluded to, crosses in the form of a narrow dike through the adjacent hornblende schist; and Mr. Percival of Newhaven pointed out to me in 1842 several trap dikes in Connecticut traversing the mica schist which forms the western border of the "new red sandstone" district of that State. I saw other dikes to the eastward of the same region, east of Newhaven; and if they are not everywhere traceable, it arises from the wide extent and depth of the "drift" or ancient alluvium which everywhere overspreads the hypogene formations. The apparently abrupt cessation of the volcanic rocks, when we enter the granitic area, arises from the more compact and crystalline form which they assume where they have been consolidated in fissures which were deep-sited originally, before the denudation of the country exposed the hypogene formations to view. Under such circumstances the narrow dikes of more modern igneous rocks are scarcely distinguishable from some members of the older and accompanying plutonic family, and they nowhere expand into dense conformable masses, nor form amygdaloids nor trap tuffs. Hence they are easily overlooked in a cursory survey, although in reality very numerous, and often persistent for great distances.

On the Geological Age of the Coal-Fields of Eastern Virginia, as determined by Fossil Remains.

I shall now consider the chronological relation of the coal-field, in determining which we have no direct evidence from superposition. The only other strata occupying a similar position in the hypogene region on the Atlantic Slope, with the exception of some of a similar character near Raleigh in North Carolina, are those commonly called the new red sandstone of Massachussets, Connecticut, and New Jersey. In part of New Jersey the strata of that red sandstone are unconformable to a part of the palæozoic series of the Appalachian system, and are therefore subsequent in origin to the movements which gave to the old carboniferous and other still more ancient groups of the Alleghany mountains, their present strike, dip, and flexures. The red sandstone therefore being posterior in date to the Appalachian coal strata, the next question is, whether the coal-field near Richmond is of the same age as the red sandstone, or of newer or older date? The difficulty of replying to the inquiry consists in this: that most of the fossils of the so-called new red sandstone are fish, or the foot-tracks of birds, without any plants, while those of the coal near Richmond are almost exclusively confined to plants, so that we have scarcely as yet any satisfactory terms of comparison in the same family of organic beings common to the two. Before alluding to the plants, I shall say something of the small number of shells and ichthyolites which I met with in the coal-field near Richmond.

Shells of the Coal-Field.

Fig. 6.



In the carbonaceous shales associated with the main seam, and usually not far above, a great number of minute flattened bivalves are often observed in some places, as at Harden's pits, north of Blackheath (see *a*, fig. 6). They resemble Cyclas in outline; they are thin and compressed, have a horny texture, oval and inequilateral, with a surface concentrically furrowed and somewhat wrinkled. They resemble Posidonomya, and more than any other the *P. minuta*. They occur in such immense numbers as to divide the shale-like plates of mica into very thin laminæ. Every fresh surface exhibits a layer of them. In their gregarious character they resemble the genus Cypris as it occurs in the cypriferous marls of Auvergne.

With them is another smaller and more convex bivalve shell which resembles a young Astarte, but may perhaps be the young of the preceding (see *b*, fig. 6). The same shell was also presented to me by Dr. Werth, from the Creek mines south of Blackheath, also in black shale.

At the Deep-run pits I saw traces of the same shell, but in none of these places in a perfect state: the genus Posidonomya in Europe is considered to be characteristic of the triassic period, in which the *P. minuta* occurs in England (see fig. 4. plate 28. vol. v. Geol. Trans. 2nd series). I have stated, that the manner in which these extremely thin shells occur by myriads, like plates of mica between the partings of the shale, reminded me of the exuviæ of the Cypris in the freshwater marls of Auvergne. Mr. Morris has shown me a recent bivalve crustacean from Bahia Blanca in South America, having a delicate, crumpled or corrugated horny shell, bearing so great a resemblance to the Posidonomya, that I cannot help sharing his doubts whether the latter genus may not be allied to Cypris rather than to any genus of the true Mollusca, *i. e.* to Avicula.

Fossil Fish.

After much careful search, and the indefatigable exertions of my friend Mr. A. F. D. Gifford, residing at the Blackheath mines, I was unable to procure the remains of more than three species of fossil fish, most of which, and the only perfect ones, are referable to a new genus of the homocercal class. On seeing these ichthyolites (September 1846), M. Agassiz, ignorant of their locality, at once suggested, from the analogy of European forms, that they were of the age of the lias; as being all homocercal, and the large smooth scales of one species belonging to the genus Tetragonolepis. This opinion would accord with the inference previously deduced from the fossil plants by Professor W. B. Rogers (Trans. Assoc. American Geol. 1840–42, p. 298).

As all the fish hitherto obtained from the sandstone (commonly called the "new red") of the Connecticut River, four or five species in number, are heterocercal, this would indicate a distinct and probably a more modern date for the Virginian coal-bearing strata. Could we therefore feel sure that the beds containing ichthyolites and the foot-prints of birds in the valley of the Connecticut were triassic, it would afford strong ground for presuming the oolitic age of the Virginian coal strata. But I conceive the question is still open, whether the Connecticut sandstone be of Permian or triassic date.

I shall now offer a description of the Virginian ichthyolites, drawn up chiefly from notes supplied me by Prof. Agassiz and Sir Philip Egerton.

Dictyopyge macrura, Pl. VIII. This species is the most abundant, occurring in strata of argillaceous sandstone about 150 feet above the main seam of coal in Chesterfield county. It is the same one which was described by Mr. W. C. Redfield, under the name of *Catopterus macrurus* (Silliman's American Journal of Science, 1841, vol. xli. p. 27). The following are the characters given by him :—

Catopterus macrurus, Large-finned Catopterus. This beautiful species is distinguished by its broad and flowing fins, of which the anal is so extended as to be nearly joined by the caudal fin. The latter is finely extended. The length of this species is from four to five inches ; its width from one and one-eighth to one and three-eighths of an inch. The margins of the fins are remarkably fine and beautiful. The posterior margin of the scales seems to be curled slightly outward, giving the surface a somewhat roughened appearance.

The genus Catopterus was instituted by Mr. Redfield for certain species of heterocercal fish from the Connecticut red sandstone, and the species under consideration having, as before stated, a homocercal tail, cannot be comprehended in it. Sir P. Egerton also remarks, that the dorsal fin is more strictly opposite to the anal than in *Catopterus Redfieldi*, which in this respect approaches nearest to the species under consideration ; the tail, according to Agassiz and Sir P. Egerton, bearing the greatest resemblance to that of the genus Pholidophorus. The numerous and uniform articulations give to its large anal fin a net-like appearance, which has led Sir Philip to suggest the generic name of *Dictyopyge*—from δικτυον, *net*, and πυγη, *anus*. The specific name of Mr. Redfield must of course be retained.

I procured several specimens of this ichthyolite, the most perfect of which here figured (Pl. VIII.) is exactly 6 inches long from the mouth to the extremity of the tail, and $1\frac{1}{4}$ inch broad, but some were a fifth shorter. I do not observe the curled appearance mentioned by Mr. Redfield, in the posterior margin of the scales, which may have arisen perhaps from their being in a disturbed or injured state. The somewhat lengthened shape of the scales of the lateral line, pointed out to me by Mr. Dinkel the artist, causes a marked dividing line between the scales above and below it. In figure *e*, Pl. VIII., the peculiar shape of these scales of the lateral line will be seen, some of them having the opening of the tube outwards, others not, and the projection of the tube in the anterior part of each scale fitting into a notch in the scale immediately preceding.

f, Pl. VIII., shows the shape of the scales immediately above and immediately below the lateral line, in which there is a small notch or incision not exhibited in the remoter scales.

b, Pl. VIII., represents the large anal fin, also seen more fully developed in fig. *b*, Pl. IX.

c, Pl. VIII., shows a faint impression of the pectoral fin.

d, Pl. VIII., shows part of the ventral fin and an impression of the rest.

Plate IX. fig. 1. represents the posterior part of *Dictyopyge macrura*, obtained in the same slab as the specimen figured in Pl. VIII. ; *d* is the ventral, and *b* the anal fin.

I may also remark, 1st, The opercular and frontal bones of the head are covered with extremely minute scales. 2ndly, The raylets on the anterior margin of the caudal fin alluded to in Mr. Redfield's description are stronger and broader in the lower lobe of the tail than in the upper. 3rdly, The insertion of the anterior ray of the dorsal fin begins nearly opposite the middle of the anal fin, and in consequence of the great extension of the latter towards the tail, it continues to be opposite the whole length of the dorsal. The pectoral and ventral fins are rarely to be seen, but have left impressions in some specimens.

Second species of the genus Dictyopyge.

Portions apparently belonging to a second species of the same genus occur in some of the slabs of stone from Chesterfield county, the scales being so much larger in proportion to the size of the individual, that in corresponding parts of the body, five scales occupy the place of seven in the preceding species.

Tetragonolepis.

Pl. IX. fig. 2. represents nearly the whole side, with part of the lateral line near the head, of a specimen from Blackheath: natural size.

Although a few fragments only of this ichthyolite were obtained, they were recognized at once by M. Agassiz as belonging to the distinct genus Tetragonolepis, and to resemble the large liassic species with smooth scales. A scale from the lateral line, magnified about four times (*a*, fig. 2. Pl. IX.), shows the manner in which the tube in some of these scales opens outwards. Each scale in the lateral line has also a notch posteriorly.

I have stated that all the fish of the red sandstone of Connecticut differ from those of Virginia. A fine collection of the former was made by Prof. B. Silliman, jun., and myself, at Durham, Connecticut, in 1842, which M. Agassiz and Sir P. Egerton have examined for me. They belong to three species:—1st, *Palæoniscus fultus,* Agassiz (*Ischypterus fultus,* Egerton), of various sizes and ages, some of the varieties comprising the *Palæoniscus macropterus* of Redfield, which is considered by M. Agassiz to be the same. Sir P. Egerton has proposed for Palæoniscus the generic name of *Ischypterus,* from *ισχυς, strength,* and *πτερον, fin,* from the great size and strength of the fulcral rays of the dorsal fin. They differ from Palæoniscus, as Mr. Redfield first pointed out, by having the vertebral column prolonged to a more limited extent into the upper lobe of the tail, or, in the language of M. Agassiz, they are less heterocercal. The teeth also, according to Sir P. Egerton, who in 1844 examined for me a fine series of specimens from Durham, Connecticut, differ from those of Palæoniscus in being strong and conical. The oral aperture is smaller and the scales smoother than in the Palæonisci of the magnesian limestone or Permian beds of Europe, in which the scales are striated and serrated on the posterior margins. Some of the *carboniferous* Palæonisci of Europe resemble the American fish in having similar smooth scales.

2ndly, *Catopterus gracilis.*

3rdly, *Catopterus Redfieldi*, a broader fish than the preceding, and with scales not so long in proportion to their depth.

These three, and all others found in the same (new red sandstone?) formation, are heterocercal. Sir P. Egerton is of opinion that far too much importance has been attached by some geologists to the circumstance of the vertebral column not being prolonged so far into the upper lobe of the tail in these genera, Ischypterus and Catopterus, as it is in true Palæonisci, when they have insisted upon it as an argument in favour of the red sandstone of Connecticut being less ancient than the palæozoic period. For at Autun, in France, we find the genus Ischypterus accompanying the true Palæonisci with fossil plants specifically the same as those of the old coal.

It would be rash to attempt to settle the chronological relations of any group of strata by the presence of some one peculiar generic form of fish; but if we are to reason on the occurrence of Ischypterus in the present state of our knowledge, it must be in favour of identifying the red sandstone of Connecticut with the beds which belong to the uppermost members of the old coal of Europe, as at Autun the coal-measures are almost passing upwards into Permian. The Irish *Palæoniscus catopterus* of Roan (or Rhone) Hill, Tyrone, referred by Captain Portlock to the trias, is a true Palæoniscus, and not allied generically either to the Ischypterus of Egerton or the Catopterus of Redfield.

Whether the Coal-Field of the James River be of marine or freshwater origin.

I know of no character in any of the fossils of this coal-field which is inconsistent with the hypothesis that all the strata may have been deposited in a lake, estuary or river-delta. The plants are all terrestrial, and the occurrence of erect Calamites and Equiseta at various heights in the series, and at points widely distant, implies, according to my view, that they were not drifted, but grew on the area where we now find them. Hence I infer the constant proximity of land, the drainage of which may have supplied a body of fresh water. Of the genus Posidonomya too little is as yet known to permit us to reason on its habits. In regard to the fish (omitting the new genus), I am informed by Sir P. Egerton that Tetragonolepis is accompanied in the British lias by Lepidotus, which last genus abounds in the freshwater strata of the Wealden in England.

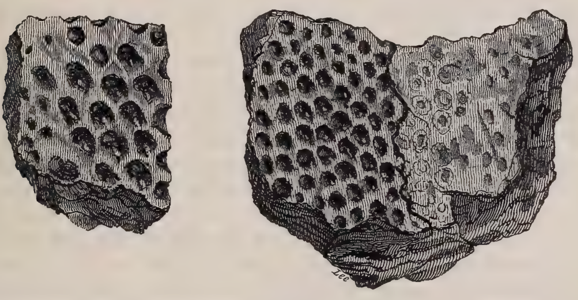
The Coal-Field probably of the age of the Inferior Oolite and Lias.

It will appear from the subjoined account, drawn up by Mr. Charles J. F. Bunbury, of the fossil plants procured by me from the coal-field, that they belong to fifteen forms, and that they bear upon the whole a very decided analogy to the oolitic and triassic Flora of Europe. The *Calamites arenaceus*, one of the most abundant plants, has as yet been traced up no higher than the trias in Europe*.

* Mr. Prestwich has mentioned the plant as occurring in the old coal of Coalbrookdale (Geol. Trans. 2nd series, vol. v. p. 488), but Mr. Morris informs me, after inspecting the specimens, that this was a mistake for *Calamites Suckowii*.

The *Equisetum columnare* is said to be common to the trias and oolite in Europe. Among the ferns, *Pecopteris Whitbiensis,* which I procured, seems to have been correctly identified by Mr. W. B. Rogers, and is one of the commonest species of the Yorkshire oolite. The large Tæniopteris is also allied to some of the Yorkshire oolite ferns. The genus Zamites is represented by many species in the oolitic rocks of Europe, but is also triassic.

Fig. 7.



The fossil, somewhat like a Stigmaria—see fig. 7 (No. 13. of Mr. Bunbury's description of plants)—which Dr. Hooker has had the kindness to figure for me, has more of the aspect of a plant from the old coal than any other, but we have not as yet sufficient knowledge of its true relations to found any argument upon it. I may remark also, that if some of the plants and the shell called Posidonomya should indicate a formation rather older than the Whitby oolite, they may still belong to part of the great jurassic period; for the Whitby coal occurs in, or immediately below, the great oolite, which is succeeded in descending order by the inferior oolite and the lias. Now as we have not in Europe any coal-fields, nor any large development of a fossil flora in these older subdivisions of the jurassic group, the Virginian strata may correspond in age either to the inferior oolite or the lias, and for that reason may have more of a triassic character in their organic remains than the coal strata of Whitby in Yorkshire*. The occurrence of the large smooth scales of a fish of the genus Tetragonolepis, so characteristic of the lias, favours this view. It has been well remarked by Prof. W. B. Rogers, that the few plants discovered by Captain Grant in connexion with the oolite-coal series in Cutch, resemble very closely those of the East Virginian coal-measures†. There can be no doubt that the Indian fossils belong to

* Some fossil plants figured and described by Professor Hitchcock, from "the new red sandstone formation of Connecticut and Massachussetts" (Trans. of Amer. Geol. 1840–42, p. 294 and pl. 13.) do not enable us to decide the age of that formation, or to compare it with that of Virginia. The supposed Tæniopteris, fig. 8, cannot belong to that genus, the striations of the leaf not being at right angles to the midrib, and the entire portion represented being of the same diameter throughout. The plant (fig. 3 and 4) is probably related to the *genus* Lycopodites, which is also found in the Virginian coal-field; if, as conjectured, it be Voltzia, this genus is common to the magnesian limestone (Permian) and trias of Europe.

† Grant, Trans. Geol. Soc. Lond. vol. v. 2nd series.

the oolitic period, from the character of the numerous marine shells found in some of the associated strata.

Upon the whole, therefore, I arrive at the same result as Prof. W. B. Rogers, namely, that the coal-field of Eastern Virginia agrees in age with the lower members of the oolitic or jurassic group of Europe, —a conclusion which is important, because these strata constitute at present the only representatives of this group hitherto discovered in the United States of North America. If future researches should require any modification of this opinion, we may then expect that the trias will be the group to which the American formation will be referable.

In conclusion I may observe, that I was much struck with the general similarity of this more modern coal-field, and one of palæozoic date near St. Etienne in France, which also rests on granitic rocks, from the detritus of which its coarse grits and sandstone are composed. In both these coal-fields upright Calamites abound; fossil plants are met with in both, almost to the exclusion of all other classes of organic remains, shells especially being absent. The character of the coal is similar, but in the richness and thickness of the seams, the Virginian formation is pre-eminent. When we behold phænomena so identical repeated at an epoch so much more modern in the earth's history, and at a time when a very distinct vegetation had been established, we may derive from the fact a useful caution in regard to many popular generalizations respecting a peculiar state of the globe during the remoter of the two periods alluded to. Some geologists, for example, have supposed an atmosphere densely charged with carbonic acid to be necessary to explain the origin of coal—an atmosphere unfit for the existence of air-breathing vertebrate animals; but this theory they will hardly be prepared to extend to so modern an epoch as the oolitic or triassic.

DESCRIPTION OF THE PLATES.

Plate VIII. Figure of *Dictyopyge macrura*, size of nature, from the oolitic coal-field of Eastern Virginia. This specimen was obtained from the Blackheath mines in Chesterfield county, Virginia. None of the parts here represented have been restored. See p. 275.

b. The anal fin, which is not so perfect as in some other specimens from the same region.

c. A faint impression of the pectoral fin.

d. Part of the ventral fin and an impression of the remainder.

e. Scale from the lateral line.

f. Shape of the scales from immediately above and immediately below the lateral line. See p. 276.

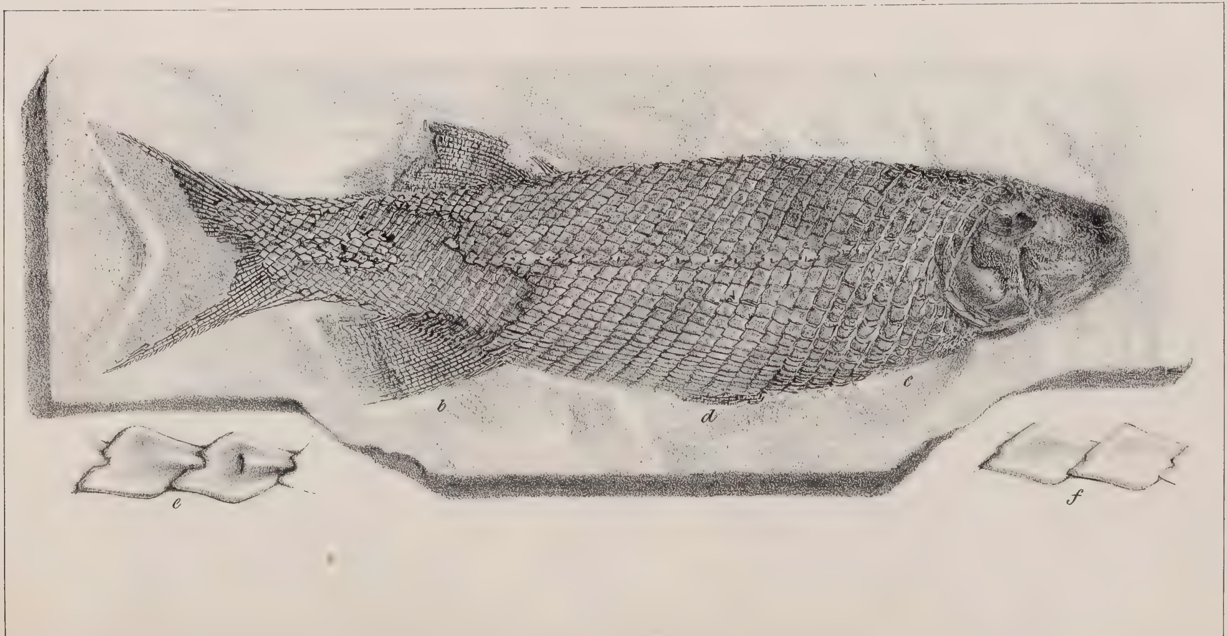
Plate IX. fig. 1. Posterior part of the same fish, *D. macrura*, from the same slab of stone.

d. Ventral fin.

b. Anal fin.

fig. 2. *Tetragonolepis*: portion of a fossil fish from the same strata, Blackheath, Virginia. See p. 277.

a. Scale of the lateral line.



Jos. Dinkel del.

Hullmandel & Walton Lithographers.

DICTYOPYGE MACRURA. BLACKHEATH, VIRGINIA.

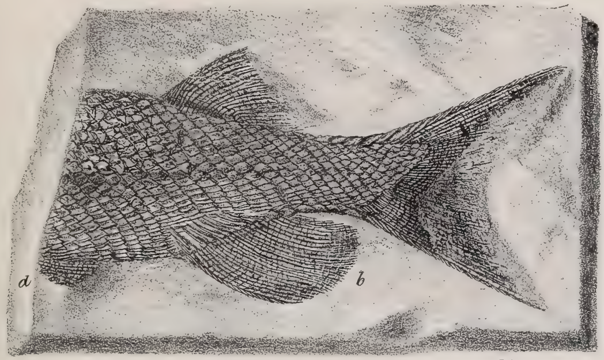


Fig. 1.

DICTYOPYGE MACRURA.

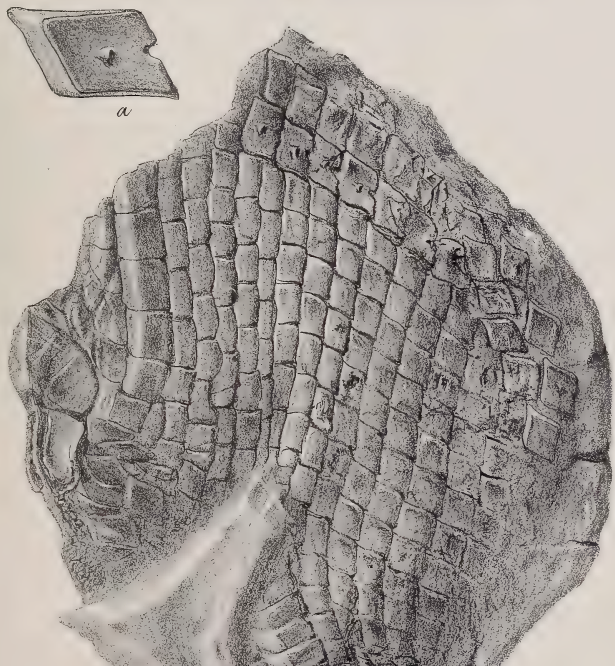


Fig. 2.

Jos: Dinkel del.

Hullmandel & Walton Lithoghographers

TETRAGONOLEPIS BLACKHEATH, VIRGINIA.

2. *Descriptions of* Fossil Plants *from the Coal-Field near* Richmond, Virginia. By C. J. F. Bunbury, Esq., F.L.S.

1. Tæniopteris magnifolia.

(Rogers, in Report of Assoc. of American Geol. p. 306–9.)

"From Clover-hill and Deep-run, Richmond."

The numerous specimens of this fine plant, collected by Mr. Lyell, although none of them complete, are fully sufficient to confirm the propriety of Prof. Rogers's determination of it as a genuine species of *Tæniopteris*, very nearly allied to *T. vittata* and *T. major*, but doubtless distinct, though the differences are not very easily reducible to a strict definition. I observe among these specimens two varieties, in one of which the frond is somewhat obovate and suddenly rounded off at the end, while in the other (though still obtuse at the point) it tapers much more gradually, so that the whole outline is more lanceolate. The manner in which the frond is in many cases creased or crumpled, shows it to have been of a thin and membranous texture, like the recent *Oleandra pilosa*, not rigid and coriaceous like most of the simple-fronded Ferns. I can perceive no trace of fructification. The midrib is very broad, flat, striated (without any distinct channel along the middle), tapering gradually, and reaching quite to the extremity of the frond. Veins extremely numerous and close, parallel, quite straight and perpendicular to the midrib, except close to their base, where they are bent at an obtuse angle; they are either perfectly simple or (not unfrequently) forked at their base, close to the midrib; almost always simple throughout the rest of their length. This character clearly distinguishes our plant from *T. major* (Fossil Flora, t. 92), in which nearly all the veins are repeatedly forked. The elliptical or somewhat obovate form of the frond, which tapers away rather gradually into the footstalk, together with its much larger size and (seemingly) different texture, will suffice to discriminate it from *T. vittata*.

As Prof. Rogers has not given us a specific character for this Fern, I would propose the following:—

Tæniopteris magnifolia:—fronde amplâ membranaceâ ellipticâ vel obovato-ellipticâ, basi attenuatâ; costâ latissimâ striatâ; venis simplicibus vel basi furcatis.

2. Neuropteris linnææfolia (n. sp.).

Tab. I.

Spec. char.—N. fronde bipinnatâ: pinnis suboppositis; pinnulis oppositis alternisque sessilibus contiguis subimbricatis orbiculatis integerrimis subconvexis; venis dichotomis flexuosis e basi pinnulæ radiatim divergentibus.

This beautiful Fern, of which I have seen only a single specimen, but a very fine one, appears quite different from any hitherto described. The frond is bipinnate and of considerable size, the specimen being above a foot long, though broken off at both ends. Primary pinnæ nearly opposite (a rather unusual character), long and narrow, nearly linear in their general outline: their partial rachis narrow, flat, slightly striated. Leaflets numerous, sessile, partly opposite and partly alternate, closely placed, so as to touch and partly overlap one another, almost circular in outline, slightly cordate, entire at the margin, a little convex, scarcely $\frac{1}{4}$ inch in length. They have no distinct midrib; the veins, which are pretty strongly marked, and not very numerous, radiate from the base of each pinnule, are wavy and repeatedly forked, not unlike what we see in the smallest lateral leaflets of *Neuropteris heterophylla*. The surface of the leaflets is everywhere granulated, or covered with minute protuberances, between the veins: this appearance may be supposed to be produced either by capsules thickly spread over the surface, or by peltate scales, such as cover the fronds of Niphobolus and of many other Polypodeæ. The former is perhaps more probable, for in all recent Ferns (that I have seen) in which such scales occur in abundance, they cover and conceal the veins. Supposing these granulations to be the remains of capsules, they will not necessarily prove that our plant belongs to the Acrostichum group; for in many Aspideæ and Apleneæ, the fructification, when old, becomes spread over the whole lower surface of the frond, though originally disposed in spots or lines.

The terminations of the primary pinnæ are everywhere wanting in this specimen; but the small, round, neat, uniform and symmetrical leaflets, and the arrangement of their veins, together with the large size of the whole plant, distinguish it so well, that there is no need to compare it specially with any Neuropteris that I can find described. The leaflets taken separately have a considerable similarity to those of the recent *Jamesonia pulchra*, a native of South America; but the frond of that plant is simply pinnated.

I have named this Fern from a certain general resemblance in the appearance of its leaflets to the leaves of *Linnæa borealis*. In its venation it does not quite accord with the normal forms of Neuropteris, but may be considered as intermediate between that genus and Odontopteris; in habit however it agrees rather better with the former, though not closely allied to any of the species hitherto known.

3. Pecopteris?

Fragments of what appears to have been a very fine and large Fern, with long ribbon-like leaflets and pinnated lateral veins, but unfortunately too imperfect to be determined. They occur in the same slab with the *Neuropteris linnææfolia*.

4. Pecopteris Whitbiensis.

(*P. tenuis*, Ad. Brongn. Veg. Foss. 322. t. 110. f. 4.)

Specimen very imperfect, yet sufficient to leave little doubt as to the identity of the plant with Brongniart's *Pecopt. tenuis*. This is united by Göppert with *P. Whitbiensis*, and indeed Brongniart admits that the differences are very slight. The midrib of the pinnules is so faintly marked, that the plant seems scarcely to deserve a place in the genus *Pecopteris*.

This, as far as is hitherto known, seems to be a species characteristic of the oolitic system of rocks.

5. Pecopteris (Aspidites) bullata (n. sp.).

Tab. II. f. 1.

P. fronde bipinnatâ: pinnulis contiguis basi discretis oblongis obtusiusculis subintegerrimis, supra ad soros bullatis; venis obliquis pinnatis; soris rotundis confertis costæ approximatis immersis, utrinque uniserialibus.

"From Clover-hill and Deep-run, Richmond."

This seems to be a new and well-marked species, but the specimens, though pretty numerous, are not in such good condition as might be wished.

The frond is bipinnate: the main rachis smooth; the primary pinnæ going off from it nearly at right angles. The leaflets are very nearly perpendicular to the partial rachis, closely placed, but not united at their bases, about $\frac{3}{10}$ inch long, oblong or broadly linear, more or less obtuse, their margins apparently entire. The midrib scarcely reaches to the extremity of each leaflet. Side-veins very obscure, but, where they can be distinguished, oblique and pinnated with three or more alternate branches. The peculiar and distinctive character of the species consists in the round pits in which the *sori* (or spots of fructification) are placed, and which produce corresponding pustular elevations on the upper surface of the frond. These are very distinct and well-defined, nearly circular in outline, placed generally close together, forming a single row on each side of the midrib and at a little distance from it, and appear to terminate the lower branches of the side-veins; a small indentation in the centre of each protuberance distinctly marks the point of insertion of the sorus. In one or two instances I think I have observed an appearance resembling the reniform indusium of the genus *Nephrodium*.

This plant doubtless belonged to the group of *Aspideæ*, and was very probably a genuine species of *Nephrodium* (or *Lastrea* of Presl). It may perhaps be the same as the new Pecopteris described (but not named) by Professor W. B. Rogers, in his paper on the coal-rocks of Eastern Virginia*; but if so, he has omitted to notice its most striking character, the *immersed* spots of fructification.

6. Filicites fimbriatus.

Tab. II. f. 2.

I find, among the specimens from "Deep-run, near Richmond," several fragments of a very singular appearance. They exhibit distinct markings, which seem to be the fructification of a Fern, at first sight much resembling what Göppert has figured in his *Asplenites divaricatus*; but I can nowhere perceive the outline of the frond, nor indeed any trace of its existence, except between these markings; whence I am led to conjecture that the capsules were seated on the edges of a contracted frond. This is the case in some recent Ferns, but I do not know any which closely resemble the appearances presented by this curious fossil. The frond is in the first instance pinnated, with long narrow pinnæ, or flattened branches, going off from it at an

* Report of Assoc. of Am. Geol. p. 311.

angle of more than 50°: these are about as broad as the main rachis (rather more than $\frac{1}{10}$ inch); their surface nearly flat, but in some instances the central part is slightly raised above the margin, so as to have the appearance of a midrib; they are again pinnated or pinnatifid, but in an irregular manner, with short pinnules or lobes placed at very unequal distances; and their edges are everywhere beset (as well *between* these lobes as along them) with the supposed heaps of fructification, which form short oblong spots. These are converted into coal; but I cannot discover in them any distinct structure.

The imperfect state of the specimens leaves in great obscurity the real nature and affinities of this curious fossil. I can trace no connexion with any better-known form, for the fragments occur separate and unmixed with anything else. Farther observations, in the mines themselves, may possibly throw some light on its structure. I think there is little doubt of its belonging to the tribe of Ferns; but as it is not referable to any genus hitherto established, and can hardly, as yet, be satisfactorily characterized as a genus, it may be left for the present under the vague and comprehensive name of *Filicites.*

7. Equisetum columnare.

(Ad. Brongn. Veg. Foss. v. i. 115. t. 13.)

"From Blackheath, near Richmond."

Numerous specimens, in good preservation, from several different pits about Blackheath. They agree so perfectly with Brongniart's description and figures, as to leave no doubt of the identity of the Virginia plant with that of Whitby, as already determined by Prof. Rogers. On one of the large uncompressed specimens, there is an appearance of the origin of a branch, which seems to have sprung from one of the joints of the stem. Nothing of the kind is noticed by Brongniart.

The *Equisetum columnare* is well known as a characteristic fossil of the inferior oolite; but it is said by Unger* to occur also in the Keuper near Stuttgard.

8. Calamites arenaceus.

(Rogers, in Report of Assoc. of American Geol. p. 304.)

Qu. also *C. arenaceus*, Brongn.?
C. Suckowii, var. δ, Brongn. Veg. Foss. 125. t. 16. f. 1.

The specimens of this Calamite, from the pits in the neighbourhood of Blackheath near Richmond, are so numerous, as to prove it to be the most common fossil plant of that locality. It is certainly the *C. arenaceus* of Prof. W. B. Rogers (in the paper already quoted); but it is also the plant described and figured by Brongniart as the variety δ. of *C. Suckowii.* It is not easy to say what really constitutes a specific distinction among the Calamites; but in the remarkable narrowness of its ridges, and the apparently constant want of tubercles at the articulations, our plant differs so much from *C. Suckowii,* that it appears to be as distinct as any of the genus. In these same pe-

* Synopsis, p. 27.

culiarities it agrees well enough with Brongniart's figures and description of *C. arenaceus,* of which however the characters appear to be somewhat obscure and ill-defined.

This Richmond Calamite varies much in size, and often attains to much larger dimensions than those assigned by Brongniart to the *C. arenaceus,* several specimens being as much as 6 inches in diameter, and one above 8 inches. The coaly envelope, or supposed bark, is very thin and extremely fragile; where it is preserved, its surface appears nearly even; in general it remains only in the furrows, which are partly filled up with it. The surface of most of the specimens (when they are not compressed) is much wrinkled and puckered, with irregular transverse folds, apparently caused by vertical pressure, and showing the substance of the stem to have been soft and pliant at the time when petrifaction took place. This appearance has been noticed by Ad. Brongniart, and is well-represented in his 16th plate, fig. 1. The ridges, on the decorticated stem, are scarcely $\frac{1}{20}$ inch broad, convex and slightly keeled; the furrows between them equally narrow.

The European *C. arenaceus* seems to be one of the most common and characteristic plants of the Grès bigarré, and occurs also in the Keuper, but not, as far as I can learn, in any other formation.

9. Calamites.

Among the specimens from "Deep-run," near Richmond, there are some portions of a slender Calamite, which at first sight appears different from the preceding kind, as the ridges, though equally narrow, are flatter, and generally appear (as it were) double, a slight furrow running along the middle of each ridge. But I find the form of the ridges, in *C. arenaceus,* so variable even in different parts of the same specimen (owing probably to the degree of pressure and the direction in which it has acted), that I do not trust to this character as a sufficient distinction; and I think it very probable that the slender stems in question may be young plants of *C. arenaceus.* They are, like that species, destitute of tubercles at the articulations, which are a little contracted.

10. Zamites obtusifolius.

(Rogers, *l. c.* p. 312. t. 14.)

"From Blackheath, near Richmond."

Several specimens, agreeing very well with Prof. Rogers's description and figure.

This and the next species have completely the habit of Mr. Morris's genus *Ptilophyllum,* especially of *Pt. acutifolium,* but the leaflets are not oblique and imbricated at the base, but attached by the whole breadth of it, as in *Pterophyllum.*

11. Zamites gramineus (n. sp.?).

I am by no means sure that this is distinct from the preceding: it may be merely a larger variety or older state of the same plant. The leaflets however are much longer and narrower in proportion, and taper more gradually towards the extremity. They are from 2 to 3 inches long, whereas those of *Zam. obtusifolius*, in the specimens I have seen, scarcely reach the length of 1 inch; while their absolute breadth is the same in both. The veins are generally indistinct; where they can be clearly seen, they are from three to six in each leaflet, parallel, and mostly equal; but in some instances (perhaps accidentally) two of them become much more strongly marked than the rest, as in Brongniart's genus *Nilssonia*.

The leaflets are not only much longer, narrower, and more grass-like, than in the *Zamites pectinatus* of our Yorkshire oolite, but seem also to have been of a softer and more pliant texture, many of them being much bent and distorted.

Of this plant there are several specimens, in a soft grey shale; some of them in the same slab with the beautiful Neuropteris already described.

12. Sigillaria? or Lepidodendron?

A very obscure and indistinct impression; the markings, as far as they can be made out, much resembling those of *Sigillaria Menardi**. They have some resemblance also to the *Ulodendron minus* of the 'Fossil Flora'; and to a specimen from the Ohio coal-field, in Mr. Lyell's collection, marked "*Lepidodendron* 3 C."

13.

Two specimens, apparently casts of small portions of a decorticated stem, but extremely obscure and unsatisfactory. Their surface is marked with small roundish-oval or nearly circular pits, placed about $\frac{1}{10}$ inch apart, and arranged pretty regularly in spiral rows, like the scars of Stigmaria. Each of these little pits is deepest near one extremity of its axis, and is there marked with a very small scar, evidently indicating the place where a bundle of vessels passed through. A small portion of carbonized bark remains on one of the specimens, but its surface retains no distinct markings.

On the whole, the appearance of these fossils is a little like that presented by the decorticated stems of some Lepidodendra; but they are too obscure to be determined with any precision. It is possible that they may be decorticated portions of the same plant to which the preceding No. belongs.

14. Knorria?

"From Deep-run, Richmond."

An impression of part of a stem or branch, about $\frac{1}{2}$ inch broad, marked with (apparently) the scars of leaves, which are arranged pretty closely, and with some regularity, in spiral lines. Each insertion is marked by a small transverse depression or furrow, rather irregular in direction and extent, from which another furrow generally proceeds downwards for a short distance. These must have been ridges or projections on the original surface of the stem which left this impression. There is a slight excavation or depression of the surface above each scar, and an elevation or puckering between them, but nothing like distinct areolæ.

* Brongn. Veg. Foss. t. 158. f. 5.

This obscure fossil seems to agree with the *artificial* character of the genus *Knorria* (see Lindley and Hutt. Fossil Flora, text to t. 95 and t. 97), and I should conjecture that it is a relic of some coniferous tree; but it is not in a state to admit of satisfactory determination.

15.

"Duval's pit, near Blackheath, Richmond."

Fragments, in a very bad state of preservation, of a plant with apparently verticillated leaves, which seem to be linear, long and narrow, flat and thin, almost grass-like, and show some slight indications of longitudinal veins. The specimens are in too bad a state to admit of accurate description, or of even a conjecture as to the affinities of the plant.

The geological evidence afforded by the fossil plants here described, is to a certain degree ambiguous. The most characteristic species appear to be the *Equisetum columnare*, the *Calamites*, the *Tæniopteris magnifolia*, and the *Zamites*. The first of these is a well-known plant of the lower oolite, but is said to occur also in the Keuper. *Calamites arenaceus*, if it be the same with the European plant so called, seems to be eminently characteristic of the triassic series: it is not mentioned, by any author I have met with, as a plant of the oolite; indeed, the great abundance of these conspicuous Calamites strikingly distinguishes the Flora of the Richmond coal-field from that of our Yorkshire oolites, of which it otherwise reminds us by several of its forms. The *Tæniopteris* is closely allied to two species of the same genus, which are peculiar to the oolitic series; yet we must be cautious how we conclude, from its affinity to those forms, that it must necessarily belong to the same geological system; for the *T. Bertrandi*, another nearly-allied species, occurs in a tertiary formation. As, at the present day, we find Ferns closely resembling one another in very distant parts* of the world, so it is possible that very similar forms of that tribe may have been repeated in successive geological epochs. In fact, in the case of Ferns, I can hardly consider anything but *specific identity* really important in a geological point of view.

The *Zamites* belong to a tribe particularly characteristic, by its abundance and variety, of the liassic and oolitic groups, though not peculiar to them. In the triassic group it seems to occur more sparingly, two species only being enumerated by Unger from the Grès bigarré, and three from the Keuper.

Of the plants which occur less plentifully in the Richmond coal-formation, the most interesting in a geological point of view is the *Pecopteris Whitbiensis*, since it is one of the species most common in our Yorkshire oolites, and, as far as I am aware, has been discovered in no other formation. The new species of Ferns here described afford us no information on this head, inasmuch as, both for the reason given above, and because the principal genera of fossil Ferns are altogether

* For example:—*Pteris aquilina* in Europe, *Pteris caudata* in the West Indies, *Pteris arachnoidea* in Brazil, *Pteris esculenta* in the South Sea islands.

artificial assemblages, I consider *generic* identity in that tribe of plants as perfectly unimportant with reference to geology.

Of the fossils noticed in this memoir, the obscure impressions numbered 12 and 13 are those which bear most resemblance to forms of the true carboniferous system; but I think it quite unsafe to draw any conclusion from specimens so imperfect. The stem numbered 14, if it were, as I conjecture, a part of a Conifer, is as likely to have belonged to the triassic series (in which Conifers are numerous) as to any other.

On the whole, then, as far as the evidence from vegetable remains is concerned, we may say with tolerable confidence that the Richmond coal-field belongs either to the triassic or to the jurassic series; and it might be referred with almost equal plausibility to either. At any rate, there can hardly be a doubt that it is of later date than the true coal-measures. All over the continent of North America, from Nova Scotia to Alabama, wherever the great carboniferous system has been examined, it has been found to be characterized by a most remarkable similarity, and almost a uniformity, in its vegetable productions. Here, on the other hand, we find an assemblage of plants, of which all that occur in a determinable or intelligible state differ essentially from those of the carboniferous system, and of which some are identical with, and others closely resemble, European fossils of the secondary series.

DESCRIPTION OF THE PLATES.

Plate X.

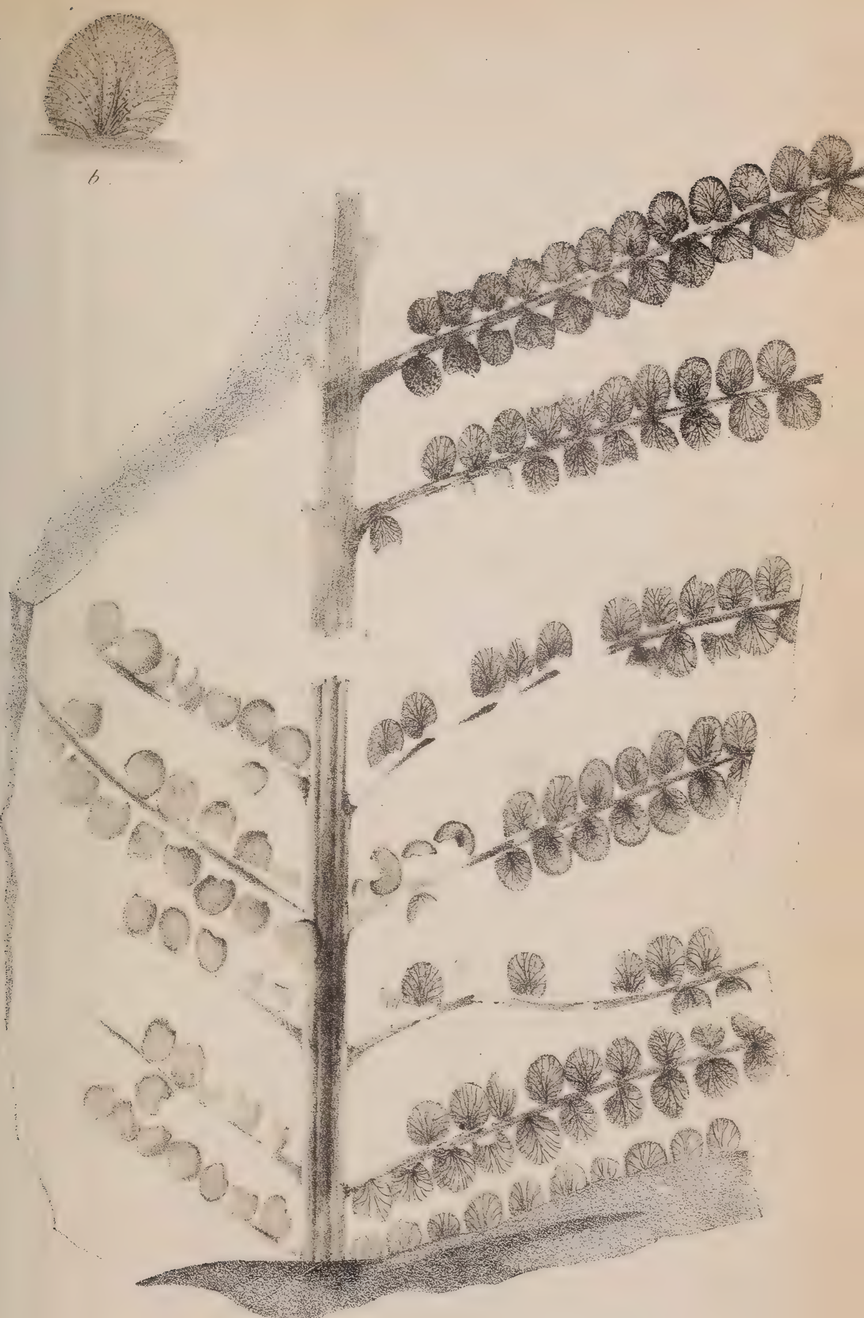
Neuropteris linnææfolia.

b. A single leaflet, slightly magnified.

Plate XI.

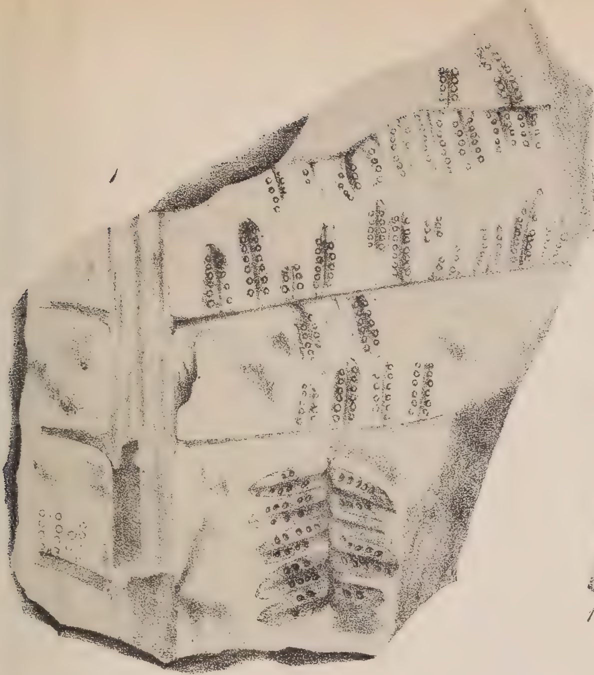
Fig. 1. *Pecopteris bullata.*
1 *a.* A single leaflet, upper side, slightly magnified.
1 *b.* Some of the pustular elevations occasioned by the fructification, magnified.
1 *c.* A leaflet, lower side, slightly magnified.

Fig. 2. *Filicites fimbriatus.*
2 *a.* A portion slightly magnified.



Neuropteris linnææfolia

C. J. Bunbury, del. Reeve, imp.

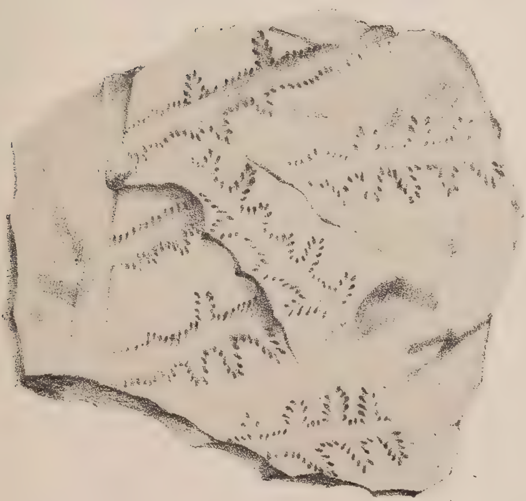


1 c.

1 a.

1 b.

Pecopteris bullata.



2 a.

Filicites fimbriatus.

C. J. Bunbury, del. Reeve, imp.

[Quarterly Journal of Geol. Soc. Vol. III, No. 11, p. 289.]

STRATIGRAPHICAL SECTION, FROM ATHERFIELD POINT TO BLACK-GANG-CHINE, IN THE ISLE OF WIGHT.

BY WILLIAM HENRY FITTON, M.D., F.R.S., &c.

OUTLINE OF THE COAST, FROM TRIGONOMETRICAL SURVEY, BY CAPTAIN L. L. BOSCAWEN IBBETSON, F.G.S., &c.

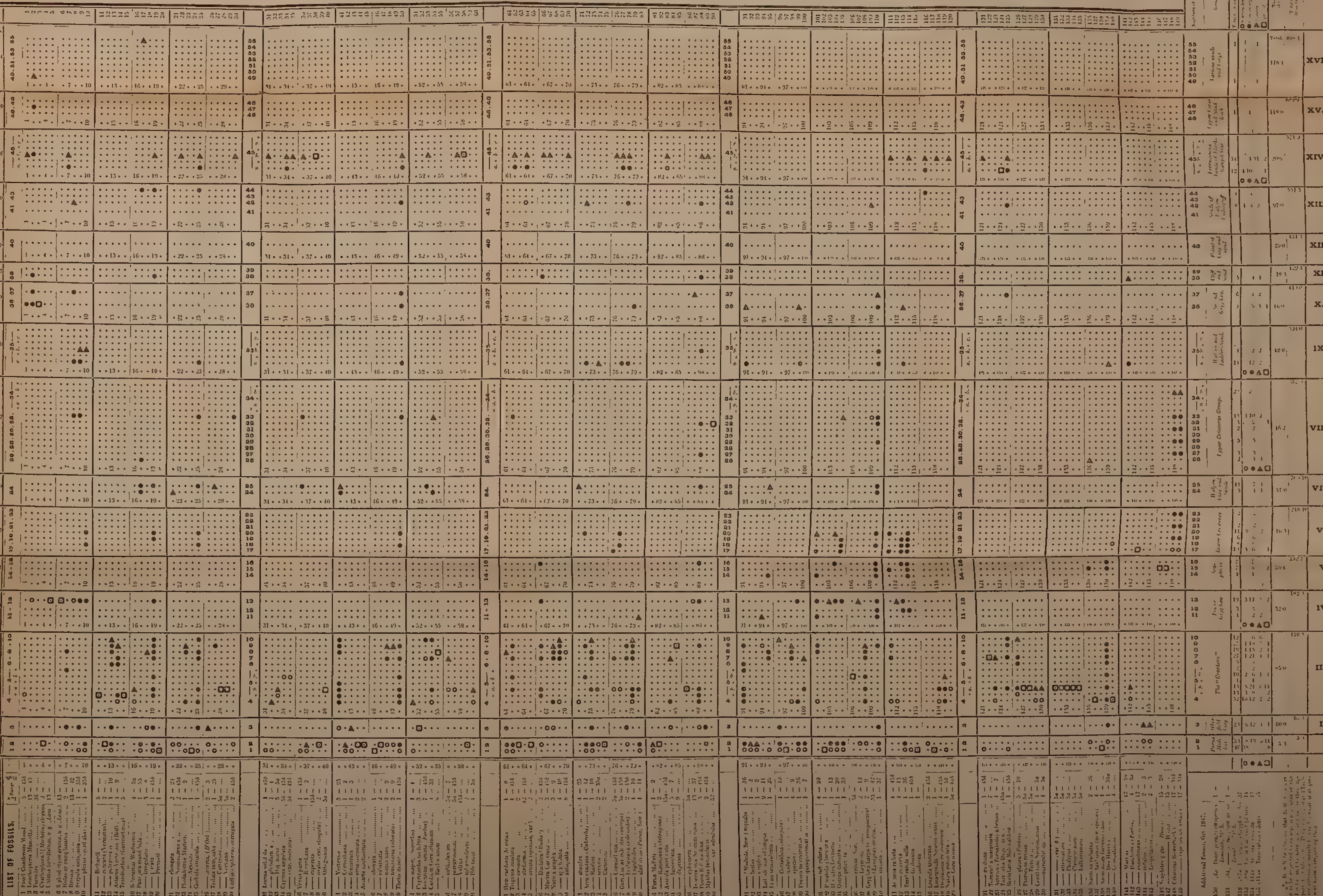
Order of Deposits on the South Coast of the Isle of Wight.

- **E.** LOWER (marly) CHALK.
- **D.** UPPER GREENSAND.
- **C.** GAULT; with characteristic fossils.
- **B.** LOWER GREENSAND.

GROUPS AND STRATA				Approximate thickness ft. in.	ft. in.
XVI.	Various sands and clays.	55	Ferruginous clay and sand...	10 0	118 4
		54	Grey sand and clay	19 0	
		53	Thin beds of sand and clay	28 0	
		52	4th sandrock; white	3 6	
		51	Dark clay and sand	21 6	
		50	White and yellowish sand and clay	22 4	
		49	3rd sandrock	11 0	
XV.	Upper Clays and Sand-rock.	48	Clay	60 0	118 0
		47	2nd sandrock	18 0	
		46	Clay	40 0	
XIV.	Ferruginous bands of Black-Gang-Chine.	45 e	Fossiliferous sand, and concretions.		20 6
		c	Third band of concretions	1 6	
			Sand	5 0	
		b	Second band of concretions	2 0	
			Sand	7 0	
		a	Lowest fossiliferous bands	5 0	
XIII.	Sands of Walpen Undercliff.	44	Sand with thin beds of clay	12 0	97 0
		43	Sand with brown iron ore	7 0	
		42	Greenish and brown sand, traces of fossils	69 6	
		41	1st or Lowest sandrock; white sand with thin layers of clay	8 6	
XII.	Foliated Clay and sand.	40	Dark foliated clay; alternating with sand, and masses of coarse ferruginous conglomerate.	25 0	25 0
XI.	Cliff end Sands.	39	Sand, with ramified concretions		19 3
		38	Light greenish sand		
X.	Second Gryphæa.	37	Greenish sand with *Gryphæa sinuata* and *Lonchopteris*	3 6	16 0
		36	Second Gryphæa Group, *Gryphæa sinuata*, in three or four beds	12 6	
IX.	Walpen and Ladder Sands.	35 e	Grey and brown sand	14 0	42 0
		c	Small Nodules, *Ammonites*, &c.		
			Sand	19 0	
		b	Serpulæ in masses, with *Terebratula*		
			Sand	6 5	
		a	Large Nodules, with numerous fossils	2 6	
VIII.	Upper Crioceras Group.	34	Sand	12 9	46 2
		b	Small Nodules, containing *Crioceras*		
			Sand		
		a	Small Nodules with *Ammonites*		
			Sand		
		33	Eighth Crioceras range		
		32	Sand		
		31	Seventh Crioceras range	16 5	
		30	Sand		
		29	Sixth Crioceras range		
		28	Sand		
		27	Fifth Crioceras range, with other fossils		
		26	Greenish sand	17 0	
VII.	Walpen Clay and Sands.	25	Brown clay, fossiliferous	33 0	57 0
		24	Sand	24 0	
VI.	Lower Crioceras.	23	Fourth Crioceras range...		16 3
		22	Sand	6 6	
		21	Third Crioceras range		
		20	Sand	2 9	
		19	Second Crioceras range		
		18	Sand	7 0	
		17	First (or lowest) Crioceras range ...		
V.	Scaphites.	16	Greenish sand	27 10	50 4
		15	Large Nodules, enclosing *Scaphites*	2 0	
		14	Brown sand, fossiliferous	20 6	
IV.	Lower Gryphæa.	13	Beds of *Gryphæa sinuata*, with oolitic iron ore	10 0	32 0
		12	*Terebratula sella* in great number	2 0	
		11	Brown and yellow sand	20 0	
III.	The "Crackers."	10	Brown clay, fossiliferous 6 ft. 0 in.	40 0	85 0
		9	Sandy clay, with Astacoids 6 0		
		8	Clay 1 6		
		7	Sandy clay, with fossils 7 0		
		6	Clay, with Astacoids, &c. 17 0		
			Sand 7 6	19 6	
		5 b	Upper range of *Nodules*		
			Sand 6 6		
		a	Lower range of *Nodules*		
			Sand 5 6		
		4	Brown clay and sand, with numerous fossils, Astacus, &c.	25 6	
II.	Atherfield Clay.	3	Pale brown and grey clay, like Fuller's earth		60 0
I.	Perna Mud-bed.	2	Upper Perna bed	2 6	5 3
		1	Lower Perna bed	2 9	

Total thickness from the Gault = 808 feet.

DISTRIBUTION OF THE FOSSILS AT PRESENT KNOWN IN THIS SECTION OF THE LOWER GREENSAND.—OCTOBER 1847.



A. THE WEALDEN.

Various species of Cyclas, Paludina, Cypris, and other fossils of freshwater;—Saurians, Pterodactyles.

EXPLANATORY NOTE.

To facilitate reference, the numbers of the Strata and of the List of Fossils (which are in different type), are frequently repeated; and in two positions,—so as to be legible both on the lines of the strata, and of the fossils.

The marks indicating the distribution of the species, are explained in the last columns on the right of the Table.

(Printed by R. and J. E. Taylor, Red Lion Court.)

PROCEEDINGS,

ETC.

POSTPONED PAPERS.

A Stratigraphical Account of the Section from Atherfield *to* Rocken End, *on the South-west coast of the* Isle of Wight. By William Henry Fitton, M.D. &c.

[Read January 22, 1845*.]

[The following paper was ordered to be printed in the Quarto Transactions, but circumstances having retarded the publications of the Geological Society in that form, it is inserted in this Journal at the special request of the author.]

The remarkable section which is the subject of the following pages had been described in papers which I published in 1824 and 1833†, with such lists of the fossils as I could then supply; but the great attention which the corresponding portion of the strata beneath the chalk has of late years excited, under the name of *Terrain Néocomien*, made me wish to examine the place anew, and to obtain a more adequate collection. Having made some progress, I employed a very active collector of specimens during the last year, and was about to return to the Island to continue my work, when I found that I should interfere with the operations which Captain Ibbetson had then begun for the purpose of extending his well-known model of the "Back" of the Isle of Wight, to Atherfield. My task has been since concluded, and I now lay the result before this Society.

It is necessary to mention here, that the collection of specimens upon this coast is impracticable without able assistance; so that it is only by residence, or frequent visits, and the aid of a quarryman, that a collection fairly representing the contents of the strata can be obtained‡. Until experience convinced me of this difficulty, I was disappointed by finding that so few additions had been made to my lists

* The interval between the reading and the publication of this paper has furnished several additions to my collection of fossils, and enabled me to go again to the coast accompanied by Mr. Morris, with whom I had the satisfaction of examining the sections at *Compton Bay* and *Atherfield*, having previously seen that between *Sandown* and *Culvercliff*. The publication also of Captain Ibbetson's and Mr. Edward Forbes's papers ('Geological Proceedings,' vol. iv. and 'Journal,' vol. i., and 'Reports of the British Association for 1844,' p. 43) gave me the benefit of their valuable observations, especially in an examination of the coast near Shanklin. The additions to the original paper now include a review of all the sections of the lower greensand in the Isle of Wight, with such other information as the author has obtained up to the present time.—(*June* 1847.)

† Thomson's Annals of Philosophy for 1824, vol. viii. Geol. Trans. 2nd Series, vol. iv. p. 103, &c.

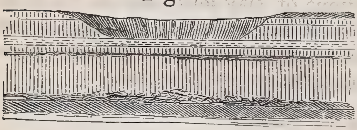
‡ My collector and guide was Charles Wheeler, now resident at Ventnor, to whose skill, both in detecting and extracting fossils, I am largely indebted.

of fossils, published many years before* ; and though my present collection, from the time and labour employed upon it, is probably the most complete that has yet been made, there still are several unexplored chasms, from which new additions may be expected.

The drawing which accompanies this paper represents a vertical surface parallel to the face of the cliffs and following their inflections. It has no pretension to metrical exactness; my principal object having been to illustrate the distribution of the fossils. The horizontal distances in the sketch are, from the construction, often erroneous; and for the thickness of the beds, I contented myself with such an approximation as could be obtained without the use of the level†.

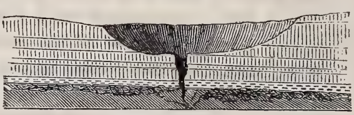
'*Chines*' *and* '*Undercliffs.*'—The strata upon this part of the coast rise uniformly, at an angle of about 2° to the horizon. The only irregularities by which the cliffs are varied, are called in the Isle of Wight, "Chines and Undercliffs," which are well described in the excellent work of Sir Henry Englefield and Mr. Webster‡; the word "*Chine*" signifying those great fissures on the shore, which are produced by the action of water in the beds of sand and clay, here unsupported by solid strata; so that when a spring or torrent has once formed a channel, it soon cuts down to the shore, as in *Walpen* and *Whale Chines*. In *Black-Gang Chine*, the process has been interrupted by a firm group of ferruginous beds, which crosses the streamlet, and has given origin to a cascade; and the continuation of these same bands has stopped the progress of other chasms (fig. 1) between Black-Gang and Walpen Chines, in one of which the clay has been entirely carried away, and a large surface of the ferruginous beds exposed in a solid floor. In *Ladder Chine* the lower part of the chasm is reduced to a narrow fissure, and finally closed before it reaches the shore, by the firmness of a group including nodules in great numbers, above which the sand is swept out in the form of a great bowl. The subjoined figures illustrate these modifications of the chine:—

Fig. 1.



Remote Cliff near Walpen High.

Fig. 2.



Ladder Chine.

* A collection, including some very fine specimens from the south coast of the Isle of Wight, has been some years exhibited at the Polytechnic Institution, placed there very liberally by Captain Ibbetson, to whom I am indebted for the freest access to its contents; but no description has been published.

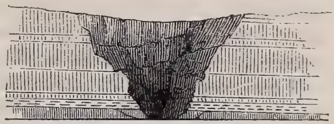
† The distances were measured with an ordinary rope of 300 feet, subdivided and checked by frequent comparison with a fixed standard in a level field. For the heights and thicknesses I used a light measuring-rod of 20 feet in four divisions, which I found very convenient in practice.

‡ 'A Description, &c. of the Isle of Wight,' 4to, 1816.

Fig. 3.

Black-Gang Chine.

Fig. 4.



Whale and Walpen Chines.

Undercliffs.—The picturesque scenery at the back of the Isle of Wight, emphatically called "the Undercliff," is a most striking example of the structure, or rather destruction, produced by the alternation of solid or permeable strata with others more retentive of moisture. In the present section, some cases occur of less prominence, but not undeserving of notice. Looking eastward, from the top of the cliff, near Atherfield, towards Rocken End, the strata are seen to rise conformably at a very small angle of inclination; but their uniformity is broken by two or three less regular shelves, and these upon examination are found to have been produced by certain retentive beds among the looser strata. The water thus kept up carries off a part of the lower mass, undermining that above; and the result is the production of a shelf or terrace, between two ranges of cliffs, one of them supporting "the Undercliff," the second forming a remoter vertical face behind.

Six or seven of these minor undercliffs formerly existed on the coast between Atherfield and Rocken End, one of which (near Atherfield) has now nearly disappeared. The most remarkable of those which remain is due to a group of clay and retentive sand, in which Captain Ibbetson was the first to discover several species of fossil shells, and which is for the greater part concealed by ruins of the upper strata. The undercliff upon this clay rises nearly at Walpen Chine, ascending westward and crossing Ladder and Whale Chines.

Another marshy undercliff, which comes down to the shore on the east of Cliff-End, has been produced by the fall of the white sand and clay No. 41, a small portion only of which is visible near Walpen High-cliff: and still other alternations of clay and sand in the beds above have cooperated with the Gault in producing the fall of the *upper greensand,* by which enormous masses of that deposit have been brought down, even to the sea-side, at Rocken End.

Divisions of the Section.

The whole series of deposits here consisting of sand and clay, with great uniformity of aspect, the most obvious divisions might be derived from their difference in mineral composition. The list of strata which I have adopted is therefore in some measure arbitrary, and intended chiefly to facilitate reference to this particular section; and I cannot too strongly caution my reader against supposing that similar subdivisions of groups, which in a geological sense are the same, are to be expected in other places, especially when the distances are great. It will presently be seen that within the Isle of Wight itself, the distant portions of continuous beds vary considerably in character:

a much greater diversity is observable between the sections of this island and those of Kent*, and still more remarkable variation in the interior of France.

The following are the divisions which I have adopted in my arrangement of the strata:—

A.—The lowest division, consisting only of two remarkable fossiliferous beds, Nos. 1 and 2, occurs immediately above the Wealden clay. From the abundance of *Perna Mulleti* in both of these beds, a species not found in any other part of the section, I have named this group from that fossil.

B.—The *Atherfield clay*, No. 3, possessing many of the properties of fuller's earth.

C.—Sand and clay, Nos. 4 to 10, including two prominent ranges of fossiliferous nodules (5*a* and 5*b*) which form a projection on the coast called the "Crackers."

D.—A series of sands and sandy clay—green, ferruginous, and brown, comprehending several important groups of fossils, extends from the Crackers group (4) to No. 45, at the top of the cascade of Black-Gang Chine; subdivided chiefly by the fossiliferous clay and sands (24 and 25), which rise on the shore between Whale and Walpen Chines.

It is to this central portion of the section that the term "Greensand" may be emphatically applied, many of the beds being tinged by green silicate of iron; but a large part consists of brown and ferruginous sand mixed with clay, for which "indurated *mud*" is probably the best name. This series is fossiliferous throughout, and is the chief abode of the genus *Gryphæa*, especially *G. sinuata*, a species which, though frequent in the lowest beds 1 and 2, and dispersed also throughout the present division, is here chiefly abundant in two subordinate groups—11, 13, and 36, 37†. The genera *Scaphites* and *Crioceras* are likewise confined to this division, the latter appearing in numerous ranges. A large portion of this part of the series contains oolitic iron in considerable quantity: and remains of *Lonchopteris Mantellii*, a fossil fern hitherto found only in the Wealden group, have been detected by Mr. Morris in so many different places, that it may be regarded as diffused throughout the whole division.

E.—The two great beds of clay, Nos. 46 and 48, the first 60, the latter 40 feet in thickness, form a mass of such importance,—though in this case destitute of fossils,—that I would place them apart with the intermediate bed of sand No. 47, as a separate division, the total thickness of which is not much less than 120 feet.

F.—The uppermost division is composed of sand, frequently white, alternating with some clay, some beds of the former of great thickness, but on this part of the coast containing few fossils, or none. This division extends from the top of the great bed of clay No. 48, to the bottom of the *Gault* above.

* Geol. Soc. Proceedings, vol. iv. p. 396, and Geol. Journal, vol. i. p. 179, &c.

† In the corresponding section on the west of Shanklin, another site of *Gryphæa sinuata* has been discovered by Messrs. Ibbetson and Forbes, in a still higher part of the series, corresponding probably to No. 41 of the section near Atherfield.

Stratigraphical Table of the Fossils.

The fossil contents of the strata composing this section are shown at one view in the *Table* annexed to this paper; the vertical columns on the left hand enumerating the groups and strata, and the list at the bottom the names of the species, in systematic order. The places of the occurrence of the species are marked by the intersection of the strata lines with those connected with their respective numbers; so that it will be easy to ascertain the species in any given stratum: and reciprocally, by reading vertically,—or turning the table and reading across from the specific names, the strata in which any given species has hitherto been found can be obtained. It will be obvious that answers to a great number of questions respecting the numbers and distribution of the fossil remains can be obtained by mere inspection from such a table, which has the advantage of giving results expressing only facts, unbiassed by any mixture of hypothesis. The names of the fossils are principally those of the catalogue of Lower Greensand fossils in the Museum of the Geological Society*; and I am indebted to my friend Mr. Morris, by whom my specimens were named, for a very careful examination of the whole of my collection, and for his valuable observations on some of the species.

Description of the Section.

In the following pages the reader is supposed to pass along the coast from west to east, and to meet the strata as they rise from the level of the sea.

Junction with the Wealden.—Having described in the Geological Society's Proceedings†, the junction between the Wealden and the

* By Prof. Ed. Forbes, Geol. Soc. Quart. Journal, vol. i. pp. 237 and 346, &c.

† Minutes of May 24, 1843, vol. iv. p. 198, &c.—As the account of this place would otherwise be incomplete, I transcribe a part of the paper here referred to, which was published before the commencement of the present 'Journal;'—with a slight addition from a 'Report' printed in the Bulletin of the Geol. Society of France (2nde série, t. i. 458, &c.):—

"The time of the author's late visit to Atherfield was very fortunate. The sea, during severe gales, having previously not only cleared away a great part of the ruin which formerly concealed the base of the cliffs, but having entirely removed the shingle of the beach to a most unusual extent; so that the junction of the Wealden with the lower greensand was distinctly exposed for several hundred yards, while a very large surface of the adjacent strata, washed perfectly clear, was visible at low water on both sides of it.

"The strata composing the section thus beautifully exhibited were the following:—

"*Weald clay*, with the usual characters, which it is not the object of this paper to describe in detail. The very uppermost beds here consist of slaty clay, and contain some characteristic fossils of the Wealden, especially *Cyclas media* and small *Paludinæ*; along with these, at the top of the freshwater strata, were *Cerithia*, probably of a new species, with one or more thin-shelled oysters or *Gryphææ*, in comparatively small number.

"The *contact* exhibits no appearance of violence. Slips in splinters as it were of the Wealden clay, not wholly detached, are surrounded rather than mixed with whitish and grey sand; above these comes a compound of clay (mud) and coarser sand or gravel, of a greenish hue, in which are fragments in great number of the bones and teeth of fishes, chiefly belonging to fresh water; and next the more uniform mass, containing at the very lowest part specimens of marine shells. The *junction* occupies about six or eight inches in vertical thickness, so that it is easy to detach portions not more than a foot thick, composed at the bottom of the Wealincumbent sands at Atherfield, I shall suppose my readers to be acquainted with what is there stated, and also with the general characters of the Wealden and its fossils.

1. The "*Lower Perna Bed*" rises on the shore a few yards east of a point immediately under the signal-staff of the Coast-Guard Station, which is taken as the zero for distances hereafter mentioned eastward. Its thickness is about two feet and a half; it varies in composition from the state of dark blue sandy clay, or mud, to that of greenish sand. It is easily diffused in water, and when exposed to the sea is soon carried away, differing in this respect from the bed immediately above; but when both are dry, and seen together in the face of the cliff, they are scarcely distinguishable. *Perna Mulleti* is found in great numbers in both of these lower beds 1 and 2, and has not yet been found anywhere else. Among the other fossils are beautiful specimens of Thetis, a genus which recurs throughout the series here, from No. 1 up to 45, or perhaps even above the latter number. Large specimens of *Gryphæa sinuata* in single valves, with a strongly marked carina, are found in this lower bed; a proof that the species must have existed for some time during or before its deposition.

The remains of fishes, chiefly teeth and small fragments of bones, are mixed with coarse quartzose gravel at the bottom of this bed; and occurring thus immediately over the Wealden, or even in contact with it, it is not unreasonable to suppose that the fish were killed by the change from fresh water to salt.

Sir Philip Egerton, who has been so good as to examine some of the fragments of teeth and bones which I found here, informs me, that they include remains of the following genera of fishes,—*Lamna, Odontaspis* (a gault species), *Saurocephalus, Hypsodon, Sphenonchus*??, *Hybodus,*—and with these are vertebræ of a fish, and a very small digital phalanx, supposed by Prof. Owen to belong to a Saurian.

2. The "*Upper Perna Bed*" differs from the lower chiefly in compactness and durability, to which qualities the prominence of Atherfield Point may probably be ascribed. It serves as a sort of oblique girder, giving solidity to the whole mass, and in fact is the only continuous bed of stone (if it deserves that name) which exists in this neighbourhood, all the other stony masses being nodular and detached.

The top of this bed rises on the shore about 520 feet east from a point beneath the flag-staff of the Coast-Guard Station*. Its final outcrop is visible in the cliff-top far westward, over the upper beds of the Wealden. It runs out into the sea as a ledge visible at low water, and its continuation at greater depths is well-known to the fishermen, from their catching crabs upon it. This prolongation is called "the *Bench*," and has been traced by land-marks to a distance of

den clay with its freshwater shells, and above containing *Perna Mulleti, Gryphæa sinuata, Panopæa,*" &c.

[In a late visit to this place, I found all the coast covered with ruin, the contact entirely concealed, and the strata distinguishable only in a few detached points.—*Sept.* 1844.]

* The concealment of the strata during all my subsequent visits to the coast prevented my verifying this distance, of which I have some doubt.

several miles from the shore, at depths from thirteen to fourteen fathoms. "The Bench," however, is not quite continuous, but after occasional breaks is found to recur in nearly the same direction, curving towards the west at some distance from the land.

The fossils of these two lower beds are so very remarkable, both as to character and number, that I have placed them in a group apart; and it is not improbable that in other places this portion of the section may be of much greater thickness. The clay above is comparatively much less fossiliferous; and nothing certainly can be more striking to the eye of a geologist than this sudden influx, as it were, of nearly a hundred new species (for that number at least has been found in the two Perna beds) immediately over, and so connected with the great freshwater deposit beneath.

The number and size of *Gryphæa sinuata* in the bed is very remarkable; some of the specimens are enormously thick, and hollow, almost chambered, by a separation of the plates.

Fossils of the Lower Perna Bed.—No. 1.

[The asterisks prefixed to the names in the following lists denote that the species so marked occur for the first time.

The mark † denotes that the species has not been found in any higher stratum of the series.]

*Panopæa plicata, *Sow.*
†*—— Prevostii, *d'Orb.*
*—— mandibula?, *Sow.*
*Pholadomya Martini, *Forbes.*
†*—— Agassizi, *d'Orb.*
*Tellina —— ?
*Astarte obovata (*A. Beaumontii*, Leym.).
*Corbula striatula, *Sow.*
*Hemicardium Austeni, *Forbes.*
*Trigonia caudata, *Agass.*
*Arca exaltata, *Nilsson* (*A. Gabrielis*, Leym.).
*—— Raulini, *d'Orb.*
*Lucina solidula, *Forbes.*
*—— globiformis, *Leym.*
*Mytilus simplex, *Desh.*
*—— æqualis, *d'Orb.* (*Modiola*, Sow.)
*—— bellus, *d'Orb.*
*Venus parva, *Sow.*
*—— fenestrata, *Forbes.*
*—— Ricordiana, *d'Orb.*
*—— Cornueliana, *d'Orb.*
*Thetis minor (*T. Sowerbii* of Forbes's list).
*—— major (*T. Sowerbii*, var. of Forbes).
*Perna Mulleti, *Leym.*
*Gervillia alæformis (*Perna*, Sow.).
†*Lima undata, *Leym.*
—— semisulcata.
*—— Cottaldina, *d'Orb.* (*elongata*, Sow.)
†*Plicatula placunæa.
*Ostrea prionota, *Goldf.*
*—— carinata.
*—— retusa.
*Gryphæa sinuata, *Sow.*
*—— lævigata, *Sow.* (*G. sinuata*, var.)
*Hinnites Leymerii, *Desh.*
*Pecten quinquecostatus ‡, var., *Sow.*
*—— interstriatus, *Leym.*
*Terebratula sella, *Sow.*
*—— Gibbsiana, *Sow.*
†*—— oblonga.
*Rostellaria Robinaldina, *d'Orb.*
†*Emarginula Neocomiensis, *d'Orb.*
*Natica rotundata?
*—— gaultina.
*Serpula —— ?
*Vermetus polygonalis, *Sow.*
†*Ammonites furcatus, *Sow.*

Fossils of the Upper Perna Bed.—No. 2.

*Panopæa Neocomiensis, *d'Orb.*
—— mandibula, *Sow.*
*—— elongata.
Panopæa plicata, *Sow.*
†*Corbula incerta, *d'Orb.*
Hemicardium Austeni, *Forbes.*

‡ *Pecten quinquecostatus*, var.? The shells from this bed differ somewhat from the *P. quinquecostatus* of the upper cretaceous system, in being longer, and the lateral areas being nearly smooth, and the intermediate ribs sometimes slightly furrowed.—M.

†*Cardium sphæroideum, *Forbes.*
Trigonia caudata, *Agass.*
†*—— ornata, *d'Orb.* (*T. spinosa*, var., Sow.)
†*—— carinata, *Agass.* (*T. harpa*, Leym.)
*—— Dædalea, *Parkinson.*
Arca Raulini.
*—— securis.
—— exaltata, *Nilsson.*
†*—— Carteroni, *d'Orb.*
†*Astarte multistriata.
†*—— substriata, *Leym.*
*—— numismalis ?, *d'Orb.*
*Corbis corrugata, *d'Orb.* (*Sphæra*, Sow.)
†*Venus striato-costata, *Forbes.*
†—— Ricordiana, *d'Orb.*
†—— Cornueliana, *d'Orb.*
†*—— ovalis, var. elongata.
Thetis minor, *Sow.*
†Mytilus simplex, *Desh.*
*—— lanceolatus, *Sow.*
†—— bellus.
†Perna Mulleti, *Leym.*
†*—— Ricordiana, *d'Orb.*
†*Serpula (Vermetus) concava.
Gervillia alæformis (*Perna*, Sow.).
*—— Forbesiana, *d'Orb.* (*solenoides*, Forbes.)
*Pinna Robinaldina, *d'Orb.*
*Lima Cottaldina‡, *d'Orb.*
Pecten quinquecostatus, var. ?, *Sow.*
—— interstriatus, *Leym. & d'Orb.*
Ostrea prionota ?, *Goldf.*
—— carinata.
*—— Leymerii, *Desh.*
Hinnites Leymerii, *Desh.*
Gryphæa sinuata, *Sow.*
*—— harpa (*semiplicata*, var.).
Terebratula sella, *Sow.*
*Ammonites furcatus, *Sow.*
—— Deshayesii.
*—— Leopoldinus, *d'Orb.*
*—— inflatus.
*Nautilus radiatus, *Sow.*
*Heteropora —— ?, *Sow.*
*—— ? gracilis.
†*Astræa ? elegans (new species).
*Holaster complanatus (*Spatangus retusus*).

3. *The Atherfield Clay.*—I give this name to the great bed next above the Perna group, in preference to that of "Fuller's *Earth*," (of which this clay has many of the characters,) to prevent its being confounded with the beds well-known in Surrey under the latter name§, but which belong to a much higher part of this series. It is here usually of a drab colour passing into bluish grey, and includes flat nodular masses like the smaller nodules hereafter mentioned in No. 4, which there contain astacoid remains. Among the fossils the most common in the lower portion is *Pinna Robinaldina*, d'Orb. Ammonites are not unfrequent; and the remains of a turtle, now in the cabinet of the Geological Society, were obtained here.

The facility with which such a clay as that above described, melts down under exposure, may readily be imagined. The encroachments of the sea on this part of the coast are rapid and unceasing, but the progress of what is called a "founder" is very gradual‖; unlike that

‡ *Lima Cottaldina*, d'Orb.—The specimens of this fossil, formerly referred to *L. elongata*, appear to be distinct from that figured in the 'Min. Con.' and described by Mr. Sowerby as having sixteen smooth and rounded ribs; whereas in these specimens the ribs are more than twenty, sharp and imbricated by the lines of growth, with an intervening small ridge at the base of each furrow, the sides of which are sometimes striated. From these characters and its general form, it is probably the *L. Cottaldina*, d'Orb. The species is certainly the same as one found in the Kentish quarries.—M.

§ No clay precisely like the true Fuller's earth of Reigate and of Nutfield occurs in the section now under consideration; nor has any such been yet found on the coast near Hythe;—another proof of the want of *exact* identity even in continuous deposits.

‖ During the summer of 1844, a portion of the cliff on the south-west of the Coast-Guard Station, about 150 feet from east to west, and 80 feet on a line at right angles to the shore, was found to be separated from the main land by a narrow crack. The mass thus marked out subsided gradually, the ruins below advancing steadily into the sea; and when I saw the place again a few weeks afterwards, the subjacent Perna beds, which previously formed the point, were of the mural precipices further on to the east, from which great flakes or irregular masses are suddenly separated, covering the shore with ruins, to be carried off with great rapidity by the waves.

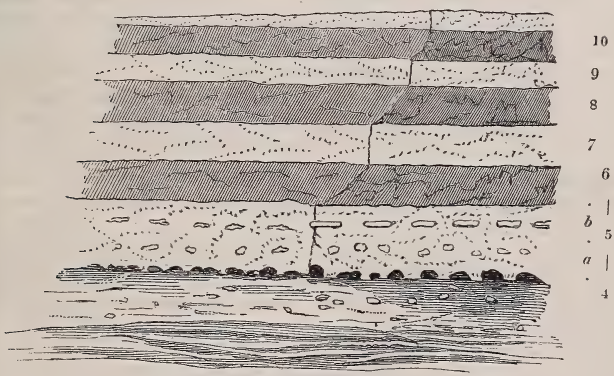
Fossils of the Atherfield Clay.

Panopæa plicata, *Sow.*
†*—— irregularis, *d'Orb.*
†*Cypricardia undulata, *Forbes.*
Mactra Carteroni, *d'Orb.*
Corbula striatula, *Sow.*
—— incerta ?, *d'Orb.*
[The striæ are scarcely visible in the specimens, but the form is the same as in the figure of d'Orbigny.]—M.
Hemicardium Austeni, *Forbes.*
Arca Raulini, *d'Orb.*
*Nucula scapha, *d'Orb.*
*Pinna Robinaldina, *d'Orb.*
†Venus fenestrata, *Forbes.*
*Venus Vectensis, *Forbes.*
*Avicula lanceolata, *Forbes.*
Gervillia Forbesiana, *d'Orb.* (*solenoides*, Forbes.)
Lima Cottaldina, *d'Orb.*
Gryphæa sinuata.
—— var. dorsata, *Leym.*
Ammonites Deshayesii, *Leym.*
*—— furcatus, *Sow.*
†—— inflatus.
Holaster complanatus.
†—— Leopoldinus.
Serpula —— ?
—— (Vermetus) polygonalis, *Sow.*

III.—"*The Crackers.*"—*No.* 4 *to* 10.

This group, which forms a slight prominence on the shore, is sustained by the solid nodules of the sand No. 5, to which the name of "Crackers" has been applied, from the resounding of the waves in the cavities below. It is perhaps the most remarkable portion of the whole section, from the great variety of its fossils. It consists of four beds of clay alternating with others more sandy, the total thickness about 90 feet ; exhibiting an alternation of slopes (or undercliffs) with nearly vertical faces, in fact a "*step* (or trap) *formation*" upon a small scale.

Fig. 5. "*The Crackers*" *Group.*



thrust outwards, cracked or broken throughout, and their fragments pushed up into heaps more than six feet above the general level. The space on the confines of the Wealden and the lower greensand which I had seen in 1843, and described as beautifully disclosing their junction, was thus entirely concealed ; while the base of the cliff eastward was uncovered, and the relations of the "Crackers" group much more clearly visible than before.—*August* 1844.

All the clays approach in character to Fuller's earth, and the sand between the nodular concretions in the lower bed (5) is sometimes indurated into a very imperfect stone.

4. This was called by my collector "the lower Lobster bed," from the astacoid remains which abound in it. It seems to be a mixture of sand with clay, like that of No. 3, at the bottom of a brownish hue, but above inclining to blue. The fossils of this bed, mentioned in the following list, occur in thin clots or clusters, often without any covering or crust, as if they had been just left upon a sand-bank at the bottom of the sea. Calcareous casts of Ammonites, chiefly *A. Deshayesii*, are frequent.

5. The complex bed (5) consists of coarse grey or brown sand, about 20 feet in total thickness, in which large concreted masses are imbedded, in two ranges (5*a* and 5*b*), composed of indurated calciferous sand-rock, abounding in fossils. The sand itself is also fossiliferous: it has furnished some clusters of Pinna, and above the upper nodules (*b*), contains fine specimens of Thetis, with a large Astacus (probably a distinct species) and small casts of *Ammonites Deshayesii* in pyrites. In the lower part, great numbers of Panopæa are found in it standing obliquely upwards.

5 *a*.—Of the lower nodules some are 6 or 7 feet long, and a foot to 18 inches in thickness, and almost composed of *Gervillia anceps* (*aviculoides*), with *Trigonia Dædalea*, *Ammonites Deshayesii*, &c. Other smaller masses contain nuclei of small agglomerated shells, commonly enveloped in a stony crust two or three inches thick; and these have been remarkably fertile in new species, many of which are not repeated in other parts of this section.

5 *b*.—The upper nodules (5*b*), about a foot below the top of the sand, consist of coarse sandy limestone or grit, including fossil coniferous wood, eroded by Teredolithes. I counted thirty-two of these masses in 100 paces, on a line descending from the cliffs to low-water mark; they were from three to five feet long, and about two feet thick, but very irregular in form and dimensions.

6–10. The beds above the "Crackers" are altogether about 40 feet thick. They consist of clay mixed with sand, which in 7 and 9 is in very large proportion; they are all fossiliferous, and the fossils throughout nearly the same. 6. The lowest bed is a brown clay, between 16 and 17 feet thick, including small nodules with astacoid remains and other fossils, in excellent preservation†. 7. Grey sand. 8. Brown clay, containing moulds of *Panopæa* (*Mya*) *mandibula* and smaller shells. 9. Grey sand with Astacoids. 10. Brownish plastic clay, containing numerous fossils. This bed once formed an undercliff of some extent, but only a slight rugged prominence is now left, which is rapidly disappearing.

† Professor Thomas Bell, into whose hands I put these crustaceans, has read a description of them before the Geological Society, to which I refer.

Fossils of the "Crackers" Group ‡.

No. 4. Clay and Sand.

Pholadomya Martini, *Forbes.*
Corbula striatula, *Sow.*
*Nucula simplex, *Desh.*
*—— spathulata, *Forbes.*
—— scapha, *d'Orb.*
Mytilus æqualis, *Sow.*
Pinna Robinaldina, *d'Orb.*
Venus Vectensis, *Forbes.*
Avicula lanceolata, *Forbes.*
*Gervillia linguloides, *Forbes.*
Gryphæa harpa, *Goldf.*
*Pecten orbicularis??
*Lima ——?
Anomia lævigata, *Desh.*
*—— convexa.
Ammonites Deshayesii, *Leym.*
†*—— Cornuelianus, *d'Orb.*
*—— Hambrovii, *Forbes.*
*Astacus Vectensis.

In the Concretions of No. 4.

*Solecurtus Warburtoni, *Forbes.*
*Cardium Cornuelianum, *d'Orb.*
*—— Ibbetsoni, *Forbes.*
Nucula scapha, *d'Orb.*
Mytilus æqualis, *Sow.*
†Lucina globiformis, *Leym.*
Venus Vectensis, *Forbes.*
*Pecten interstriatus, *Leym. & d'Orb.*
*Anomia radiata, *Sow.*
*—— convexa.
*Actæon Albensis, *d'Orb.* (*Tornatella albensis.*)
Natica rotundata, *Forbes.*
*Cerithium Neocomiense.
*—— turriculatum.
*Dentalium cylindricum.
Ammonites Deshayesii, *Leym.*
*—— Cornuelianus, *d'Orb.*
*—— Hambrovii, *Forbes.*
—— furcatus, *Sow.*

No. 5. Sand including the Nodules 5 a and 5 b.

Panopæa plicata.
*Lucina Dupiniana, *d'Orb.*
Thetis minor.
Venus Vectensis, *Forbes.*
Trigonia rudis § (*Dædalea*).
Gervillia linguloides, *Forbes.*
Mytilus æqualis.
*Rostellaria glabra, *Forbes.*
Pinna Robinaldina, *d'Orb.*
†*Serpula Richardi, *Leym.*
Astacus Vectensis, *Bell?*
*Teredolithes (Gastrochæna).

No. 5 a. Lower Nodules.

Panopæa plicata, *Sow.*
†Solecurtus Warburtoni, *Forbes.*
Corbula striatula, *Sow.*
†*Tellina Carteroni, *d'Orb.* (*T. angulata*, Desh.)
†*—— Vectiana, *Forbes.*
†Cardium Ibbetsoni, *Forbes.*
—— Cornuelianum, *d'Orb.*
*—— subhillanum, *d'Orb.*
*—— peregrinosum, *d'Orb.*
Arca Raulini, *d'Orb.*
—— securis.
*—— Cornueliana, *d'Orb.*
Trigonia caudata.
†*Lucina Dupiniana, *d'Orb.*
Pinna Robinaldina, *d'Orb.*
†*Venus Orbigniana, *Forbes.*
—— Vectensis, *Forbes.*
Thetis minor, *Sow.*
†*Avicula ephemera, *Forbes.*
*Gervillia anceps, *Desh.* (*aviculoides*, Sow.)
—— linguloides, *Forbes.*
—— alæformis (*Perna*, Sow.).
Mytilus æqualis.
Pecten quinquecostatus.
Gryphæa harpa, *Goldf.* (*subplicata*, Roemer.)
Rostellaria glabra, *Forbes.*
†*Pterocera Fittoni, *Forbes.*

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‡ I have endeavoured to keep apart the specimens found in each of the beds belonging to this group. But some of the species occur in all of them; those especially of No. 4 and 5 *a* are very nearly the same.

§ There is some difficulty in defining this species from the mere fragment figured by Parkinson: the specimens have been identified by M. d'Orbigny with his *T. rudis*, of which the *T. nodosa*, Sow., is probably but a variety; but it is certainly distinct from *T. spectabilis*, Sow., which is considered identical by M. d'Orbigny. In comparing the Isle of Wight specimens with the true *T. Dædalea* of Blackdown, there is much less difference between them, than between the same Blackdown species and the *T. Dædalea* figured in the 'Palæontologie Française.'—M.

†*Pterocera retusa‡ (*Rostellaria*), *Sow.* [Geol. Trs. 2nd Ser. iv. pl. 18, f. 22].
†*Cerithium Lallierianum, *d'Orb.*
†* —— turriculatum.
†* —— —— (var. β).
†* —— Neocomiense.
†* —— attenuatum.
†* —— Phillipsii.
†* —— Clementinum.
Dentalium cylindricum, *Sow.*
†Actæon albensis, *d'Orb.* (*Tornatella*, Forbes.)
Natica rotundata.
* —— Cornueliana, *d'Orb.*
*Rostellaria Robinaldina, *d'Orb.*
—— glabra, *Forbes.*
Ammonites Deshayesii, *Leym.*
† —— Hambrovii, *Forbes.*

No. 5 b. Upper Range of Nodules.

Panopæa plicata, *Sow.*
Arca exaltata, *Nilss.*
Thetis minor, *Sow.*
†Natica rotundata.
Trigonia caudata.
*Cyprina angulata.
*Cyprina angulata.
* —— —— (var. *rostrata*, Sow.).
†Ostrea retusa, *Sow.*
Ammonites Deshayesii, *Leym.*
*Holaster complanatus (*Spatangus retusus*).

No. 6. Clay.

Astacoid remains, remarkably well-preserved.
Modiola æqualis, *Sow.*
Rostellaria glabra.
Vermetus polygonalis.
Serpula (*Vermetus*).
Ammonites Deshayesii.

No. 7. Sandy Clay.

Panopæa plicata, *Sow.*
Corbula striatula, *Sow.*
*Isocardia ornata, *Forbes.*
*†Cardium Cornuelianum.
† —— subhillanum.
*Actæon albensis ?, *d'Orb.*
Rostellaria Robinaldina, *d'Orb.*
—— glabra, *Forbes.*
Astarte numismalis.
Trigonia caudata, *Agass.*
—— rudis (Dædalea), *d'Orb.*
Arca Raulini, *d'Orb.*
—— Cornueliana.
Nucula scapha, *d'Orb.*
*Nucula spathulata, *Forbes.*
*Ammonites Deshayesii, *Leym.*
*Thetis minor, *Sow.*
*Gervillia linguloides, *Forbes.*
—— Forbesiana, *d'Orb.* (*solenoides.*)
†Pecten quinquecostatus.
Astacus (portions of).
†Avicula lanceolata, *Forbes.*
Lima semisulcata.
—— (species).
Gryphæa semiplicata ?, *Roemer.*
Anomia radiata.
†*Tornatella marginata.

No. 8. Clay.

Panopæa plicata, *Sow.*
—— irregularis.
Corbula striatula, *Sow.*
†Hemicardium Austeni, *Forbes.*
Arca Raulini, *d'Orb.*
Nucula antiquata ?, *Sow.*
* —— scapha, *d'Orb.*
—— spathulata, *Forbes.*
Venus Vectensis, *Forbes.*
*Cardium Raulinianum ?
Gervillia linguloides, *Forbes.*
Lima —— ?
†Pholadomya Martini.
Pecten orbicularis, *Sow.*
Gryphæa harpa, *Goldf.*
Ammonites Deshayesii.
Vermetus polygonalis.
Holaster complanatus.
Serpula polygonalis.

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‡ The specimens referred to this species differ somewhat from the *P. bicarinata*, in the absence of the peculiar gibbosity on the body whorl and the spreading over or encrusting of the columella, and in having only two instead of three intermediate ribs (see d'Orb. fig. of *P. bicarinata*) between the larger carinæ on the last volution. It is very distinct from *P. retusa*, Sow., by the more elongated form, and the less number of smaller costæ which occur on the upper and lower part of each volution. *P. bicarinata* is quoted as from the Gault of Ervy, &c.—M.

No. 9. Sandy Clay.

Panopæa plicata, *Sow.*
†Pholadomya Martini, *Forbes.*
Tellina —— ? (*inæqualis* ?)
†Gryphæa harpa, *Goldf.*
—— sinuata, *Sow.*
Anomia radiata, *Sow.*
*Avicula depressa?, *Forbes.*
Rostellaria Robinaldina ?, *d'Orb.*
Vermetus polygonalis, *Sow.*
†Astarte numismalis, *d'Orb.*
—— transversa (*obovata*).
Arca exaltata ? (young), *Leym.*
†Nucula scapha, *d'Orb.*
Nucula spathulata, *Forbes.*
Trigonia rudis, *d'Orb.*
—— caudata, *Agass.*
†Astacus Vectensis.
Mytilus æqualis, *Sow.*
Pinna Robinaldina, *d'Orb.*
Venus Vectensis, *Forbes.*
Thetis minor, *Sow.*
Gervillia Forbesiana, *d'Orb.*
—— linguloides, *Forbes.*
†Lima (species).
Pecten orbicularis, *Sow.*
Ammonites Deshayesii, *Leym.*

No. 10. Clay. Uppermost Bed of the Crackers Group.

Panopæa plicata, *Sow.*
Corbula striatula, *Sow.*
Cardium Cornuelianum, *d'Orb.*
Isocardia ornata, *Forbes.*
†Arca Raulini.
†Nucula spathulata, *Forbes.*
Venus Vectensis, *Forbes.*
†Gervillia linguloides, *Forbes.*
†Lima Cottaldina, *d'Orb.* (*elongata*, Sow.)
Rostellaria Robinaldina, *d'Orb.*
†—— glabra, *Forbes.*
†Serpula (Vermetus) polygonalis, *Sow.*

Groups IV. to XIII. Nos. 11 to 45.—This central portion of the series consists of green and brownish sands, alternating with clay, one group of which, about the middle (Nos. 24 and 25), deserves especial notice. All the beds are fossiliferous; many of them including nodules, containing as a nucleus, masses of shells, or sometimes a single Crioceras or Ammonite of great size. The uppermost beds of this division contain many of the same species as the very lowest group 1 and 2, in this respect differing much from the sandy strata immediately above, which on this coast have afforded scarcely any fossils. But this great difference is only local.

Two principal groups (IV. and X.) of this division contain *Gryphæa sinuata* in great numbers; the latter being here the upper limit in the range of that species. But scattered shells of Gryphæa appear throughout the lower beds of this section; and near Shanklin two or more additional ranges of Gryphæa have been found by Captain Ibbetson and Mr. Forbes, distinctly above the beds which there represent Nos. 36 and 37‡.

Ten or more ranges of nodules also make their appearance here between 17 and 35, containing Crioceras, of which one species only (*C. Bowerbankii*) has been hitherto described; nor have the beds which contain these fossils been yet examined with sufficient attention.

The genus hitherto called Scaphites also occurs in this part of the division, chiefly in No. 15.

The cliffs here are cut through by three Chines (*Whale, Ladder,* and *Walpen Chines*); they are in some places mural, especially between the Crackers and Whale Chine, and on the east of Walpen. Two of the principal heights are *Atherfield High-Cliff,* about 129 feet above its base, and *Brown's Down,* about 169 feet. *Walpen High Cliff,* the chief prominence on the coast west of Black-Gang Chine, is about 184 feet above its base on the sea-shore.

‡ Report of British Association, 1844. See hereafter, p. 317–318.

IV. *Lower Gryphæa Group* (*Nos.* 11, 12 *and* 13).

11. The bed immediately above the "Crackers Group" consists of brown or rust-coloured sand, with indications of fossiliferous nodules at the bottom. Thickness about 21 feet.

12. *Terebratula bed*: next is a stratum 2 feet in its greatest thickness, of sand containing *Perna alæformis*, with *Terebratula Sella* in profusion. This latter species has been found also near the bottom of this section in the second Perna bed,—above in No. 45, and in several intermediate places, thus pervading the whole series of fossiliferous strata; but it is nowhere so numerous as here.

13. *The Lower Gryphæa bed*, which is conspicuous on the shore under Atherfield High Cliff, is about 10 feet thick, 7 or 8 feet at the lower part consisting of brown and reddish sand and sand-rock, with polished fragments of brown iron ore; above which are ranges of *Gryphæa sinuata*. In the coarse sand at the bottom, *Pinna Robinaldina* (d'Orbigny) is frequent; and in the fallen masses on the shore the brown iron ore is distinctly oolitic—a form of iron ore which has not hitherto been recognized in the Lower Greensand of England‡. But the ferriferous beds of this formation in Surrey and Sussex so much resemble these, that the presence of oolitic grains among them is highly probable.

In the larger fallen masses on the shore here, are fine specimens of *Hinnites Leymerii*, with *Ostrea Leymerii* in one or two continuous ranges, and indications of perhaps two other species of Ostrea, one remarkable for the thinness of the shell. Very large specimens of *Gryphæa sinuata* with a strongly marked dorsal ridge are frequent.

Fossils of the Lower Gryphæa Group. (*Nos.* 11, 12, 13.)

11. †Gervillia alæformis (*Perna*, Sow.).
†Lithodomus oblongus.
Gryphæa sinuata (var. *Couloni*).

12. Terebratula Gibbsiana, var.
—— sella, *Sow.* (in profusion).

13. *Lower Gryphæa Bed.*

*Lonchopteris Mantellii.
†*Cricopora § gracilis.
†Heteropora §.
Brissus.
Panopæa plicata, *Sow.*
Trigonia rudis.
Pinna Robinaldina?, *d'Orb.*
—— sulcifera?, *Leym.*
*Inoceramus Neocomiensis, *d'Orb.* (*concentricus*?, Forbes).
Gryphæa sinuata (many varieties).
†Ostrea Leymerii.
—— carinata?, *Sow.*
—— prionota.
Pecten orbicularis.
—— interstriatus, *d'Orb.*
—— striato-costatus?, *Leym.*
†Hinnites Leymerii.
†Anomia convexa, *Sow.*
Terebratula sella.
Serpula plexus (*gordialis*?, Goldf.).
—— antiquata.

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‡ Oolitic iron ore is abundant also in the Lower Greensand near Vassy in France, where I have seen it under the guidance of M. Cornuel; and apparently throughout the range of this deposit from thence to *Auxerre*.

§ Mr. Lonsdale has informed me since these sheets were sent to the press, that he does not consider the genera of the corals which I had sent to him for examination as having been precisely ascertained; I have therefore added a query to the name of each genus:—and I hope that Mr. Lonsdale's health and leisure will allow him to examine generally the corals of this part of the subcretaceous system at no very distant time.

Groups V. VI. *and* VIII. *Scaphites and Crioceras.*

The only account of these remarkable genera from the lower greensand which has been published being that of Mr. Sowerby (Geol. Trans. 2nd Ser. vol. v. pl. 34), I requested that gentleman to examine the specimens in my collection, and he has favoured me with some remarks upon them*; to which at my request he has added a sketch (upon a scale of $\frac{1}{10}$th of the natural size), that my readers may have before them all the species hitherto found near Atherfield.

Fig. 1.

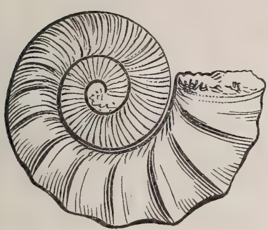


Fig. 2.

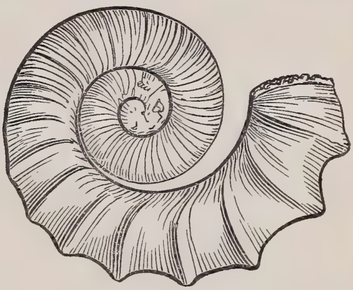
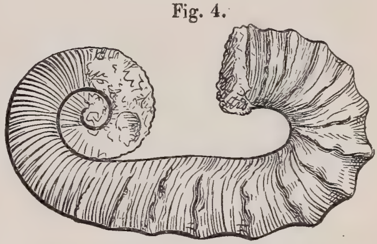


Fig. 3.

Fig. 4.



Figs. 1 and 2, *Crioceratites Bowerbankii*, Sow., of two varieties ; the second differing from that previously published in the greater divergence of its outer whorls.

Fig. 3 is *Scaphites Hillsii* (Geol. Trans. 2nd Ser. iv. pl. 15, fig. 1 and 2).

Fig. 4, *Scaphites gigas* (Geol. Trans. 2nd Ser. v.), *Ancyloceras gigas*, D'Orb. pl. 34, f. 2.

The cliff of sand occupied by these fossils extends upon the shore from the rise of the top of No. 13 to a point about 1300 feet east of

* Mr. Sowerby states, that "the difficulty of arranging these genera arises from the great variation of their characters; the space between the whorls differing much in those which have been called Crioceras—as in fig. 1 and fig. 2—both of which may be referred to *Cr. Bowerbankii*. But since none of the species have a second curvature of the shell, after it becomes straight, it appears to me that this genus ought not to be disturbed. An exception to this character occurs in *Scaphites Hillsii* (fig. 3), which so nearly resembles fig. 1 that Prof. Forbes considers them as of the same species; the only difference being that the ribbed portion of the last whorl (fig. 2 and 3) is, in *S. Hillsii*, produced nearly in a straight line and afterwards incurved. Still it appears to me to be better to retain this species, than by uniting it with *C. Bowerbankii*, to give up one or perhaps both of the links in the chain between Ammonites and Scaphites. Until we know the

Walpen Chine—equivalent to about 120 feet of thickness. I have given in the Table the vertical distances between the several ranges.

VI. *Scaphites Group* (14, 15, 16).

No. 14 is brown and rust-coloured moist sand, above which are large concretions (15), each frequently enclosing a single Scaphite or large Ammonite, as a nucleus, with other smaller fossils. The thickness from the top of 13 to the centre of the nodules is about 18 feet. The sand is itself fossiliferous, and at two or three feet below the Scaphites are agglutinated clusters of *Gryphæa sinuata* of great size, with *G. lævigata* (*G. Couloni*) and *Terebratula Gibbsiana*.

15. *The Scaphites nodules* are about 18 inches to 2 feet in thickness; I found a specimen of *S. gigas* (fig. 4) in one of them; in a second range, at a short distance above, the species proved to be *Scaphites Hillsii* (fig. 3); and a third range, of uncertain species, is said to occur higher up, in Whale's Chine. Large specimens in my own collection of an Ammonite, supposed to be *A. Deshayesii*, were stated to have been found in this bed; one of these is about 15 inches in diameter and 3 inches thick.

16. The interval, about 22 feet, between No. 15 and the first or lowest Crioceras range No. 17, is occupied by dark grey sandy clay or mud, containing near the top fine specimens of *Gryphæa sinuata* with other fossils.

Fossils of the Scaphites Group.

14.	Pecten orbicularis. Gryphæa sinuata, *Sow.* Terebratula Gibbsiana, *Sow.*	Terebratula multiformis ?, *Roemer.* Lima semisulcata ?
15.	Gryphæa sinuata. †*Scaphites gigas. †*—— Hillsii. Anomia radiata.	Nautilus radiatus. Ammonites Deshayesii. —— Mantelli (*d'Orb.* fig. 103, *not* 104)‡.
16.	Gryphæa sinuata. Pinna Robinaldina, *d'Orb.* Ostrea carinata.	Terebratula sella (broad). —— Gibbsiana.

VI. *and* VIII. *Crioceras Ranges.*

The two groups in which the genus *Ancyloceras* of D'Orbigny has hitherto occurred (17 to 23, and 26 to 34) are separated by a thickness of about 50 feet of sands and clay. The number of ranges affording

sexes and economy of the animals of these shells, the characters can be only artificial, and the boundaries arbitrary.

"*Scaphites gigas* (fig. 4 above), (*Hamites gigas* of Min. Con. t. 593. fig. 2) is distinguished by six tubercles on each side, in place of ribs on the straight parts.

"*Hamites grandis* (Min. Con. t. 493. f. 1) has scarcely any ribs—only straight portions being known to me; but it can hardly be confounded with *Ancyloceras Hillsii*: and I presume that it is referred to by Prof. Forbes accidentally—*grandis* very probably being printed for *gigas*."

‡ "This Ammonite is between *A. navicularis* (Mantell, Geol. of Sussex, 198, t. 22. f. 5) and *A. Nutfieldiensis* (Min. Con. t. 108), but nearer to the former;—and quite distinct from *A. Mantellii* of Min. Con. 55, to which D'Orbigny has united it."—(*Mr. Sowerby.*)

the specimens have not exactly been ascertained, but is supposed to be about ten or twelve‡. I have myself seen but few of these *in situ*, but have no reason to doubt the statement of my collector, who pointed out their places. At the top of the sand above-mentioned (16), the first or lowest range of Crioceras rises on the west of Whale's Chine, and is succeeded by two other ranges, all three enclosed in sand about nine feet thick. The lowest range is said to have furnished the finest specimens. The sand around them and above retains impressions such as might have been produced by a mass of vegetable stems which have altogether disappeared, leaving only their compressed moulds in the sand or mud through which they were diffused.

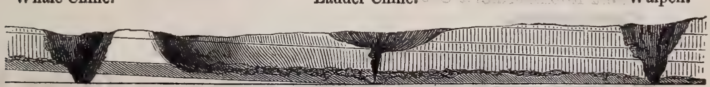
23. A fourth range of nodules crosses the bottom of Whale's Chine, whence all the ranges together decline gradually into the sea.

Fossils of the Crioceras Range 17 *to* 23.

19, 20.	Panopæa plicata, *Sow.*		†Pecten orbicularis ?, *Sow.*
	Arca Gabrielis, *Leym.*	17,18, 19.	†Ostrea prionota, *Goldfuss.*
	(A. exaltata, *Nilsson* ?)		Terebratula Gibbsiana ?, *Sow.*
17.	Anomia radiata.		—— sella, *Sow.*
	Arca Cornueliana ?, *d'Orb.*	20 ?	†Ostrea carinata,
†*	—— consobrinus, *d'Orb.*		Gryphæa sinuata, *Sow.*
18, 20.	Serpula plexus.		Scaphites gigas.
	Corbula striatula, *Sow.*		*Ammonites Martini, *d'Orb.*
	Thetis minor, *Sow.*	17,19, 21,23.	*Crioceras Bowerbankii, *Sow.*
	Gervillia anceps (20), *Desh.*		(*Ancyloceras*, d'Orb.)

Whale's Chine.—The eastern side of this chasm is about 140 feet high, the opening at its upper part about 180 feet wide. The distance from the shore to a bridge over the streamlet which empties itself at the Chine, is about 300 yards; the Crioceras beds, rising gradually inland, are visible in the banks, and would no doubt supply good specimens. The relations of the succeeding beds 24 and 25 are visible within the Chine, where they contain numerous fossils.

Whale Chine. Ladder Chine. Walpen.



It will be observed that the eastern side of Whale Chine stands out somewhat prominently, dividing the undercliff, and rising immediately from the shore to the height of about 140 feet; so that the Chine must have cut through the strata when the general face of these cliffs was much nearer to the sea than at present. The chasm interrupted the descent of the waters coming from the western portion of the inclined stratum of clay No. 25, at the same time draining, and giving additional solidity to the mass on its eastern side. A renewal therefore of the undercliff commences gradually on the east of this

‡ If the genera Scaphites and Crioceras be identical, as Professor Edward Forbes supposes, No. 15 will be the first or lowest range of this group, and the whole number of ranges will be fifteen or sixteen.

projecting buttress, and is continued thence to the shore at Walpen Chine. The prominence of the mass which forms the eastern side of Black-Gang Chine may be ascribed to a similar cause, the ruin between the Chine and Rocken End being analogous to that on the east of Whale's Chine above-mentioned.

VII. *Walpen and Ladder Sands and Clay* ‡.—*Nos.* 24 *and* 25.

24. The *Crioceras nodules* (23) are succeeded by (24) a dark greenish mud composed of sand and clay, altogether about 27? feet thick, which is first visible on the east of Whale's Chine, and goes out below the summit of Atherfield High Cliff. It contains nodules including large Gryphæa and *Ammonites Martini*.

25. The clay No. 25 has been the chief agent in the production of the undercliff which extends from Walpen Chine to the top of the cliff on the west of Brown's Down; a natural subdivision and conspicuous feature in the series of cliffs which form this section. Its top first rises at the foot of the cliff, about 90 feet east of the opening of Walpen Chine; it is continued below the fissure at Ladder Chine, and is well seen within Whale's Chine above the sandy beds 24; it is about 28 feet thick §, the lower part a brownish plastic clay, containing very good specimens of *Panopæa* (*Mya*) *mandibula*, with many other fossils, discovered here by Capt. Ibbetson. The upper part, between Walpen and Ladder Chines, is much mixed with sand, and contains *Pinna Robinaldina* (d'Orb.), with several other bivalves, and a Dentalium.

Fossils of Nos. 24 *and* 25.

24. †Panopæa elongata?	Venus (Vectensis).
—— mandibula?, *Sow.*	Vegetable impressions, not determinable.
Gryphæa sinuata.	
25. Panopæa mandibula?, *Sow.*	Isocardia Neocomiensis (*qu.* ornata??), *d'Orb.*
—— plicata, *Sow.*	Corbula striatula, *Sow.*
†Tellina inæqualis?	†Lima semisulcata?
†Venus Vectensis.	Gryphæa sinuata, *Sow.*
—— near to *parva.*	Pinna Robinaldina.
Scaphites gigas?	
Nucula ——?	

VIII. *Upper Crioceras Ranges.*—*Nos.* 26 *to* 34.

These nodules can be traced from the shore beneath Walpen High Cliff, through the lower chasm of Ladder Chine, crossing Whale's Chine, and finally going out on the east of Atherfield High Cliff, where the four ranges can be seen together, with occasionally a fifth. The measures detailed in the Table were taken at that place. The largest specimens of Crioceras came, I was informed, from No. 33,

‡ This name, referring to local position, is better than that of *Fossiliferous Clay*, because all the clays west of Black-Gang Chine contain fossils; and the *sands* also are fossiliferous in many instances.

§ I could not obtain a direct measurement of the thickness of these beds; and that which I have assigned to the clay is less than my guide supposed it to be. The cut on the preceding page represents the general aspect of this part of the shore, with the passage of this group through Whale Chine.

near its rise on the east of Walpen Chine: the masses containing the fossil are composed of sand with stem-like impressions, already often mentioned; and in some of the larger I found *Ammonites* (*Martini*), *Gervillia solenoides, Trigonia alæformis* and *Terebratula sella.*

The sand No. 34*b*, containing the small nodules which are the highest in point of range of the genus Crioceras, crosses Ladder Chine and may be seen in the chasm beneath it: about 4 feet from No. 33 are intermediate concretions (34*a*) said to contain small Ammonites. This appears to be the site also of some large fragments of a very hard stone with impressions of a ribbed fossil, apparently a Nautilus, the precise place of which I could not ascertain.

Fossils of the Second Crioceras Ranges.—Nos. 26 *to* 34*b*.

26. Panopæa mandibula.
Nautilus radiatus.
27–32. Crioceras Bowerbankii, *Sow.*
Pinna —— ?
32. Mytilus lanceolatus (var. *edentulus*).
Gryphæa sinuata, *Sow.*
Ostrea (two species).
33. Cardium Cornuelianum (with other fossils).
34*a*. †Ammonites Martini.

IX. *Walpen and Ladder Sand.—No.* 35.

A mass of uniform greenish and grey sand, about 40 feet thick, occupies the foot of the mural cliff for about 1300 feet, between the rise of the uppermost Crioceras range and that of the second Gryphæa bed No. 36. Its upper part is best seen in Ladder Chine; in the lower part are several fossiliferous ranges, among which the following are remarkable:—

35*a*, which I have taken as the base of this stratum, is a range of nodules about 1½ foot thick and often 4 feet long, of dark olive-green stone, with nuclei of fossils resembling those of No. 45 above—Brissus, Serpula, Thetis, Gervillia, Modiola, Cucullæa, Corbula (*striatula*), Venus, Cardium, Terebratula, Nerinea, Ammonites.

35*b*. About 6 feet higher up is a bed, almost continuous, but varying from a few inches to a foot in thickness, which consists for the greater part of thread-like Serpulæ, apparently twisted together, with broad *Terebratula Sella, Pectens, Gryphæa sinuata* and *Gr. lævigata* (*Couloni*).

35*c*. A range of detached fossils at wide intervals, much-decomposed (possibly Scaphites), was visible within the upper part of Ladder Chine, about 14 feet from the top of the sand.

X. *The Upper Gryphæa Group.—Nos.* 36 *and* 37.

No. 36, between 18 and 20 feet thick, occupies at the base of the cliff about 625 feet‡. About 4 feet at the bottom is yellowish and brown

‡ The cliff near the rise of 36 is much lower than the other parts of the shore, and in some places not more than 40 feet high. It is, thus far eastward from Walpen Chine, mural, with an undercliff above it, and a second retired cliff within, which is continued to Walpen High Cliff, gradually coming nearer to the sea. The

sand, with some clay, including small nodules, containing Brissus and *Ammonites Martini*, with detached valves of Gryphæa. Next are seen the nearly parallel edges of *Gryphæa sinuata*, in ranges indicating three or four continuous strata, with irregular clusters between them. Then greenish indurated sand, containing various shells, with carbonized vegetable impressions; and nearer the top another range of detached, very thick-shelled *Gryphæa sinuata*, with fossiliferous nodules above it. The ferruginous matter of this bed is in some places distinctly oolitic, like that of the lower Gryphæa group (No. 13).

No. 37 is a mass, not more than $3\frac{1}{2}$ feet thick, of greenish sand, containing nearly the same assemblage of fossils as No. 45, with large specimens of *Gryphæa sinuata*; this being the highest point in this section which has afforded that species.

Most of the varieties of *Gryphæa sinuata* figured by Mons. Leymerie exist in my collection from this coast; but the number from different points is not sufficient to decide whether the different forms are appropriated to particular groups or strata,—as seems to be the case near Vassy in France, where Mons. Cornuel assured me that he could at once assign each variety of form to a special place in the section of that vicinity. Many specimens of Gryphæa here are distinguished by the prominence and irregularity of the dorsal ridge and the great accumulation of shell about the hinge. The interior of the shell also is sometimes almost chambered in consequence of the separation of the plates.

The vegetable remains in Nos. 36 and 37 have a glistening surface like that of plumbago. They were found by Mr. Morris to be distinctly portions of *Lonchopteris Mantellii*, a fern of the Wealden hitherto found in that deposit only, but which seems to be diffused in fragments nearly throughout the whole of the lower greensand. Its occurrence amidst shells exclusively marine, makes it probable that when these remains were deposited in the detritus which now forms the lower greensand, some portion of the Wealden land was still above the sea; but the fragments of Lonchopteris found here are very small, and so confusedly mixed together, that they may have been transported from great distances. In No. 36 they are accompanied by *Inoceramus* (*gryphæoides?*), a marine species not hitherto seen in any other part of this section.

Large masses of genuine greensand are frequently found upon the shore west of Cliff-End, fallen from the upper part of the mural face or from the remoter cliff above; and great flakes are seen from time to time to be detached from the exterior of the mural cliff, parallel to the general face, and apparently cutting without interruption through portions of what, in other places, seem to be distinct strata. These masses consist of sand of a full green colour, in some places marked or varied in a very striking manner by small spots or patches of a much lighter hue than the rest, and of a somewhat regular figure, so as to resemble the ramifications of certain fuci. The

masses fallen from the higher portions are rich in fossils. The whole series hereabouts deserves examination from the fossiliferous concretions which it contains.

same appearance precisely occurs in the lower greensand at Tilburstow Hill in Surrey ‡ and at the top of the quarries near Maidstone, Kent §. The greensand in all these cases appears to have included stem-like bodies, the place of which is now occupied by a fine sand of quartz, the contrast of its hue becoming indistinct in dry specimens, but conspicuous when moistened.

Fossils of the Cliff-End Gryphæa Group.—Nos. 36 *and* 37.

36. Coniferous wood.
†Mytilus æqualis (*Modiola*, Sow.).
Thetis minor, *Sow.*
Gervillia Forbesiana, *d'Orb.*
†Pecten interstriatus, *Leym.*
Gryphæa sinuata, *Sow.*
(Several remarkable varieties.)
†Terebratula sella, *Sow.*
†*Fucoides ?
Fragments of Lonchopteris Mantellii.

37. Thetis minor, *Sow.*
Rostellaria Robinaldina, *d'Orb.*
†Brissus —— ?
Lonchopteris Mantellii, *Brong.*
†*Inoceramus gryphæoides ?

XI. *Cliff-End Sand with Concretions.—Nos.* 38 *and* 39.

38. Nearly uniform sand about 14 feet thick; this includes a thin bed of retentive fossiliferous clay about two feet from the bottom, containing *Trigonia Dædalea*, &c.; near the top are concretions with Pinna and other species.

39. Dark bluish clay and greensand, thickness 13 feet to 14 feet, including pyrites, and alternating with layers in which oblique rifts ("false stratification") are conspicuous. It contains many cylindrical stem-like concretions about an inch in diameter, which are frequent also in other beds hereabouts, and which, especially when branched, as they frequently are, might be ascribed to organization; but they are generally found to contain pyrites still unchanged and to include particles of sand.

Fossils of Nos. 38 *and* 39.

38. Panopæa plicata, *Sow.*
Pinna Robinaldina, *d'Orb.*
Trigonia rudis ||.
†Ammonites Martini, *d'Orb.*
Lonchopteris Mantellii, *Ad. Brongn.*

39. No fossils have been obtained from this bed.

XII. *Foliated Clay and Sand.—No.* 40.

40,—which is about 22 feet thick, consists principally of a compact very dark blue clay, approaching to shale, in continuous flakes, seldom more than an inch in thickness, alternating with greenish translucent siliceous sand, and containing nodules of pyrites ¶. The bed includes also large irregular masses (3 or 4 feet—sometimes even as much as 13 or 15 feet in length and 1 or 2 in thickness) of a coarse sand-rock

‡ See Geol. Trans. 2nd Series, vol. iv. p. 139.

§ Mr. Sowerby informs me that the spiculæ of sponges have been found by Mr. Bensted in the lighter spots here described, near Maidstone.

|| There is some difficulty respecting this species; it appears to be the same as that figured by D'Orbigny as *T. rudis*, and very distinct from *T. Dædalea* of the same author, the latter still differing slightly from the true *T. Dædalea* of Parkinson.—M.

¶ I sought carefully here for lignite, which has been mentioned as occurring in this bed, but without success.

or conglomerate, marked by rifts of false stratification. The top of the bed upon the shore between Cliff-End and Black-Gang Chine, which at first has the appearance of a distinct continuous stratum, consists of one of those coarse masses, but the true compound character of the group is well-seen on the N.E. of Walpen Chine, at a point accessible only from above. It seems not to be continued farther westward than the Chine. No fossils have been found in it.

This compound stratum of laminated clay and sand is of importance, from its sustaining the undercliff between Walpen and Black-Gang Chines. It recurs very distinctly at Shanklin Chine, and on the shore thence eastward,—where also it supports a similar and remarkable undercliff.

XIII. *Sands of Walpen and Black-Gang Undercliff.—Nos.* 41 *to* 44.

The vertical distance from 40, to the ferruginous group 45, which keeps up the streamlet of the cascade at Black-Gang Chine, is about 100 feet, of which but a small portion is visible in the cliffs near the Chine; the rest being concealed in the undercliff, or accessible with difficulty above. This part of the series therefore cannot be well examined in the section near Atherfield; but the corresponding beds are very distinctly exposed between Bonchurch Cove and Shanklin, and with some important features which are wanting here.

41. *First Sand-rock,* about 10 feet thick. This is the first bed of pure sand in the ascending series, anticipating as it were the upper division, a great part of which consists of white sand. It is at present visible only in one place at the base of the upper cliff near Walpen High. It consists of loose, white sand, intershot with thin flakes of grey clay, a compound well-fitted to retain moisture; and giving way under pressure, while it has immediately above it sand and sand-rock of slight coherency,—the fall of the whole mass and the production of the quagmire in the undercliff on the west of Black-Gang Chine are clearly explained.

42. Above 41 is a series of beds, about 70 feet thick, imperfectly seen here, and affording very few distinguishable fossils; in which the succession appeared to be as follows:—

	ft.	in.
d. Light green and yellowish sand, giving a bright green trace under the pick	25	9
c. Brown cohesive sand slightly protuberant, with casts of large *Astarte Beaumontii* with Pinna, Pecten, and plicated Terebratula	1	6
b. Greensand, tough and retentive of moisture	12	6
a. Sand in three divisions, together equal to 29 feet: at the bottom of the lowest bed, immediately above No. 41, is a coarse gravel with pebbles of quartz and Lydian stone	29	8
Total thickness of 42	69	5

43. A prominent portion of the cliffs between 41 and 45 is brown, coarse sand, with a more rugged surface than that of the adjoining cliff, and about 7 feet thick. *a.* The lower part (3 ft. 6 in.), containing polished particles of brown iron ore, has some resemblance to the

sand of the Gryphæa beds beneath, Nos. 13 and 36*. *b*. The upper part is reddish and brown sand (3 ft. 6 in.).

44. About 12 feet of sand, alternating with thin beds of dark greenish or black coherent mud, or clay mixed with sand. One such bed about a foot thick was found by Captain Ibbetson to contain fossils: in another about 6 feet above it, of 8 or 9 inches, I found a Panopæa, and other species, like those of the Perna clay No. 1, at the bottom of this section.

Fossils of Nos. 41 *to* 44.

In 41, 42 and 43, very indistinct traces only of fossils have been found.

In 44,—Panopæa plicata, *Sow.*
—— mandibula, *Sow.*
Corbula striatula, *Sow.*
Lingula truncata, *Sow.*

XIV. *Ferruginous Bands of Black-Gang Chine*†.—*No.* 45. *a, b, c.*

This group is one of the most remarkable in this section, being, here, the limit between the fossiliferous beds of the series, and those in which fossils have as yet been extremely rare. This contrast is probably no more than local; but a similar group is found in nearly the same part of the series in so many other distant points as to deserve especial notice. It rises on the shore about midway between Rocken End and Black-Gang Chine, and can be traced continuously to Walpen High Cliff, where its decomposition is very favourable to the extraction of the fossils; and though no more than vacant moulds of shells, these are so well characterized, that the species can be identified in several cases with those of the *Perna group*, at the very bottom of this section.

The species here are the same also with those found in the corresponding part of the lower greensand at Parham Park and other places in Sussex, and near Sandgate in Kent‡; the fossiliferous masses are not distinguishable from those of Horseledge near Shanklin, where in fact the beds are a continuation of those at Black-Gang Chine.

The group 45 may here be subdivided as follows—the total thickness being about 20 feet:—

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* See hereafter, p. 318, for a list of the species found near Shanklin, in what seems to be the corresponding portion of the series there.

† *Cascade of Black-Gang Chine* (1843):—

	ft.	in.
Height of the spot where the fall begins, above that where the water springs off from the cliff	8	0
Vertical fall of water (62 ft. 10 in.)	63	0
Bottom of the fall, above high-water mark	20	0
Height of summit above high-water mark	91	0

‡ Some very remarkable specimens from the site here referred to were obtained by Mr. Simms during the excavation of the railway tunnel at Saltwood, near Hythe:—see Proceedings of Geol. Soc. iv. p. 208, and Journal, vol. i. p. 34, &c.

	ft.	in.
c. Ferruginous concretions, the upper part of the group, over which, at Black-Gang Chine, the streamlet runs, immediately above the Cascade	1 0 to 1 6	
Sand, subfossiliferous, brown and yellow	5	0
b. A second range of ferruginous concretions, abounding in the impressions and vacant moulds of shells. This, near Walpen High-Cliff, is the part most abundant in fossils, which are easily detached	1	0
The intermediate sand between *a* and *b* itself fossiliferous	7	0
a. Consolidated ferruginous sand-rock, irregular in thickness, and in some places divided into two layers, containing many fossils	5	0

Fossils of No. 45.

45 *a*. Corbula striatula, *Sow.*
Cyprina angulata ?, *Sow.*
Thetis minor‡, *Sow.*
*Trigonia alæformis, *Park.*
—— caudata, *Ag,*
*Avicula pectinata ?
Gervillia anceps, *Desh.*
Gervillia solenoides, *Defr.* (*Forbesiana* ?, d'Orb. §)
Lingula truncata, *Sow.*
Rostellaria Robinaldina, *d'Orb.*
†*Turritella Dupiniana ?
Holaster complanatus.

45 *b*. Fossil coniferous wood.
Panopæa plicata, *Sow.*
†—— Neocomiensis, *d'Orb.*
†Pholadomya Martini.
†Cardium peregrinosum, *d'Orb.*
†*Cardium Voltzii, *d'Orb.*
†Corbis corrugata (*Sphæra*, Sow.).
†Cyprina angulata, *Sow.*
†—— rostrata, *Sow.*
†Isocardia Neocomiensis, *d'Orb.*

‡ After comparing, with the assistance of Mr. Sowerby, a large number of specimens of Thetis with the original species figured in the 'Mineral Conchology,' the correct determination of the different forms appears difficult, in consequence of some of the characters being variable.

The true *Thetis minor* (M. C. t. 513. f. 6), belonging to the ferruginous band No. 45 of the Table, is also found at Shanklin, Parham Park, &c., and has not, I believe, been discovered in the Gault of England, although M. d'Orbigny cites it as common to that formation in France and this country; but his figure does not well agree with our species. It is characterized by the globose form and narrow ligulate palleal sinus, which distinguishes it from *T. major* (M. C. t. 513. f. 2, 4) of the upper greensand (Devizes, &c.), which has a broader sinus, and the shell is more compressed, and attains a larger size. The species from Blackdown, originally named *Corbula lævigata* (M. C. t. 209. f. 1, 2) by Mr. Sowerby, and subsequently (Index) referred to *T. minor*, is less gibbose than that species, and approaches therefore in this character to the specimens of Thetis obtained from the "Crackers" group of the lower greensand; the ligulate sinus, however, and the palleal impression are similar to *T. minor*. M. d'Orbigny considers this a distinct species, and, under the name of *Thetis lævigata*, cites it as from the upper portion (Terrain *Aptien*) of the lower greensand, and identifies it with those from the Crackers group in the Isle of Wight. The specimens figured in the Pal. Franç. t. 387. f. 1, 2, do not appear to have well exhibited the sinus, palleal impression, and the regularly radiating puncta, as D'Orbigny describes, the latter being found only on the anal portion of the shell. The *T. minor* (M. C. t. 513. f. 5) from Pinhay, near Lyme, is a gibbose species of the general form of the Isle of Wight specimens, but differs from them in the sinus gradually widening and being very broad at the base, as well as the palleal impression having a different arrangement, agreeing in this respect with the figure of d'Orb. (P. F. t. 387. f. 4, 5).

If therefore the specimens from the "Crackers" (Isle of Wight) and Blackdown are the same, we must retain for them the name of *Thetis lævigata*, using *T. minor* for the more gibbose forms, as before observed. Roemer has united *T. minor* and *major* under the name of *T. Sowerbii.*

All the species are marked by a regularly radiating series of minute raised puncta, which, when worn away, leave only small dots on the surface of the shell, sometimes difficult to observe.—M.

§ These shells are certainly nearer in form to *G. solenoides* than to *G. Forbesiana*, which occurs lower in the series. M. d'Orbigny considers the species as distinct.—M.

†Lucina solidula, *Forbes.*
†Mactra (Carteroni ?).
†Arca Cornueliana ?, *d'Orb.*
†Nucula antiquata, *Sow.*
†Trigonia alæformis, *Parkinson.*
†—— caudata, *Agassiz.*
†——rudis ?, *Parkinson*(*Dædalea*?).
†Pinna Robinaldina, *d'Orb.*
†*Cytherea caperata (*Venus*, Sow.).
†Venus parva, *Sow.*
†Thetis minor, *Sow.*
†Corbula striatula, *Sow.*
†Mytilus lanceolatus, *Sow.*
†Gervillia anceps, *Desh.*
†Gervillia solenoides (*Forbesiana* ?, d'Orb.)
†Lingula truncata, *Sow.*
†Avicula pectinata ?
†Anomia —— ?
†Terebratula multiformis (var. *Gibbsiana*, Sow.).
†*—— sulcata, *Parkinson.*
†Natica Cornueliana, *d'Orb.*
†—— Gaultina ?
†Rostellaria Robinaldina, *d'Orb.*
†Dentalium cylindricum ?, *Sow.*
†Holaster complanatus, *Ag.*
Lonchopteris Mantellii, *Brong.*

[No very well-defined fossils have been found at Atherfield, above this group.]

XV. *Upper Clays and Sand Rock.*

The two great masses of clay, Nos. 46 and 48, being together not less than 100 feet in thickness, I have thought it expedient to place them with the intermediate sand-rock No. 7, in a group apart; since, besides the importance of so great a bulk of clay, it is by no means improbable that in other sections the equivalents of these beds may be fossiliferous.

46. Above No. 45, a stratum of *clay*, full 40 feet thick, which rises between Black-Gang Chine and Rocken End, crosses the Chine about 90 feet above the shore, and passing westward forms a small undercliff. The clay is dark grey, in some places almost black, containing, especially near the bottom, pyrites, with portions of lignite; the structure in some places is slaty. I have sought repeatedly for fossils in this great stratum, but without success, and they are undoubtedly very rare; but on the confines of this bed, and the sand next above it, are ferruginous concretions, with evident traces of shells, though the species are not distinguishable.

47 :—somewhat more than 18 feet thick, consists of uniform white and fawn-coloured siliceous sand. The bottom rises about 580 feet west of Rocken End, and the stratum being continued thence under the sea, has a share in the formation of the ledge, or series of ledges, which produces the formidable "race" near that point. Westward it crosses Black-Gang Chine, and is visible from thence to its outcrop between Cliff End and Walpen High Cliff. Seen from the heights near Atherfield it forms a conspicuous line in the section, contrasting strongly with the clays above and below.

The sand of 47 is dug near Rocken End for the manufacture of glass. It contains here no fossils; and though, from its position, clearly of submarine origin, is scarcely distinguishable by external characters from the great freshwater sand-rock of Hastings‡.

48. Is a mass of clay mixed with sand, not less than 60 feet thick, in which I do not know that any fossils have been found. Its rise on the shore east of Rocken End is at present concealed; but it is

‡ No. 47, it will be recollected, is the second of the series of sand-rocks which form a principal portion of the upper strata of this section; the first being No. 40, at the bottom of the undercliff on the west of Black-Gang Chine.

conspicuous in Black-Gang Chine, between the two sand-rock beds 47 and 49. The upper part is of a dark grey or blackish hue, with a somewhat slaty texture. About 30 feet from the bottom is a range of ferruginous nodules. The lower part is a dull greenish and grey coarse iron-shot mass, traversed by numerous rifts, and apparently containing much pyrites.

XVI. *Various Sands and Clays.—Nos.* 49 *to* 55.

The series from the top of 48 to the bottom of the gault occupies a thickness of more than 130 feet, throughout which fossils are here extremely rare. Within the fissure of Black-Gang Chine it is not easy to subdivide or to measure these beds, and my numbers in the Table, obtained without levelling, are no doubt short of the true thickness. The greater part consists of sand scarcely concreted, which breaks down easily under the hammer, and in some places is intimately mixed with dark argillaceous or carbonized matter. Some of these sand beds also contain green particles in small proportion.

The mineralogical character of these upper strata here differs from that of their representatives in Kent and Surrey, where the upper sands contain chert in great abundance; and near Folkstone some of the fossils also are siliceous, like those of Black Down in Devonshire.

The upper beds of this section are continued eastward of Black-Gang Chine, beneath the gault, at the same slight inclination. They are thence concealed beneath the undercliff on the east of Rocken End, and do not reappear, so far as I am informed, between that point and Bonchurch Cove.

In the sandy clay at the very top of the section in Black-Gang Chine I found specimens of three or four species, among which a *Panopæa* and a *Venus* could be distinguished. And casts of a *Solarium* and of an *Ammonite* are mentioned by Captain Ibbetson and Mr. Forbes as occurring in the same situation*. These, it will be observed, are all genera known to occur in the gault immediately above.—No other fossils have come to my knowledge.

Superficial gravel and sand.—Throughout this section, the top of the cliffs is coated with transported matter, abounding in fragments of chalk flints; frequently 10 feet, and sometimes even 20 feet in thickness. The bottom of this deposit is so like the sand of the strata beneath, that it is often not easy to distinguish them. This lowest part, on the heights at Walpen, is clearly stratified, and deserves examination.

Gault.—The bluish clay above the lower greensand at Black-Gang Chine, and thence eastward, has afforded in the upper part few fossils, or none; but very near the bottom it contains Ammonites and other characteristic shells, which, with the position and thickness of the beds containing them, leave no doubt of the perfect correspondence of this deposit with the gault of other parts of England and of France. Among the species is *Ammonites Raulinianus* (recognized by Mr. Sowerby), which has not before been obtained in the English

* Geol. Journal, vol. i. p. 191.

gault. But the fossils, both of this stratum and of the upper greensand of the Isle of Wight, are for the greater part unknown, or at least unpublished.

Postscript (*July* 1847).—*Trigonometrical Section of the Coast.*—The Table and sectional drawing which accompany this paper were laid before the Geological Section of the British Association at Southampton, in September 1846; and on the same occasion Captain Ibbetson produced a geometrical elevation of the coast near Atherfield, exhibiting, on a very large scale, the succession of the strata there. After the meeting at Southampton, Captain Ibbetson was so good as to place his elaborate drawing at my disposal, and I then hoped to avail myself of it to a much greater extent than is practicable in the present volume. I am now obliged to confine myself to giving a geometrical outline of the cliffs between the chalk and Atherfield, from a drawing by Captain Ibbetson, on the same scale with my own approximate section, and likewise preserving the true relative proportion between the heights and horizontal distances. This outline also shows, by the parallelism of the lines bounding the great divisions which Captain Ibbetson has adopted, the absence of disturbance and interruption during the formation of the lower greensand; and adds the important fact, that while the strata below the gault are inclined at an angle of 2° to the horizon, those above the gault are nearly horizontal. I have added to my own sectional drawing an indication of this fact, on the authority of Captain Ibbetson.

In the reduction of my own section I have sacrificed all attempt at effective representation of the coast, by an endeavour to confine the heights to the same scale as the distances. Captain Ibbetson's measurement makes the total thickness of the section from the Wealden to the Gault 833 feet*. My estimate falls within 805—the difference being about 30 feet; and I am convinced that my numbers throughout err by defect, and not by excess. In round numbers the thickness may be safely taken at full 800 feet.

Section at Compton Bay.

When we have well examined the section near Atherfield, the same strata will be easily recognized in that of *Compton Bay,* which is six miles distant in a direct line. On the N.W. of Brook Point the upper beds of the Wealden are exposed, with the characteristic fossils; to which has recently been added the *Unio Valdensis,* described by Dr. Mantell. The first member of the Atherfield series which meets the eye is a grey and bluish clay, with the Perna group at the bottom of it, containing particles of oolitic iron ore; and here I found, in a detached mass about a foot in thickness, one of the largest specimens I have ever seen of *Perna Mulleti,* with *Panopæa plicata* and *Cardium sphæroideum.* I was informed that the stratum containing these is visible at low water, ranging towards the south of east. The

* Erroneously printed 843 feet at p. 190 of this Journal, vol. i.

clay above, which is evidently that of Atherfield, contains nodules of light brown indurated clay in great numbers, with valves of *Gryphæa sinuata*.

The cliffs at this place are in general so much obscured by ruin that exact boundaries between the groups cannot easily be found; but the next mass of brownish clay and sand evidently corresponds to the "lower lobster bed" No. 4. The "*Crackers*" are concealed; and after a space occupied by ruin comes a great mass of ferruginous sand and sand-rock, in some places of a dull crimson hue, and abounding in brilliant oolitic grains of iron ore, which strongly reminded me of that which is dug for smelting (the "*minière*") near Vassy. The whole of this mass of ferruginous strata may be from 100 to 150 feet in thickness; a prominent portion in the lower part representing probably the lower Gryphæa bed, No. 13 of Atherfield. About 70 feet of dark clay succeed, and then again rust-coloured matter, which appears to hold the place of the ferruginous bands at Black-Gang Chine, as it includes masses almost composed of moulds of Thetis, spiral univalves, an Ammonite, &c. Over this is dark clay again, alternating with a series of yellowish sand and sand-rock, answering to those of Black-Gang-Chine; and finally a series of sands, with a brown stratum at the top, immediately over which the dark blue clay of the *Gault* is well-exposed and accessible. Nothing in short can be more satisfactory than the general indications of correspondence with the strata described in the foregoing pages, although their precise identification would be difficult or impracticable, from the intermixture of the various debris.

Sandown Bay, and Coast near Shanklin.

The eastern extremity of the undercliff from Bonchurch to Shanklin northward, corresponds to that which is partially concealed at present beneath the undercliff on the east of Rocken End. Near Bonchurch fortunately the strata are fully exposed upon the shore, and can be examined with ease. I shall return to this part of the coast, but shall first mention the section on the north-east of *Sandown Bay*; which though obscure at the upper part, affords at the bottom a better view of the junction with the Wealden than any other place that I know of, with the exception of Atherfield:—the section corresponding, as to geological site and high inclination of the strata, to that of Compton Bay, from which it is distant in a direct line about fifteen miles. I have long since described the succession in Sandown Bay, and noticed the fossiliferous bed, like the Perna group at Atherfield, which forms the boundary between the lower greensand and the Weald clay. In this place Mr. Warburton found, at low water, some very fine specimens of *Perna Mulleti*; and my collector having since, by my direction, examined the shore at low tides, has sent me a large collection which affords a list of nearly forty species, agreeing perfectly with those of the Atherfield Point.

Species in the Perna Bed, at Redcliff near Sandown Bay.

Arca Raulini.
Astarte obovata (*Beaumontii*).
Avicula depressa.
Cardium sphæroideum.
Corbis corrugata (*Sphæra*).
Cucullæa Cornueliana.
Cyprina angulata (young).
Gervillia aviculoides.
—— linguloides.
—— alæformis (*Perna*, Sow., very good specimens).
Gryphæa sinuata.
—— —— (small).
—— harpa.
Modiola legumen (*simplex*, Leym.).
Mytilus lanceolatus.
Modiola æqualis.
Panopæa plicata.
Panopæa plicata (var.).
Pecten circularis.
—— quinquecostatus?
Perna Mulleti.
—— alæformis.
—— Ricordiana? (? tetragona of Geol. Trans. iv. p. 130.)
Thetis —— ?
Trigonia alæformis.
—— Dædalea.
Terebratula Gibbsiana.
—— Sella.
Tellina angulata.
Trochus.
Turbo.
(Several oblong bivalves, indistinct.)
Ammonites.

I do not know whether this group or bed is divided here, as it is at Atherfield, into two parts; but above it the "Atherfield clay" is here perfectly distinct; and my collector, who is well-acquainted with the strata, found, nearer to the base of Redcliff, a nodule containing moulds of a spiral univalve (*Rostellaria Robinaldina*?) which he considered as belonging to the "Crackers."

After passing westward over the slight curve formed by the Hastings-sands, as we advance on the coast towards Shanklin, the Perna bed ought to be found at very low tides above the Weald clay beneath the Barrack-hill; and here my collector did find a Panopæa in what he knew to be the Perna group. A fault (at Small-Hope Point), by which the continuity of the strata is broken, and which I had mentioned as having been pointed out by Sir John Herschel*, was again discovered here, and carefully examined by Captain Ibbetson; who has informed me, that in a quarry not far from the shore, within the cliff of sand-rock between the Barrack-hill and Small-Hope Chine, he found specimens of Crioceras, in the site where they were to be expected. The cliffs thus far are so much decomposed that the strata are scarcely distinguishable; but between the shoulder or prominence at Little-Stairs Point and Shanklin Chine, a bed, of which a large surface is uncovered at low water, corresponds to one of those in the second Gryphæa group No. 36, beneath Walpen High-cliff. This, which, as it is here seen, may be truly called an ancient oyster-bed, is studded with clusters of *Gryphæa sinuata*, with *Ostrea prionota*, and has precisely the appearance that would be exhibited if any of the beds of Gryphæa, the edges of which are visible on the west of Cliff-end, &c., were extensively laid bare.

The "oyster-bed" is an excellent point of recognition. The next stratum above it, which forms a shelf or narrow undercliff at the foot of the adjacent cliffs, is evidently a continuation of the foliated dark clay and sand (No. 40) of the shore between Black-Gang Chine and

* Geol. Trans. Second Series, vol. iv. pp. 192, 193.

Cliff-End; and has had here a precisely similar effect in the structure of the coast, the narrow undercliff upon its surface being traceable to its rise on the west of Shanklin Chine. This stratum is here likewise composed of alternate beds of very dark slaty clay and greenish sand; and above it a continuous range of cliffs extends to Bonchurch Cove, obviously the same as to position with those between Nos. 40 and 45 of Black-Gang Chine, but, here, containing a great number of distinguishable fossils.

Great interest is attached to this part of the shore from the existence, in a spot which seems to correspond nearly to No. 43 of the Atherfield list, of at least two new and perfectly distinct ranges of *Gryphæa sinuata*. I regret the more that it is not in my power to give a measured section of this place, as the "report" of Captain Ibbetson and Mr. E. Forbes's paper, which contains the description of it*, does not enter into detail; but I shall state here what I found in confirmation of their discovery, as this striking difference in two portions of the coast so near to each other, bears upon the general question of the division and identification of strata in detached places.

a. Immediately above the dark clay representing No. 40, a course of white sand-rock, answering to No. 41, appears on the shore, about 100 paces east of the first prominence or shoulder after leaving Shanklin Chine.

b. (In ascending order) is greenish and grey sand, about 3 feet thick, marked by white circular and oval spots of much lighter hue,—apparently the sections of cylinders or tubular bodies, the white marks being in some cases circular rings. With these are lighter patches very like those seen upon the shore near Walpen Chine, and other places above-mentioned at p. 308-9.

c. About five feet higher, in a grey or greenish sand-rock very rich in fossils, is a range of small nodular masses, including nearly fifty species as follows:—

Lonchopteris Mantellii.
Coniferous wood.

Cricopora?? gracilis.
Cellepora (same as at Farringdon).

Brissus.
Salenia (same as at Farringdon).
Nucleolites lacunosus, *or* Olfersii (I believe the former).—M.

Vermicularia concava.
—— polygonata.
Serpula Richardi?

Terebratula pseudojurensis, *Leym.* (a new species near to.—M.)
—— sella, *Sow.*
—— multiformis, *Roemer.*
Terebratula Gibbsiana, *Sow.*
—— A small gibbose species, probably the same as the *T. subtrilobata*, var. *inflata* of Leym. [may be the shell figured as *T. faba* in Fitton?]

Anomia convexa.
—— radiata.
—— lævigata.
Ostrea prionota.
Gryphæa lævigata.
—— sinuata and varieties.
Pecten interstriatus.
—— orbicularis.
—— quinquecostatus.
Lima Cottaldina.
—— undata.
—(a new species very prettily marked).
—— semisulcata.

* See Report of Brit. Assoc. 1844, p. 43.

Avicula lanceolata.
Gervillia alæformis.
Perna Ricordiana, *d'Orb.*
Arcopagia. Two species—probably belonging to this genus.
Cyprina rostrata ?
Venus —— (two species ?).
Thetis minor.
Modiola æqualis.
Trigonia alæformis.

Nucula lineata (same as the Blackdown, and differing from *N. scapha*).
Arca Raulini.
Arca Marullensis.
—— Cornueliana.
Pectunculus Marullensis.
Cardium Ibbetsoni.
Isocardia Neocomiensis ?

Rostellaria Robinaldina.
Pterocera —— ?
Actæon (two species).
Cerithium —— ?
Turbo —— ?
Natica lævigata.
—— near to Cornueliana.
Ammonites (*A. consobrinus*, young ?).

d. About ten feet higher up is the first of the new beds of *Gryphæa sinuata* above-mentioned; and about eight and a half feet from it another range of Gryphæa, the upper I believe of two discovered by Captain Ibbetson. The place on the coast we were informed is called "Shanklin Point." The specimens of the second bed here are large and distinct, the Gryphæa marked by a prominent ridge, and with them is *Ostrea carinata*. The sand which includes these fossils contains oolitic iron ore, like that of both Gryphæa groups (13 and 36) near Atherfield, and their situation corresponds well to that of No. 43 of my section and Table.

Here then are equal portions, each about 100 feet in thickness, of beds not merely corresponding as to general position, but almost continuous, and less than eight miles apart; yet in the one, near Black-Gang Chine, we find no recognizable fossils, or scarcely any, while the other contains two prominent ranges of a characteristic species, with nearly fifty smaller fossils, in great abundance! Nothing surely can better show the great variation produced by slight distance,—or prove more clearly the necessity for caution in forming subdivisions of the deposits in which such local differences are to be found.

e. The next group, ascending, is that of Horseledge, which furnishes the nodules sold by the collectors at Shanklin Chine, consisting of ferruginous masses not distinguishable from those of No. 45 of the Table, and already mentioned as resembling also those of Parham Park in Sussex, Sandgate and other places. It will be sufficient to mention here the following species, which are common to all those places:—

Specimens from "Horseledge" on the shore west of Shanklin.

Panopæa plicata, *Sow.*
Trigonia alæformis, *Park.*
Thetis minor, *Sow.*
Gervillia anceps, *Desh.*
Terebratula sella.
Terebratula multiformis ?, *Roemer*, (*T. sulcata* ? Park.) at Horseledge only.
Littorina rotundata (*Natica* ?).
Rostellaria Robinaldina, *d'Orb.*

I shall not carry this description farther, not having examined the remainder of this section in detail; but it was evident that the upper beds of the series are much more fossiliferous here than at Black-Gang Chine.

Table of Fossils.

The most striking facts appearing on the face of the table, are the extraordinary accumulation of species in the lower part, and the rapid diminution in their number in the middle and upper strata; till at last a thickness of more than 200 feet at the top of the section here is almost destitute of fossils,—an extreme exhaustion, however, which appears to be confined to this part of the coast.

The thickness of the entire section is about 800 feet; the total number of species found in the strata about 150.

The following is a condensed view of some of the numerical results derivable from the table:—

Distribution of the Species.

Groups.	Numbers of strata in the Table.	List of strata.	Fossil contents of the strata.		Approximate thickness.			
			Species first appearing.	Total No.	Feet.	Inches.	Feet.	Inches.
XVI.	55—49	Various sands	0	2	126	8	245	2
XV.	48—46	Upper clays	0	5	118	6		
XIV.	45 *a b c*	Ferruginous bands	5	34	19	6	19	6
XIII.	44—41	Walpen sands and undercliff	0	4	97	6		
XII.	40	Foliated clay	0	0	22	0		
XI.	39—38	Cliff-End concretional beds	0	5	28	0		
X.	37—36	Second Gryphæa	1	14	23	6		
IX.	35	Walpen and Ladder sands	0	18	40	0		
VIII.	34—26	Second Crioceras	2	24	34	6		
VII.	25—24	Walpen and Ladder clays and sand	0	16	55	0		
VI.	23—17	Lower Crioceras	4	35	16	3		
V.	16—14	Scaphites	3	16	40	0		
IV.	13—11	Lower Gryphæa	3	24	33	0		
		Thickness, Nos. 44 to 11	...	...	...	...	389	9
III.	10—4	The "Crackers"	48	83	83	0		
II.	3	Atherfield clay	6	22	60	0		
I.	2—1	Perna group {No. 2—32; No. 1—44}	76	76	5	3		
		Thickness, Nos. 10 to 1	...	...	...	...	148	3
		Total No. of Species	148	Total thickness			802	8

Summary of the Distribution of the Fossils.

Number of species first appearing.	Thickness.	First appearance of species.	Total species.	Disappearance of species.
	feet.			
In No. 55 to 46 (inclusive)	242	0		2
In No. 45, "Ferruginous bands"	20	5		33
From No. 44, "Walpen Sands," to No. 11, "Lower Gryphæa" (inclusive)	390	13		39
Total from No. 55 to No. 11 (inclusive) = 652 ft.	...	...	18	
From No. 10 to No. 4, the "*Crackers*"	83	48		45
In No. 3, "Atherfield Clay" alone	60	6		5
In the Perna group { No. 2. / No. 1. }	6	{ 32 / 48		17 / 7 }
Total number of species from No. 10 to the bottom of No. 1 } = 149 ft.	...	...	130	
Total thickness (about)	801			
Total number of species			148	148

Range and relative Frequency, or Number of Places in the series of Strata in which the Species have been found.

Numbers of species.	Names of species.	Number of places of occurrence.	Range in the strata.
1	(Gryphæa sinuata)	18	1—37
1	(Panopæa plicata)	17	1—45*b*
2	Thetis minor, Corbula striatula	15	1—45*b*
1	(Pinna Robinaldina)	12	3—45*b*
1	(Ammonites Deshayesii)	11	1—35*a*
1	Terebratula sella	10	1—45*b*
9	Species occur in four places only	4	
15	In three places only	3	
37	Twice only	2	
50†	Species occur only once in the series of strata	1	
146			

It will be found that 130 species, or about $\frac{6}{7}$ths of the whole number, make their appearance in the lowest groups, from Nos. 1 to 10, within a thickness of about 150 feet; so that 18 species only originate in the remaining 650 feet above; and this predominance of the lower part would be still more remarkable, if the table could have exhibited the proportionate thickness of the strata;—the lowest or *Perna* group

† Of these 50 species, 20 occur in Nos. 1 and 2,—2 in No. 3,—18 in Nos. 4 to 10,—10 in Nos. 13 to 45.

producing 76 species in a thickness of less than 6 feet; while the clay next above, 60 feet thick, gives but 6 new species; the "Crackers" group again, over the clay, between 80 and 90 feet, giving 48 new species, besides those brought up from the lowest part of the section.

The comparative range of these species is also deserving of notice: 24 which had just appeared in Nos. 1 and 2 go no farther; 5 disappear in the clay No. 2; and 45 more go no higher than the Crackers, Nos. 4 to 10. So that the groups I. and III. are not only the most productive of new species, but are marked also by the sudden extinction of about 70 of those which had originated within them.

The most obvious inference perhaps from the first view of this great disparity might be, that the lower part of the section ought to be separated from the upper strata, and form a division apart; and if relative numbers alone were to be taken into the account, and it were found that the disproportion existing here was of general occurrence in distant situations, such a separation might be expedient; but the universality of such a state of things has certainly not yet been proved; and the question of detaching these lower strata from the upper series, with which they are conformable in position, and bear every appearance of having been continuously deposited, is not simply numerical, but is intimately connected with the zoological relations of the animals whose remains are found in the strata.

The explanation therefore of this extraordinary distribution of the fossils, given by Professor E. Forbes in an early number of this Journal*, seems to be well-founded; and it is supported by reference to the habits of marine animals, and their mode of distribution at the bottom of actually existing seas. According to this view, the Perna and the Crackers group—deposited immediately after the depression of the Wealden shore into the sea of that period, were produced under circumstances which were peculiar and exceptional. The sudden disappearance or extinction of many of the species which we find them to have contained was not a change of inhabitants, but an absolute depopulation to a certain extent, for no successors or representatives of the extinguished species have been discovered. But a residuary portion of the occupants of the sea was continued, receiving but few additions, and rapidly thinning out, till at length, on the appearance of the gault, the whole was changed; so that, in a general view, one system only of organic remains pervades this series, the same species recurring or reappearing wherever similar conditions prevail; while the occasional presence of other and additional animals seems to have arisen from incidental and local circumstances more or less favourable to their wants and mode of existence.

Thus, while a general abundance of fossils almost everywhere distinguishes the lower part of the subcretaceous system, variety in the distribution of species, and not precise identity, in different localities,

* Journal of the Geological Society of London, vol. i. p. 192, &c. In referring to this publication, I ought to add, that my impressions upon this subject (which I hope have been correct) were derived in part, or principally, from conversations with the author, and from the discussions at the meetings of the Geological Society.

appears to be the rule; as will be evident by a comparison of sections, —by which great variation has been proved to exist within very short distances. The Kentish limestone alone shows the dissimilarity between the two principal English sections, and the comparative lists of fossils in more distant places, with much agreement, show always many differences of detail.

And thus it is by no means impossible that repetitions of the Perna, or of the Crackers' group, may be found to recur within this series of strata in other countries, in different geological places from that which they occupy at the base of the present section.

Above the *Crackers*' group, from No. 11 to 44 inclusive,—a thickness of about 390 feet,—twelve new species only are added to the residuary list of fossils: the Crioceras being of this number, a genus which both originates and disappears in this division; and *Gryphæa sinuata*, one of the most numerous shells, with many of its prominent varieties, also appears here for the last time. In the group 14, next above, there is a small influx of species; five which had not occurred before making their appearance here*, with twenty-nine others brought up from the lower strata, twenty-seven of which originate below No. 8 of the Crackers' group: and sixteen of this last-mentioned number come even from the Perna beds† Nos. 1 and 2.

If the preceding observations be just, it can hardly be expected that subdivisions founded upon the distribution of groups of fossils will be generally applicable in remote places;—a doubt which is supported by the examination of some new arrangements proposed by high authority. The only indication of natural subdivision in the upper part of the section at Atherfield appears in No. 45, in which about five-and-thirty species have been found. The eye is at once carried to this division of the Table, which is strongly contrasted with the spaces above and below; and the group is not only, in this section, the apparent limit between a fossiliferous tract and what is here a barren region, but agrees in position and fossils with others which are prominent in Kent and Sussex. But in the lower parts of this very section several other ranges of concretions exist, containing similar masses of the same species, which in fact pervade the whole of this section up to No. 45*a*. Among these the range of nodules 35*a*, about 150 feet below, is so rich, that if it were more accessible, and in a state of decomposition favourable to the extraction of its fossils, it would rival the concretions of No. 45, at Black-Gang Chine, or Horse-ledge near Shanklin.

It is satisfactory to find that the views above expressed are borne out and extended by the independent evidence derived from a larger collection of specimens, and the simple stratigraphical apposition given in the annexed table. But, whatever be their explanation, the facts

* The five species which first appear in 45, and they have not been found in any other stratum, are *Venus caperata, Cardium Voltzii, Trigonia alæformis, Avicula pectinata, Turritella Dupiniana.*

† Many of the species repeated in 45, it will be observed, do not appear in the intermediate strata; but their existence there is highly probable, the less productive strata having been much less examined than the more fertile.

still remain; and the object of this communication is not to anticipate results, but to promote inquiry. Geologists, especially those of the continent, who have not access to continuous sections so distinct as those of our coasts, may perhaps be gratified, and find it useful, to have placed before them the means of comparison with the beautiful section which it has been above attempted to describe.

France.

As the shortest method of enabling the reader to compare the deposit at Atherfield with those of France, I have placed together in Plate XII. four vertical sections drawn to the same scale.

1. Representing the order of the beds or strata at Atherfield, as above described.

2. Is copied from Mr. Simms's valuable section of the same deposits at Hythe, in Kent, in which the lowest group contains most of the characteristic fossils at Atherfield, but above these is the mass of "Kentish limestone," about 100 feet in thickness; and this, although the total thickness of the section at Hythe falls short of that of Atherfield by 359 feet.

The section just mentioned, with the present communication, contains, I believe, a fair epitome of the principal characteristics of this portion of the subcretaceous strata which have as yet been brought to light in England.

3. Is reduced from M. Cornuel's elaborate section of the environs of Vassy (Mém. Géol. Soc. de France, tom. iv. p. 229), the value of which I myself have had an opportunity of appreciating in a short excursion to that neighbourhood, during which I had the advantage of M. Cornuel's conversation and assistance.

4. The 4th figure in this Plate is an enlarged copy of the general section subjoined by M. Leymerie to his geological memoir on the Department of the Aube*.

I should have preferred two French or continental sections more remote than these, which intersect a range of country on the south-east of Paris, throughout which the subcretaceous deposits must be nearly alike; but even if I had known where other sections were to be found, I must have adverted to the first on account of the talent and conscientious accuracy which M. Cornuel has devoted to the tract around him, and to that of M. Leymerie, from the various ability by which his memoirs are distinguished, and the beauty and value of the plates annexed to his excellent paper on the Aube. I should be highly gratified if what has been stated in the preceding pages, and in other previous publications in England of the last three years, could induce this eminent geologist to reconsider his identification of the Terrain Néocomien with our Wealden, since I cannot but believe that it is unnecessary to the explanation of the phænomena.

* Mémoires de la Société Géologique de France, tom. iv. p. 291, and tom. v. p. 229.

To each of these French sections I have annexed, in colours, what I suppose to be the equivalent portions of our subcretaceous groups; and I shall now subjoin a list of some of the fossils obtained by myself at Vassy, which correspond to those of Atherfield, for the names of which I am in part indebted to M. D'Orbigny; adding to these a similar list from Auxerre, of specimens collected by M. Lajoye, and entrusted to me by my friend M. Constant Prevost.

The proportionate thickness of the sections above-mentioned stands thus, approximately:—

	Gault.		L.G.S.		Total.
At Atherfield..........	100	....	800	....	900
Hythe	126	....	407	....	533
Vassy	66	....	200	....	266
M. Leymerie's district on the Aube	100?	....	556	....	656

The subjoined list of fossils, from the neighbourhood of Vassy, is taken from specimens collected by myself, under the direction of M. Cornuel, near that place, principally from the *Marnes* and *Calcaires à Spatangus,* and at one of the quarries where the *minière* (oolitic iron ore) is dug for the manufacture of iron.

There seems to be no doubt of the identity of the tract which affords these fossils with that of the Kentish limestone near Hythe.

Species from the "Calcaire à Spatangus" *near Vassy; found also near Atherfield.*

Arca Gabrielis.
—— securis.
Astarte gigantea.
—— numismalis?
Gervillia aviculoides.
Gryphæa sinuata.
—— (var.) subsinuata.
—— (var.) falciformis.
—— (var.) aquilina.
—— (var.) dorsata.
Lithodomus.
Natica prælonga.
Nautilus (radiatus?).
Panopæa Prevostii.
—— Neocomiensis.
Pecten interstriatus.
—— quinquecostatus*.
Pholadomya gigantea.
Plicatula placunæa?
Serpula filiformis.
Spatangus retusus.
Spondylus Roemeri?
Terebratula suborbicularis.

Species from the quarries of "Minière" (*oolitic iron ore*) *near Vassy.*

Astarte numismalis.
Cardium peregrinosum.
—— Voltzii.
Cerithium.
Corbis corrugata (*Sphæra,* Sow.).
Cyprina (spec. unknown), *d'Orb.*
—— rostrata.
Isocardia Neocomiensis.
Littorina rotundata, *Sow.*
Mactra ——?
Mya plicata, *Forbes.*
—— (not known).
Natica lævigata, *d'Orb.*
—— Cornueliana, *d'Orb.*
Pholadomya (Prevostii) Neocomiensis, *d'Orb.*

* This species is inserted here and in some other places with doubt, M. d'Orbigny being of opinion that *Pecten quinquecostatus* does not occur in the lower greensand; and also that *P. orbicularis* of this deposit differs in some of its characters from the species described under that name by Mr. Sowerby. See Palæont. Française, tom. iii. p. 590.—M.

Pecten quinquecostatus.
Pterodonta, *d'Orb.*
Rostellaria Robinaldina.
Trigonia caudata, *Agassiz.*
Trigonia divaricata, *d'Orb.*
Unio Martini, *d'Orb.*
? Ammonites Deshayesii.

The group called *Argile à Plicatules,* in M. Cornuel's section, nearly agrees I believe with the *Terrain Aptien* of M. d'Orbigny, which the latter conceives to constitute a well-marked and permanent division in the subcretaceous series. But in the Atherfield section the only Plicatula that has been found appears at the bottom in the lowest Perna group; and if the species in the following list, which comes to me from Mr. Morris, be characteristic of this proposed division, its *universal* prevalence is more than doubtful, since a great majority of the species are found, almost exclusively, in the much lower members of our section, and some of them only there.

Species of the "Terrain Aptien."	*Places of occurrence near Atherfield.*
Astarte sinuata?	Lower Perna bed.
Panopæa Prevostii.	Atherfield clay.
Mactra Carteroni. Thetis lævigata.	Specimens from the Crackers' group No. 4 have been thus named by M. d'Orbigny. Species of the genus (Thetis) pervade the whole section from No. 1 to 45.
Corbula striatula.	Lower Perna bed.
Gervillia linguloides.	In No. 4 of 'the Crackers' group.
—— Forbesiana (*solenoides* of Geol. Mus.).	In the upper Perna bed, Atherfield clay, and 'Crackers' group.
Lima Cottaldina.	Upper Perna bed, and upper part of 'Crackers' in 9–10.
Natica Cornueliana.	In 5*a*, lower nodules of 'the Crackers' group.
Ammonites Martini.	In the sand (18) of the lower Crioceras group.
—— Deshayesii.	Found principally in the lower part of the section from 2 to 9, the Perna group and 'Crackers;' also in 15, with Scaphites, and in 34*a* of the upper Crioceras group.

I have already intimated the general grounds on which it might be questioned whether any natural subdivisions do universally exist: the argument derivable from the facts just stated would be, that, admitting such a division to be discoverable, the assigned species are not characteristic of it.

The true relations of the strata near Vassy, between the lower "Marnes" of M. Cornuel and the representative of the Portland stone, have been a subject of difficulty to the author himself; and I cannot help thinking that these strata really represent a part of our Purbeck series,—the lowest member of the Wealden;—which would increase the probability that the ferruginous sands above them belong to those of Hastings. M. Cornuel states that there is a discordance of stratification between the list of questionable beds, which he calls "terrain *suprajurassique,*" and those of Portland; and the principal species which he assigns to his "oolite *vacuolaire**" is a Cyrena, of which

* It may be mentioned, as an empirical point of resemblance, that an oolitic stone which has very much the general character of *freshwater* limestone, and in

he states he has not discovered the slightest trace in his *Terrain crétacé inférieure* : with this are found *Mytilus, Melania*, an *Avicula*, and a small species of *Pholadomya* ; *Cyrena fossulata, Avicula rhomboidalis*, and *Pholadomya parva*, appearing in myriads in the doubtful tract near Vassy. Now it deserves remark that all these genera exist in the Purbeck of England, and that M. Dunker, in his recent important work, has figured more than thirty species of Cyrena from the Wealden of Northern Germany*.

I have not, in person, examined any part of M. Leymerie's district on the AUBE ; but specimens of the *Gault* fossils from the vicinity of Troyes, given to me by M. Clement Mullet, identify that deposit with ours ; while the number of species in the Terrain Néocomien of M. Leymerie, to be found in the Table annexed to this paper, can leave no doubt that the strata which contain them are the same ; a resemblance supported by the continuity of this tract with that of Vassy. Nor should I despair of finding even traces of the Wealden also in the department of the Aube.

A valuable collection of specimens from the vicinity of AUXERRE, which was placed at my disposal by my friend M. Constant Prevost, has enabled me to compare some of the fossils of that country with the subject of the present paper. The collection was made, evidently with great care, by M. Delajoye himself, the author of some excellent observations on that region, which appear in the French *Bulletin* for 1838†. The specimens consist chiefly of a calcareous stone of a buff colour, apparently tinged by iron (no doubt a portion of the *Calcaire à Spatangus*), and many of them contain particles of oolitic iron ore. The following list will show the affinity of the deposit from whence they come with our lower greensand :—

List of specimens from Auxerre.

Arca Gabrielis.
Artemis Vectensis, *Forbes*.
Astarte gigantea ?
—— obovata (*A. Beaumontii*, Leym.).
—— near to laticostata.
Cardium imbricatorium.
—— Voltzii.
—— peregrinosum.
Cerithium terebroïde.
Crassatella Robinaldina.
Cyprina rostrata.
Exogyra harpa.
—— Couloni (*lævigata*, Sow.).
Gervillia aviculoides.
—— anceps ?
Isocardia Neocomiensis.
Natica bulimoides.
—— Cornueliana, *d'Orb*.
Panopæa Neocomiensis.
—— plicata.
Pecten quinquecostatus ?
—— orbicularis ?
Pholadomya elongata, *d'Orb*. (*P. gigantea* of *Sowerby* : Geol. Trans. 2nd ser. iv. plate 14, fig. 1.)
Pteroceras.

which the oolitic particles have left only vacant cavities (which no doubt M. Cornuel would regard as "vacuolaire"), is frequent in the thin beds of the Purbeck limestone, immediately above the Portland, in the Vale of Wardour. The whole of these peculiar beds in Dorsetshire, Oxfordshire, and Bucks, well deserves a careful examination. The researches of the Rev. Mr. Brodie show how much can be done by such an inquiry.

* 'Monographie der Nord Deutschen Wealdenbildung.' Brunswick, 1846.

† Tome x. p. 21, &c.

Rostellaria Robinaldina.
Serpula, spec. of.
Corbis corrugata, *d'Orb.*
Spatangus retusus.
Trigonia carinata (*T. harpa*, Leym.).
—— caudata.
—— ornata, *d'Orb.* (*spinosa*, Sow.)

I cannot close these pages without expressing my hope that the history of the *Kentish Limestone*, including the catalogue of its fossils, may be extended and published without delay. This deposit, we now know, is the *Calcaire à Spatangus* of foreign geologists, and probably exhibits that portion of the Terrain Néocomien as distinctly as most of the continental types,—with this important advantage, that its connexion with the adjoining groups, both above it and below, is here distinctly seen. When I call to mind the number of good collections from this tract already existing, but now detached, and the zeal and intelligence of the proprietors, I cannot doubt that co-operation only is required to produce a most valuable catalogue of the fossils. Mr. Hills, formerly of Court-at-street near Hythe, and now connected with the Institution at Chichester, has long since distinguished himself by the discovery of new species in the former vicinity. Mr. Bensted of Maidstone and Mr. Mackeson of Hythe are well-known for their zeal and success as geological inquirers; and Mrs. Smith of Tunbridge Wells is possessed of a cabinet full of rare and interesting fossils. From these four persons only,—and there must be many more,—I am convinced that materials for an excellent list of Kentish fossils could be obtained, if a well-arranged plan for their publication were set on foot; and in the meantime, it must be recollected, the history of our English strata below the chalk is incomplete.

London, July 15, 1847.

t Farham Park in Sus

" Terrain Jurassique Superieur."

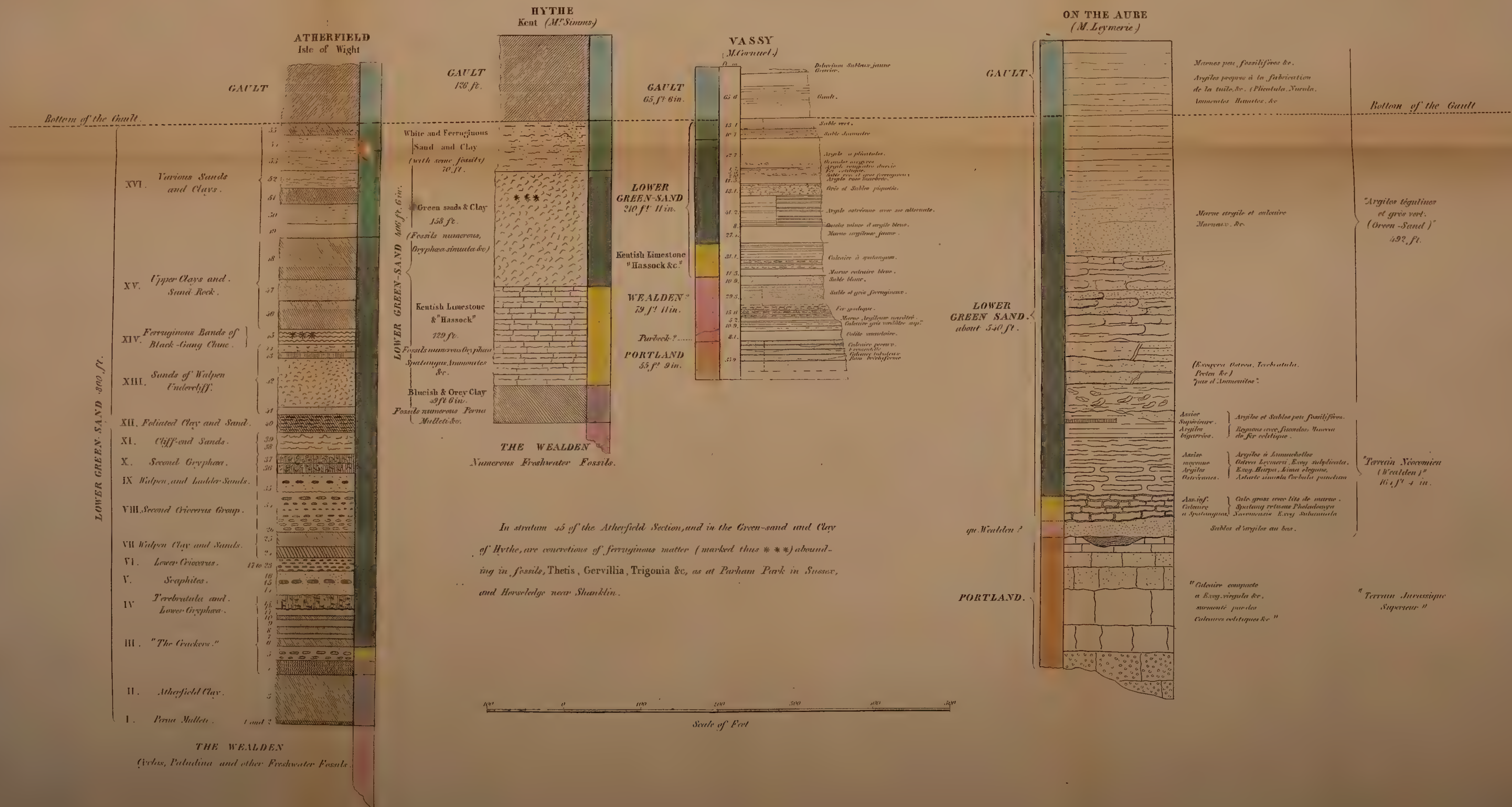
200 300

of Feet

on Stone by Reeve Brothers.

COMPARATIVE SECTIONS OF THE LOWER GREEN-SAND IN ENGLAND AND FRANCE.

to illustrate Dr. Fitton's Paper on the Coast at Atherfield &c.



*In stratum 45 of the Atherfield Section, and in the Green-sand and Clay of Hythe, are concretions of ferruginous matter (marked thus * * *) abounding in fossils,* Thetis, Gervillia, Trigonia &c, *as at Parham Park in Sussex, and Horseledge near Shanklin.*

The publication of the Table referred to in the preceding pages having been retarded by an accident to one of the wood-cuts, I availed myself of the delay to go to Atherfield, where, I was informed, great changes had taken place on the coast during the last year. This account I found (in August) to be correct; the whole of the section from the rise of the uppermost beds of the "*Crackers*" group, westward, to Atherfield Point, being overwhelmed by ruins, from the undermining of the cliff of sand and clay, so that the original features of the place were no longer distinguishable, and even the divisions of the strata scarcely to be seen. The coast beneath the cliffs also, throughout the section from Rocken End to Atherfield, was covered deeply with shingle, rising everywhere up to the base of the cliffs, and entering even into the Chines. The fallen masses, if there were any remaining on the shore, were thus entirely concealed:—and this state of things will probably be continued until the sea, during the gales of winter, carries off the shingle again.

The *mural* cliffs, especially between Cliff-End and Walpen Chine, were much altered by the falling away of large *flakes* parallel to the general surface, such as I have mentioned at p. 308 as cutting without interruption through the apparent divisions of the strata: so that the entire mass of sand and clay here composing the cliff would seem to be continuous;—the divisions, which are prominent after long exposure, either not existing generally, or being in a great measure superficial. I could no longer recognise the separation of No. 37 from No. 36: and the concretional masses of Nos. 38 and 39 were, for the greater part, not to be distinguished; and nowhere so prominent as they had been,—and as it is possible they may become again after exposure.

The surface of the great mass of shingle above-mentioned was so nearly level, and so uniform throughout, as to enable me to revise the measures of horizontal distance with great advantage; and the long continuance of dry weather having rendered several points accessible which in general cannot be approached, I obtained some direct measures of height and thickness—as at Black-gang, and within Whale's Chine—which were very satisfactory. The drawing, therefore, from which the Cut prefixed to the Table has been reduced, is thus more correct, or less erroneous, than before, and perhaps sufficiently so for the purposes of geology. But the reduction of it to the present scale has absolutely excluded such a representation of the features of the coast, as I could have wished to exhibit.

Under the circumstances above described, no addition to my collection of species was to be expected; but I obtained and have added to the Table some new localities of the species already known. The principal of these additions came from a point on the east of Black-Gang Chine indicated in the upper section of the Table by the word "*Fossils*";—where a bed of sand, part of No. 42, apparently unmixed with calcareous matter, was disclosed at the foot of the cliff. This I suppose to represent, or to be near the site of, the calciferous nodules on the east of Shanklin, described at pp. 318, 319, as abounding in fossils.

The specimens obtained here include several of the species most common in the middle portion of the present section, especially in No. 35 and No. 45:—*Thetis, Gervillia, Trigonia* (*alæformis*), *Rostellaria, Natica*;—with *Ammonites Martini*? and another Ammonite, possibly *A. Deshayesii.*

The new places of species thus added to the Table will necessarily produce some difference from the numbers mentioned in the summaries given at pp. 320 and 321; but not such as materially to affect the general results, or to invalidate the argument connected with them.

Since my return to London, Mr. Saxby, of Mountfield near Bonchurch at the eastern extremity of the great "Undercliff," a zealous and judicious collector, has been so good as to send me some specimens from his cabinet, which include the following species, previously unknown upon this coast:—

1. A new and very well characterized species of *Nautilus*. This Mr. Morris will describe, under the name of *Nautilus Saxbianus*. It comes from the lower bed of the Crackers' group, No. 4.

2. *Pinna Gallieni*? (of D'Orbigny);—in a calcareous mass, said to be from No. 14, the sand between the Lower Gryphæa and the Scaphites groups.

From the opposite extremity of the great Undercliff—

3. *Pleurotomaria gigantea* (Geol. Trans. 2nd Series, vol. iv. pl. xiv. fig. 16), from Red-Cliff, Sandown Bay; the species being apparently the same with *P. Pailletteana* of D'Orbigny—Terrains Crétacés, vol. ii. pl. 189;—where, however, the former name and plate have escaped the notice of the author.

4. *Trigonia carinata*, also from the Red-Cliff—same place.

5. With the foregoing species from the Lower greensand is a waterworn mass, found loose upon the shore near Rocken End, and consequently of uncertain original site. It seems to have formed a portion of a *Clathraria*; and, when carefully examined, will probably afford some valuable information respecting that fossil genus.

My friend Mr. Lonsdale informs me that he has ascertained the existence of three new genera and some new species of corals, in my collection of specimens from the vicinity of Atherfield. He will, I trust, himself describe and publish an account of his discoveries in detail; and in the meantime he has favoured me with the following names, as an addition to the list of the Table:—

No. of List in the Table.		Strata.
4.	Cyathophora? (*Michelin*) elegans;—(new species), *Lonsdale MSS.* (*Astrea elegans* of the list at p. 296 above)	I.
5.	Chisma furcillatum;—(new genus), *Lonsdale MSS*................ (*Heteropora* of the list at p. 296)	13
6.	Siphodictyon gracile;—(new genus), *Lonsdale MSS.* .... (*Cricopora gracilis* of the lists at p. 302 and p. 318) ...	13
6 *a.*	(No. 150) Diastopora;—(new species), *Lonsdale MSS*................	I.
6 *b.*	(No. 151) ——;—(new genus, not yet named), *Lonsdale MSS*....	I.

It is perhaps superfluous to state, as a caution to the less experienced geologists into whose hands this paper may fall, that the descriptions and lists of fossils which it contains, are only *approximations*: and that when the "first appearance" or "the disappearance of species" is mentioned in the columns of the Table, no more is intended to be signified, by the former expression, than that the species are from the *lowest point*,—by the latter, from the *highest point* where they have as yet been found: the future discovery of additional species, and of the same species, in other places, being highly probable.

W. H. F.

25th October, 1847.

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

January 1st to March 31st, 1847.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

Académie Royale des Sciences de Paris, Comptes Rendus de l', tome xxiii.; Mémoires, tome xix.; and Mémoires présentés par divers Savants, tome ix.

Agricultural Magazine, January to March 1847.

Agricultural Society (Royal), Journal. Vol. vii. part 2.

American Journal of Agriculture. Vol. ii. No. 2. *From Charles Lyell, Esq., V.P.G.S.*

Asiatic Society of Great Britain and Ireland (Royal), Journal. No. 17. part 2.

Athenæum Journal, January to March.

Berwickshire Naturalists' Club, Anniversary Address, 1846.

Cornwall, Royal Geological Society of, Twenty-third Annual Report.

Geographical Society (Royal), Journal. Vol. xvi. part 2.

Irish Academy (Royal), Transactions. Vol. xxi. part 1.

———, Proceedings. Nos. 48 to 61.

London Institution, Catalogue of the Library of. Vols. ii. and iii.

Philadelphia Academy of Natural Sciences, Proceedings. Vol. iii. Nos. 4 and 5.

Philosophical Magazine. Nos. 198 to 201. *From R. Taylor, Esq., F.G.S.*

Royal Society, Proceedings. Various Numbers.

Vaudoise Société des Sciences Naturelles, Bulletin. No. 13.

Washington, Astronomical Observations at the United States' Naval Observatory. Vol. i.

Zoological Society, Transactions. Vol. iii. part 4.

———, Proceedings. Nos. 161 to 166.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names in italics presented by Authors.

Agassiz, L. Recherches sur les Poissons Fossiles. *From L. Horner, Esq., P.G.S.*

Anonymous. Vestiges of the Natural History of Creation. Sixth Edition.

Ansted, D. T. The Ancient World.

Colquhoun, E. Pye. Translation of the Topography of the Harbours of the Long Walls of Athens, by the late H. N. Ulrichs.

De Koninck, L. Notice sur quelques Fossiles du Spitzberg.

Gardner, George. Travels in the Interior of Brazil. *From Messrs. Reeve, Brothers.*

Grove, W. R. On the Correlation of Physical Forces. *From the London Institution.*

Jobert, A. C. G. The Philosophy of Geology. First Part.

——— Ditto. Parts 1 and 2, English and French. *From B. Botfield, Esq., M.P., F.G.S.*

Krusenstern, Paul von, und Alexander Graf Keyserling. Wissenschaftliche Beobachtungen auf einer Reise in das Petschoraland, im Jahre 1843. *From Sir R. I. Murchison, G.C.S.S., V.P.G.S.*

Logan, W. E. Geological Survey of Canada, Report of Progress for the year 1844.

Lyell, Charles, jun. Principles of Geology. Seventh Edition.

Mantell, G. A. Geological Excursions round the Isle of Wight.

Phillips, John. On the Remains of Microscopic Animals in the Rocks of Yorkshire.

Schimper, W. P. et A. Mougeot. Monographie des Plantes Fossiles du Grès Bigarré de la Chaîne des Vosges. Part 3, Acotylédonées.

Williamson, W. C. On some of the Microscopical Objects found in the Mud of the Levant, &c.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

April 28, 1847.

The following communications were read:—

1. *Introduction to a Second Memoir of* Capt. Vicary *on the Geology of parts of* Sinde. By Sir R. I. Murchison, G.C.St.S., F.G.S., F.R.S.

Geologists are indebted to the enterprising and lamented Burnes for the first general sketch of the structure of the region watered by the Indus. In subsequent years we were furnished with more detailed information by Capt. Grant, who, collecting fossils in the Run of Cutch, gave us the means of ascertaining that in addition to the nummulitic and conglomerate rocks partially described by Burnes, other portions of that tract were of Jurassic or Oolitic age (Oxford clay, &c.).

When the brilliant victories gained by Sir Charles Napier added Sinde to the British possessions, that officer resolved to ascertain more precisely the geological structure and real mineral condition of the new province. Having driven back the Belooches into their mountains, he directed Capt. Vicary, whom he selected for the purpose, to prepare a report on the geological relations of these tracts, which, with the exception of the partial and rapid journeys of Pottinger, Grant and Christie, were unknown to Europeans. The report of Capt. Vicary on the previously unexplored Muree country, from Shakpoor to the Degra valley *, was accompanied by a case of fossils collected under circumstances of unusual difficulty.

Having had the honour of being entrusted by the Earl of Ellenborough and Sir Charles Napier with that report of Capt. Vicary and with his fossils, I laid them before this Society, and an account of them is printed in the second volume of our Quarterly Journal, p. 260.

I have recently been favoured with another letter from Sir Charles Napier, who, previous to the late occupation of the Punjaub, desired Capt. Vicary to gain all possible information respecting the country near Kurrachee at the westernmost debouchure of the Indus, and also to explore the region along the eastern edges of the Hala Mountains, and between that range and the Indus.

This object was to a great extent attained (*i. e.* for a distance of about 200 miles from S. to N., viz. from Cape Monze to the hills west of Larkhana †), when the war of the Punjaub compelled Capt. Vicary to rejoin his regiment and proceed with it to the station of Subathoo, situated on one of the southernmost spurs of the Himalaya Mountains. By this circumstance geologists were sure to profit; for we now learn that long and rapid as were his marches, Capt. Vicary never lost sight of the rocks and their fossils. The collections of the latter are, it is true, still deposited in the distant military quarter of Subathoo, whence we may expect to receive them after some delay. In the meantime it appears to me to be highly desirable that the memoir of Capt. Vicary and his sections should be made known to the Geological Society; since it is certain that the Hala Mountains, which are essentially composed of nummulitic limestones, are surmounted by tertiary shelly conglomerates and beds charged with bones of quadrupeds, many of which are of the same character as those described from the Sub-Himalaya or Sewalik Range by our able associates Dr. Falconer and Major Cautley.

In short, we are now in possession of important additional materials to enable us clearly to define the western limits of that grand former coast-line first laid down by Dr. Falconer ‡, along which terrestrial animals lived in the tertiary period; and after comparing the discoveries of Capt. Vicary with other admirable data of Major Cautley and Dr. Falconer, we can now unhesitatingly say, that the animals of their Sewalik types which once lived on the northern shore of the great tertiary depression of Hindostan were also inhabitants of its western shores, or the north and south ridges of nummulitic limestone, sandstone, &c. (based on older and Jurassic rocks) which actually form the western limits of British rule or influence in the East.

From what I can gather from foreign geologists and palæontologists, particularly from Von Buch, E. de Beaumont and A. d'Orbigny, it

* Shakpoor is in lat. 28° 42′, long. 68° 40′, and the Degra valley in lat. 29° 3′, long. 69° 45′.

† Cape Monze is in lat. 24° 50′, and Larkhana in 27° 30′.

‡ See Transactions of the Royal Asiatic Society.

would appear that they consider these nummulite limestones of Hindostan to be the exact equivalents of the great "terrain à nummulites" of the continent of Europe, which ranges from the Mediterranean into Egypt. M. von Buch had, indeed, the kindness to delineate in a small map (in a note addressed to me last year) the whole range of these rocks from Europe across Egypt and Persia to Hindostan. This "terrain à nummulites," whether connected as by some geologists with the uppermost cretaceous strata, or considered as by others to be of true tertiary age, is admitted by continental writers to lie between the "calcaire grossier" above and the white chalk beneath it. To what exact extent, however, some species of nummulites may descend into unequivocal cretaceous rocks loaded with secondary fossils, does not seem to be yet finally settled; for although M. d'Orbigny contends that no true *Nummulina* has been found in strata containing such cretaceous fossils, several other authors have asserted the contrary*, and Professor Edward Forbes is even of opinion that in the Mediterranean (Ægean) such Nummulinæ occur in limestones beneath the scaglia or representative of the chalk.

To return, however, to the memoir I now communicate, I am conscious that much has been already done by others in ascertaining the general range of the nummulitic beds from Sinde to the northern portions of the Suleeman range and along the base of the Himalaya chain†, on which subject, as well as on the nummulitic salt region, references may be made to Falconer, Jacquemont, Lord, Hutton, Griffiths, Jameson, &c.

On the present occasion, however, I am bound also to call special attention to the efforts made by Capt. Vicary to describe in detail the increment of the diurnal tidal accumulations near Kurrachee; to his patient exploration of the eastern edges of the Hala Mountains, and his transverse sections of the same; to his curious observations on the linear outbursts in those tracts of hot springs in conjunction with cross fractures of the ridges; to the extraordinary accumulations of travertine, and above all to his copious collections of fossil vertebrata from the extensive tracts of the Hala Mountains, along which he has traced bone-beds similar to those of the Sewalik Hills. I have therefore written these introductory lines concerning an absent explorer, in the persuasion that his zealous endeavours and the enlightened support of my former brother-officer Sir Charles Napier will be duly appreciated by geologists.

* See Sections and Descriptions of the Northern Flanks of the Eastern Alps by Professor Sedgwick and Sir Roderick Murchison, Trans. Geol. Soc. 2nd Ser. vol. iii. p. 301, and the Terrain Hétrurien of Professor Pilla, Trans. Geol. Soc. France, vol. ii. p. 163.

† I learn from Dr. Falconer, that about eighteen months ago, Lieut. Blagrave, employed as a surveyor in Sinde, sent home a large collection of pleistocene, eocene and nummulitic fossils.

2. *Notes on the Geological Structure of parts of* SINDE. By Capt. N. VICARY of the Hon. East India Company's Service, in a letter addressed to Sir R. I. MURCHISON, G.C.St.S., F.G.S., F.R.S., and communicated by him to the Geological Society.

SIR,—The following geological notes were written during an excursion from Kurrachee to Sukkur in November and part of December 1845, and as so little is known with respect to the geology of Sinde, I trust that even these rude notes may not prove unacceptable.

The station of Kurrachee, lat. 24° 53′, long. 67° 17′, is situated upon a coarse-grained, dirty yellowish, arenaceous rock, held together by a calcareous cement. In some places this rock is loose-grained and easily worked, in others hard and containing sufficient calcareous matter to afford an impure lime. In all places it contains fossils in abundance. This rock, although conformable, lies higher in the series and is more recent than that which composes the elevated parts of the Hala range of mountains. It is in many places directly overlaid by a calcareously cemented conglomerate, in other places a sandstone of some thickness intervenes. This sandstone is usually destitute of fossils, but near Kurrachee some of its thin beds, varying from 1 inch to 2 or 3 feet in thickness, are composed almost exclusively of fossil shells.

The pebbles forming the conglomerate are all rounded, and for the most part derived from the nummulitic limestone of the Hala range, and I found some broken remains of oysters and Cerithia in the rock. A conglomerate retaining the same character is found flanking the eastern face of the Hala Range, from Cape Monze to the west of Mittun-Kot. In some places it attains sufficient elevation to constitute a distinct and well-defined range, and is often of vast thickness. We are still in want of information as to its extent in a northerly direction along the base of the Sulleemaun Range.

The neighbourhood of Kurrachee is characterized by low hills, not exceeding 200 feet in height. In many places they appear like islands in a shallow sea, and a subsidence of 150 feet would make them so; in other places they form a continuous narrow range for two or three miles. They are often capped with the conglomerate, disintegrated at the surface, but still cemented beneath. The low intervening valleys and plains are composed of the same coarse arenaceous rock on which Kurrachee stands. It is evident that the conglomerate, sandstones, &c. have there been removed by the action of water; by tidal action perhaps, while the whole country was submerged. About three miles east of the station there is a low range of hills running nearly parallel with the sea-coast, from which they are now distant between four and five miles. The rock is a fine-grained sandstone without fossils, in some places capped with conglomerate, in other places that rock has been swept away. The western face of this sandstone forms an abrupt cliff, and undoubtedly has at some period been subjected to the ebb and flow of the sea. The cliff is everywhere eroded by the action of the waves, and is in many places pierced by saxicavous mollusks. About a mile to the southward of these hills, and three miles to the S.E. of Kurrachee, the coarse arenaceo-calcareous rock is elevated into low hills, which present a very remarkable appearance. The surface is divided into numerous parallel-sided, cistern-like figures by septa of a harder calcareous rock, which has better resisted the action of the elements. The septa are of various thickness, 6 inches to a foot in height, and include areas of two or three square yards. At this place I found Astrea abundant, a shield-shaped Clypeaster, a very large species of Conus (10 inches to a foot in length), a large Strombus, and a bucciniform Volute upwards of 14 inches in length, and not unlike the "Sunk" of the Brahmins. All these specimens were too heavy for a travelling geologist's collection. In the valley, at the base of this hill, there are two springs of intensely salt water.

The following table will serve to give a general idea of the relative position of the beds composing the Hala Range, and the formations existing in Sinde:—

1. Conglomerate.
2. Clays and sandstone.
3. Upper bone-bed.
4. Sandstone, fossils rare.
5. Lower bone-bed.
6. Coarse arenaceo-calcareous rock with *Cytherea exoleta*? and *exarata*: Spatangi: no Nummulites.
7. Pale arenaceous limestone with Hypponyces, Nummulites, and Charoideæ.
8. Nummulitic limestone of the Hala Range.
9. Black slates, thickness unknown.

The bone-beds are of a deep rust-colour, often soft, but in many places hard and appearing as if vitrified. In such places there are no fossils, the rock is arenaceous, owing its colour to iron, and seems to be partly cemented by it. The upper bone-bed is often absent, as in the vicinity of Kurrachee. I have seen a few bones in the lower part of the sandstone No. 4. The bone-bed No. 5 is found throughout the Hala Range from Cape Monze to the Beloochistan hills N.E. of the Bolan Pass; and how much farther it may be produced in a northerly direction remains to be determined. This bone-bed is of variable thickness (from 50 to 500 feet), but preserves the above-mentioned character everywhere, and is easily recognized even at a distance.

No. 6. The rock of the vicinity of Kurrachee is easily recognized by the abundance of a fossil which I take to be *Cytherea exoleta*, and the absence of nummulites. The next in descending order, No. 7, is not often seen as a distinct bed. It is distinguished by the number and size of individuals belonging to the genus Hypponyx which it contains, and also by vast numbers of a small circular-shaped fossil.

No. 8 constitutes the backbone of the Hala* Range, and abounds with nummulites, &c. I shall make an attempt hereafter to point out such fossils as are peculiar to each bed, and in the absence of any designation I shall refer to each bed by the numbers given above.

The harbour of Kurrachee is protected by two rocky islets and Minora Point, all of the same formation. A section on the seaward

* The southern portion of the Hala Range is styled "Hala or Hurbooe Mountains" in Walker's Map (Brahooick of Pottinger).

face of Minora Point exhibited the following details in a descending order:—Conglomerate 60 feet; sandstone 3 feet; bed composed almost exclusively of Ostreæ 2 to 4 feet; sandstone 5 feet, at base becoming highly calcareous, and there containing innumerable Turritellæ; lastly a fine-grained sandstone extending to the base of the cliff, in which no fossils were apparent.

Minora Point is connected with the Hala Range about 25 miles distant, in the direction of Cape Monze, by a narrow bank of dry sand, which alone separates the present harbour from the open sea. On the eastern side of the harbour there is also a dry bar of sand, stretching from Clifton towards Minora Point. Within the harbour there are mud flats* covered by water at each tide, abounding with three species of Cerithium, one of which I recognized as being also common at the mouth of the Ganges. In the deep water *Placuna placenta* is most abundant, and has been fished for from time immemorial on account of the pearls often found in the shells. An island close by is covered to the depth of four or five feet, and to an extent of two acres or more, with shells accumulated in this way.

At present no river discharges itself into the harbour, the channels affording little water unless during falls of rain, which I was told take place about once in four years; but there is every reason to think that a branch of the Indus at one time discharged itself here. The general shape of the harbour with its bars and mud flats is favourable to this idea. About half a mile to the westward of Minora Point in the direction of Cape Monze, the action of the sea and wind on the beach has laid bare a stratum of black clay containing vast numbers of oysters and broken Cerithia belonging to the species now living in the harbour. At first I was inclined to consider that this was a post-pliocene formation, but I remarked that an inshore wind, or sea-breeze as it is called, prevails for a great portion of the year, and blows at times with considerable violence. This wind is constantly drifting the dry sand into the harbour and filling it up, the discharge of water every tide no doubt again carrying out a portion of the sand thus drifted. The sea however is gradually gaining on the harbour, and will continue to gain on it by the gradual drifting forward of the sand belt, and I have no doubt that the stratum of black clay with Ostreæ above noticed, was at one time *within* the harbour and formed a portion of its flats. On the land side the harbour is also gradually filling up from the quantity of detritus carried into it by every fall of rain, which remains wherever it is left by the temporary flood. There is *now* no river affording a constant supply of water to carry forward such a deposit, and it is affected only by tidal action, which is not sufficient to keep the harbour open. The sea opposite the mouths of the Indus is, as is well-known, shallow, and it is also shallow opposite Kurrachee. At Clifton, on the eastern side of the harbour, at low-water mark, I found the broken stems of trees with roots in their natural position. The grain of the wood was still perceptible, but Pholades had pierced it in all directions and were still domiciled in it.

* The flats are generally covered with a species of mangrove, *Ægiceras fragrans*.

About a mile-and-a-half east of the station there is a post-pliocene clay about 60 to 100 yards in breadth, 6 to 10 feet in depth, and a mile in length, which fills a depression, or denudation, in the arenaceous rock No. 6. It has been cut through by a water-course, and in the section exposed I found numerous Pupæ, Planorbi, Melaniæ, a Terebellum, numerous broken columellæ of Cerithia, and some beads made of fish-bone, in all respects similar to those worn by native children at the present day. Close to this on the surface I found some fossil bones of crocodiles, but in a rolled and broken state.

From Kurrachee in the direction of Munga-Peer to the foot of the lower hills (the outskirts of the Hala Range), a distance of about four miles, for the most part a dead level, but rising gently near the base of the hills. It is possible that the ancient branch of the Indus, above alluded to, found its way to the harbour in this direction. Sections exposed by digging wells in the plain give the following descending succession:—(*a*) 8 to 10 feet of a stiff yellow clay, containing numbers of Planorbi, Pupæ, Melaniæ*, with fragments of a small species of Cypræa, and occasionally of oysters and Cerithia. (*b*) A bed of pebbles evidently derived from the broken-up conglomerate. (*c*) Sand resting on a light blue laminated clay. Approaching the hills the plain becomes gradually obscured by a bed of gravel and large pebbles, increasing in depth to the base of the range on which it rests. From the base of the hills to Munga-Peer I followed the course of a valley; the rock composing the elevations on either side being the nummulitic limestone of the Hala Range with its peculiar fossils. Munga-Peer is a basin enclosed by hills excepting to the N.W. and the valley by which I entered from the S.E. There are two hot springs situated near the centre of the basin; both rise from partings of the strata, which at these points crop out at an angle of 50°. The springs are about half a mile apart, and the water is sweet. That of the most northern is so warm (124° Fahr.), that I was obliged to withdraw my hand immediately. The other is 99°.

There is not a vestige of a volcanic rock near, but the nummulitic limestone through which the springs burst has been rendered somewhat crystalline by heat, and the fossils in the rock are almost obliterated. The basin of Munga-Peer is partly filled with a post-pliocene formation similar in all respects to that noticed above. In addition to the shells above-mentioned, I found an Arca and a Nerita. The Cerithium is exactly the same as that now existing in the harbour of Kurrachee. I found this clay formation mounting up to a pass through the hills to the westward, at an elevation of 300 feet above the level of the basin. To the N.E. this clay contains a great quantity of "Konkur," the well-known tufaceous formation of India. A little farther in the same direction there is a narrow cleft in the range of hills separating Munga-Peer from the plain without, through which the drainage of the basin is effected by a small stream, on whose banks I found considerable quantities of a pure white salt, in some

* This Melania is found recent throughout Sinde, and I have often seen them in water too salt to drink.

places 6 inches in depth; but as my specimens are lost, I cannot describe it*. From Munga-Peer I proceeded in a north-westerly direction to the Hubb River; after the first mile the land gradually slopes into the valley of the river, in the bed of which I found numerous rolled fragments of the black slate upon which the nummulitic limestone is known to rest. This being the boundary of our possessions in Sinde, and finding that the formation differed in no respect from that already visited near Deyra in Northern Sinde, I returned to Kurrachee.

From hence, owing to the difficulty of procuring both water and supplies, I was necessitated to proceed in a north-easterly direction towards Hyderabad, instead of moving along the foot of the highest range of the Hala as I wished. This direction had its advantages, however, as it led me across all the water-courses descending from the Hala Range to the Indus.

Leaving the above-mentioned salt-springs on my left, and clearing the rock formations of Kurrachee, I came upon an extensive plain composed of a tenacious yellow clay, similar to that seen at Munga-Peer, and like it abounding with Pupæ and Melaniæ. The clay is, in many places, concealed beneath hills of loose drifted sand: $2\frac{1}{2}$ miles beyond Jemadar-ka-lande and about $15\frac{1}{2}$ miles from Kurrachee, I came upon low sandstone hills with still lower hillocks of various-coloured clay on their northern aspect. I found here scattered on the surface large quantities of the fistular fossil which I have noted under the name of Tubularia, pieces of silicified wood, a tuberculate Pleurotoma, and a small fossil bone. No water being procurable here, I pushed on to Guggul, 25 miles in an easterly direction from Kurrachee, and 13 miles from Jemadar-ka-lande. At about the seventh mile from Jemadar-ka-lande, I came upon a calcareously-cemented sandstone with numerous Tubulariæ and Ostreæ. Thence to Guggul there is a plain of tenacious yellow clay, similar to that between Kurrachee and Jemadar-ka-lande, but with gravel beds occasionally coming to the surface. The sections exposed by the Guggul show that the clay at that place rests on a fine-stoned conglomerate. In the clay immediately above the conglomerate, I found Melaniæ and Pupæ abundant.

Hence to Nao-nehal, on the right bank of the Maulmaree river† (now dry), 11 miles. The country from Guggul to within a quarter of a mile of the Maulmaree rises gradually, and at that place terminates in a sharp escarpment with a general N. and S. direction.

* A shallow pond receives the water of one of the hot springs, and in it upwards of 300 crocodiles are domesticated. They have been there from a very remote period, and it seems difficult to say when they were first placed there. They breed, and the young ones are even more numerous than the old. Many of them are quite tame, allowing themselves to be touched and patted with the hand. The species is well known in India under the name of "Mugger." (*Obs. by Dr. Falconer.*—"The Mugger crocodile of India is perfectly distinct from the Nile species. There are even three Indian species of true crocodile.")

† All the river beds are dry at this season from Kurrachee to Kotree near Hyderabad, but water is found by digging to a greater or less depth in the river beds.

Fig. 1.

The clays and conglomerate gradually thin off and cease at about the sixth mile from Guggul, and are replaced at the surface by an arenaceo-calcareous rock agreeing closely with No. 6. The descent from the cliff is effected by the Rund Pass, and the elevation above the Maulmaree river may be about 450 to 500 feet. Near the pass there are many scattered islet-like plateaux of small elevation, and appearing as if they had been subjected to the action of water; their overhanging margins were in some places bored by saxicavous mollusks. An examination of the cliff (although its base was usually obscured by debris) showed that the lower beds become still more arenaceous, until they assume the form of a fine-grained, pale yellow sandstone; beneath this there is a variegated (red, white and blue) laminated clay, apparently devoid of fossils. In the debris at the base of the cliff I found some fossil bones evidently disengaged from the arenaceous rock above, as they differ greatly from the fossil bones usually found in Sinde, which for the most part owe their hardness to hydrate of iron. The bones found here are soft and with a calcareous infiltration. Many of them appear to have lain at the bottom of the sea previous to fossilization, have been rolled by the action of currents, and are occasionally pierced by boring mollusks. The fossil most abundant in the lower part of this rock is an Ostrea with the upper valve flat and smooth, the lower concave and costate, and evidently a gregarious species. A very large Pecten also occurs, upon which I shall make some remarks hereafter. Nummulites are very rare, but Clypeastra and Spatangi most abundant. Hence I followed the course of the river bed in a northerly direction along the base of the "Bubbera Steppe" for about seven miles. In the sands and gravel of the river I found innumerable detached nummulites, which are often carried forward even to the Indus, and are doubtless brought down from the Hala Range. The Maulmaree during rain becomes an impetuous and impassable torrent.

The fossils of the Bubbera Steppe are almost obliterated, apparently by the former action of heat. At the time when the steppe was uplifted, a portion of rock about 200 yards in length was left in a mural and almost perpendicular position, and is now about sixty yards from the general line of the Bubbera Steppe. The intervening space is characterized by calcined clays and broken masses of a vitrified arenaceous rock.

In examining the hills to the eastward of the Maulmaree, I found a pale yellow arenaceous limestone with nummulites (No. 7) lying immediately beneath the coarse non-nummulitic rock of Kurrachee (No. 6). In the depressions and water-courses I found comminuted and broken fossil bones in vast abundance, but no entire specimen. From this to Kawranee is 15½ miles in a north-easterly direction; at about the fifth mile I emerged by a pass into a tolerably level country, small hummocks of a pale yellow limestone with Hypponyces occasionally protruding from the general level. The surrounding country is composed of the yellow clay above-mentioned, with Melaniæ, Pupæ, &c., but in many places concealed beneath sand-hills.

In the Kawranee river bed, now dry, a good section of the pale yellow limestone (No. 7) is exposed. In this stratum I observed an Hypponyx and two species of Nummulites to be most abundant, with large quantities of a minute fossil, which was well-known to our army in Caubul under the name of "Petrified Rice*," claws of Crustacea, a Nautilus, a large Cytherea ?, and many other fossils.

I proceeded hence to Rodh, thirteen miles over an extensive plain. In some places water-courses had cut down to the rock beneath, which I found to be identical with that of Kawranee (No. 7).

Sections exposed by the Rodh river exhibit conglomerate, cemented towards the base, but disintegrated above, and in many places surmounted by yellow clay of inconsiderable thickness, containing Melaniæ and Pupæ, but no other fossils.

Hence to Woor, 18½ miles in a north-easterly direction. For the first mile conglomerate occasionally protruded through the clay, and then a sandstone nearly horizontal, with pebbles and fossil wood scattered on its surface; the general aspect of the country up to the ninth mile being level. At this point I came upon the pale yellow limestone (No. 7), and hence, by a gentle ascent for about three miles, to the Junnett Pass, where I found fossils in all respects agreeing with those obtained at Kawranee.

The country between Kurrachee and Kotree is characterized by a succession of steppes; the slopes at a small angle to the west coincide with the stratification, and the abrupt cliffs have an easterly exposure, at the bases of which water-courses are usually found.

To the N.N.E. of Junnett Pass, 1½ mile, there is an outlier forming seven peaks, known to the natives by the name of Saut-Raee. These peaks have an elevation of from 300 to 400 feet above the plain, and are for the most part composed of the yellow limestone (No. 7). I was unable to visit them, as the only water obtainable at this season in that neighbourhood was putrid and unfit to drink; in fact no water was to be had between Rodh and Woor, 18½ miles. From Junnett Pass, by a gradual descent to Woor, where the country is a level plain, the section exposed by the Woor river is nowhere deep, but shows that the yellow clay of the plain rests on conglomerate. In the river bed I found numerous nummulites in the sand and gravel; both banks are flanked to a great distance by hills of drift sands, generally crowned with Tamarisk and *Acacia Catechu*. From this to Kotree twelve miles of level country, being made up of an

* This fossil was since taken to Paris by Sir Roderick Murchison, and was identified by M. A. d'Orbigny to be an Alveolina. The associated forms of this class are in the limestones of Sinde Nummulina and Assilina (D'Orb.).

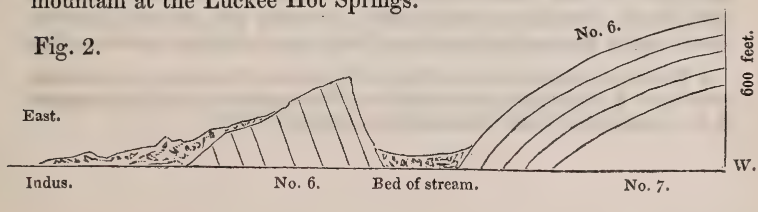
irregular coating of sand resting on the same yellow clay so often alluded to. Kotree is on the right bank of the Indus opposite to Hyderabad.

Having taken in supplies, I proceeded hence to Ukka-Nag, a spring of sweet water in the hills, about seventeen miles N.N.W. from Kotree: thirteen miles of this was over the plain through which the Indus now finds its way to the sea. I then came upon hills of small elevation trending N.N.E. and S.S.W. The range here is composed of isolated hills not exceeding 400 feet above the plain of the Indus, their apices level with nearly horizontal strata, their sides abrupt and precipitous, the uppermost beds being in all respects similar to the non-nummulitic rock (No. 6). The valleys or intervening spaces between these hills have been much disturbed. A variegated clay abounding with gypsum is of common occurrence, but contains no fossils. A brown rust-coloured rock is abundantly distributed on the surface near this, in the form of large rounded boulders, and the Kotree blacksmiths occasionally visiting this place select the most promising specimens, and transport them to Kotree for the manufacture of iron.

Hence, in a northerly direction, I proceeded to Buchera in the plain of the Indus for about fifteen miles, and the country passed through held the same character to within half a mile of the base of the hills: here I found the conglomerate resting on a thin bed of arenaceous rock which I could not identify, and which reposed upon No. 7. The conglomerate eventually disappeared beneath the yellow clay of the plain.

Water was not to be had within the hills at this season of the year; I was therefore obliged to continue my journey as far as Luckee through the plain of the Indus. The Kotree range of hills terminates nearly west of Majinda, and is succeeded by another range trending nearly north as far as Sehwan; the water of this range, except at Rennie-kote, is salt and unfit for use; the hills attain considerable elevation (from 600 to 800 feet) above the Indus, towards which their aspect is very precipitous; they are the abode of the true Ibex. Between this range and the Indus there are numerous low hillocks of aluminiferous clay, from which the Sindees manufacture alum. I was unable to ascertain the exact relation of these clays with respect to the beds entering into the formation of the more elevated range. The proper time to explore this place would be after a fall of rain, when water would be obtainable from ponds.—Moved on to Luckee, which is about sixteen miles to the southward of Sehwan. The range here approaches the river, and is of easy access. It is not so high here as further to the southward, and becomes gradually lower in a northerly direction towards Sehwan, where it terminates. The following section will give some idea of the range of mountain at the Luckee Hot Springs.

Fig. 2.

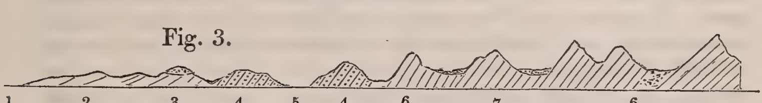


I obtained the above section from a transverse cleft dividing the range, like many others in the neighbourhood; and from the base of one of them a hot spring issues, the water of which is highly saline. The curvature of the beds composing the range of hill on the western side of the valley is indeed very interesting, and would at once arrest the attention of the most unobservant person. The bed of the stream (for the most part dry) has a mean breadth of about ten yards. I followed it in a southerly direction for about four miles with the same mural precipices on either side of me: the mural beds to the eastward have evidently been thrown over at the time of upheaval, and were once an overlying portion of the formation to the west. The outer or more eastern face (that next the Indus) is a heap of ruins or debris, composed of angular blocks of the same rock, of all sizes, and from the base of this, for two miles towards the Indus, there is a "boulder gravel," derived from the disintegrated conglomerate. The upper beds of this range are similar to the Kurrachee rock No. 6, and in the clefts are seen to rest on No. 7. The fossils in the rock in the vicinity of the hot springs are almost obliterated, a circumstance previously remarked near the hot springs of Munga-Peer. I entered the valley by a narrow cleft in the eastern barrier opposite to the village of Luckee; the stream of the valley finds egress at the same point. Opposite to the pass, and on the western side of the valley, there is another hot spring; the water of which is highly mineral, and contains sulphur combined with calcareous matter and some salt; it is of the colour of soap-ley and also detergent. A dense scum is constantly rising to the surface of the pond over the spring: some Sindees, who appear to be constantly in attendance here, skim it off, and when a sufficient quantity is collected, take it away for the purpose of obtaining the sulphur which it contains. They were averse to answering my questions, and would give me no information as to the quantity obtained in the process. I noticed that a quantity of air is extricated from the spring, and is constantly rising in bubbles to the surface. The whole valley smells strong of sulphuretted hydrogen, which to some persons is very oppressive, causing violent headache. Near the spring, in a perpendicular face of rock beyond my reach, a hole about three inches in diameter was pointed out by my guide; some years since an inflammable gas issued from this, and having become ignited, was known and revered by the Sindees under the name of "Puri ka Chiragh," or the Peris Lamp. It became extinguished some time ago (as the Sindees say) because some impure idolator had bathed in the well.

The water which runs from this spring has great reputation amongst the natives of this country as a remedy in cutaneous diseases. I noticed that it encrusts leaves, branches, &c. with a calcareous coating, and I found some of the species of Melania, so common in Sinde, living in the stream. This is worthy of notice, because the water is so strongly impregnated with saline matter that it is not drinkable. From hence to near Sehwan the character of the range is the same; at about the fourth mile the Indus washes its base, and the cliff next the river is in ruins, composed of angular blocks of all sizes. Near this place, in the bed No. 7, I found tolerably perfect specimens of a species of Crab, and large but broken specimens of Hypponyx, some portions of which were one inch and a half in thickness. Further on I crossed the range, which, as I before stated, loses its elevation and eventually disappears near Sehwan. To the west there is a broad valley with numerous low isolated hills of sandstone, and various coloured clays; but I regret not having had time to examine this place with attention.

From Sehwan I moved across an alluvial plain to Treenee, a quarter of a mile south of the Munchal Lake, and about fourteen miles west of Sehwan. The Munchal Lake at this season was about twenty miles in length (east and west), ten miles in breadth, and is in many places of great depth. I have no doubt that it was excavated in former times by the Indus; the southern side of the lake is for the most part flanked by low hills, which turned the course of the old stream sharply from a southerly direction to east, or perhaps the northward of east, to pass the range of hills terminating near Sehwan. The back-water caused by such a sharp deflection of the current I suppose to have excavated the lake: during the season that the Indus rises it still continues to receive a supply of water, but the current is insignificant. The low hills near Treenee are composed of indurated clays passing downwards into an arenaceous rock, and occasionally capped with boulders derived from the conglomerate. Hence for fourteen miles round to the western margin of the lake, my road lay for the most part through the low hillocks above-mentioned. Alum is obtained by digging in this formation somewhere near to this place (Shah-Hussan), but the Sindee guides took care that I should not see where they procured it. Hence N.N.W. to Gaza-Peer, seven miles; up to about the fifth mile, I was passing through these low hills, and on approaching the Hala Range the beds are seen to be capped with conglomerate, and eventually to sink down, the conglomerate only appearing at the surface. The latter rock in a short time also disappears beneath the surface of a level plain two miles in breadth, being the distance to Gaza-Peer. These small hills belong to No. 2. of the Table, page 335, and are similar to those mentioned as flanking the Sehwan range near Majindah; they also correspond with those near Ooch, north of Shickarpoor; the beds dip to the east at various angles from 20° to 35°. Gypsum is occasionally found in the clays; I made most diligent search, but was unable to detect a single fossil form. The yellow clay filling the valley is perfectly level, and abounds with Viviparæ, Pupæ and Melaniæ; I could not obtain a section anywhere, but have reason to think that the whole rests on the conglomerate.

Fig. 3.

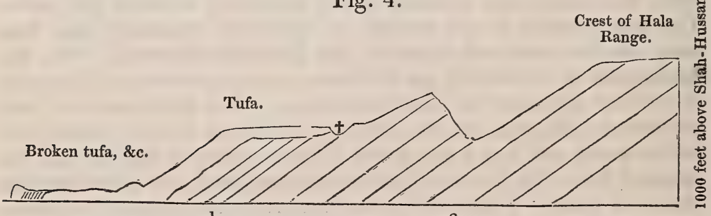


1. Shah-Hussan.
2. Indurated clays.
3. Aluminous, gypsum rare.
4. Conglomerate.
5. Alluvial? valley, Gaza-Peer.
6. Vitrified sandstone.
7. Kurrachee rock No. 6.

The above rough section from Shah-Hussan to the crest of the Hala Range, about sixteen miles (though not very correct), will I hope be sufficient to give a general idea of the beds forming the Hala Mountains ; the western beds, marked as vitrified sandstone, strongly resemble the bone-beds, but bones at this point are exceedingly rare, and I found but a few small broken pieces of them.

The conglomerate rises from beneath the clays of the valley at Gaza-Peer, attaining an elevation of from 100 to 250 feet, and forming a well-marked range, stretching north and south as far as I could see; it exhibits an arrangement into distinct beds, dipping to the east at angles varying from 30° to 45°, the cement being calcareous, and the stones mostly of nummulitic limestone. I found a few minute portions of quartz and some Ostreæ (broken) imbedded in it. Moving west, across a narrow valley, I came upon a range equal in height to the conglomerate at Gaza-Peer, with the same direction and general dip; it forms a mural barrier, passable only by those occasional transverse, or east and west clefts, so common throughout the Hala Mountains: the rock is of a rust-colour, the weathered surface of the beds often polished and having the appearance of vitrified sandstone. Next (moving west) came upon the Kurrachee rock No. 6, with its usual fossils; this also forms mural cliffs. Further west there were mural barriers, composed of a hard sonorous rock devoid of fossils, and also appearing like vitrified sandstone: they form two or three parallel, wall-like ranges, and in some places attain an elevation of 400 feet from their base. I found a few detached and broken morsels of bone here, but no other fossils. Passing through these natural walls, I came upon a recent tufaceous formation of great extent, reaching to the base of the highest range of the Hala Mountains, about two miles. At first it was much broken and intermingled with fragments of the neighbouring rocks, and from the quantity of detached masses dispersed on the surface, even to Gaza-Peer, I imagine that in former times it must have covered a very wide area. Shortly afterwards I reached the tufa *in situ*, nearly horizontal, containing casts of leaves, branches, &c., numerous Pupæ and Melaniæ. It is to be remarked, that the place thus noted is one and a half mile from the waterfall of Peeth, a point where this tufaceous rock is daily forming. Peeth is at the foot of the central and highest range of the Hala Mountains, and when seen

Fig. 4.



1. Arenaceous limestones with nummulites, fossils indistinct. † Hot spring.
2. Nummulitic limestone No. 8.

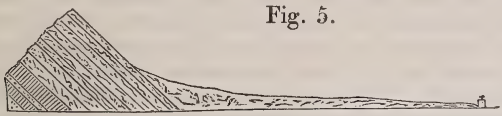
from half a mile distance it presents an extraordinary and interesting spectacle.

A valley opens out on the confined plain at the foot of the hills; the mouth of the valley, about 500 yards across, seems as if a wall, not unlike the glacis of a fort, had been built from side to side; a waterfall precipitates itself from above at this distance like a silver thread, the scanty green grass on either side helping to throw it into relief. Close by there are a few scattered trees of *Tecoma undulata*, which aid in softening the monotony of a scene otherwise naked and barren. On reaching the foot of this natural glacis, where I encamped, I found that the rock was entirely composed of recent tufa deposited from the stream of water now flowing. Its height is better than 300 feet, and in some places is of great thickness. The only section I could obtain (near the southern margin) gave a depth of from 25 to 30 feet. It appears stratified (if I may use the term), owing to its deposition in successive layers; the dip on the glacis is from 35° to 45°, accommodating itself to the dip of the nummulitic limestone beneath. The lower and older beds are yellow, the upper and newer white. I found numerous shells imbedded in it, all agreeing with the species at present existing in the neighbourhood. On the face of the glacis there are five elevated tufaceous walls at irregular distances; each wall varies from a foot or less to five feet in height, with the sides in some places nearly perpendicular; three of these are prolonged with a height of five feet for some distance into the plain below; all are channeled above; four of them are old and deserted beds of the stream; the fifth is the course of the present stream, which is not larger than an English mill-stream. The water is derived from a hot spring, and is warm at the head of the waterfall, but becomes cool and parts with much calcareous matter in its descent. The deposit is more rapid on the margins of the stream than in its bed, and hence the walls originate. They occasionally break down from floods or other accidental causes, when the stream spreads over the glacis, giving a fresh coat of deposit over a considerable area; in time the stream again contracts, forming its lateral barriers, and eventually, when limited in its channel, becomes elevated in the manner I have attempted to describe. There are several wide fissures in the tufa, formed doubtless at the time of earthquakes: most of them have been filled up with broken tufa and some foreign substances cemented by a new calcareous infiltration. From the head of the waterfall to the hot spring is about 650 yards. The tufa extends to the spring, but thins off gradually, and here rests on the upturned edges of the limestone beneath. The hot spring rises at the foot of one of the numerous transverse clefts which everywhere intersect the Hala Mountains. The water smells of sulphuretted hydrogen, but has little other mineral flavour, tasting like boiled water, and has a pale green colour. Gaseous bubbles are disengaged from the head of the spring along with the abundant discharge of water. I have endeavoured to give some idea of this place, because a recent freshwater formation of considerable extent exists, the causes of which are now in operation. In the valleys north and south of this place (Peeth) there are also other tufaceous formations, often of great extent, but the streams or springs from which the deposit was formed have long ceased to exist, and the tufa is broken and dilapidated. From the hot spring I ascended the crest of the Hala Range, which at this place has an elevation of about 1500 feet above the sea; the rock is the nummulitic limestone so often alluded to as constituting the backbone of these mountains. The beds dip at about 30° to the east, the limestone is hard, compact and subcrystalline, and the fossils at this point are very imperfect and ill-preserved. The range, characterized by isolated peaks, becomes gradually elevated towards the north, and in that direction was enveloped in clouds at the time I ascended. A continuous ridge, only broken by narrow clefts (formed I presume at the time of upheavement), conveys to the mind the best idea of them. The highest portion of the Hala Range is not more than 3500 feet above the sea. I was unable to prosecute my examination further in this direction owing to the utter deficiency of water in the mountains, and I therefore returned to Peeth. Hence I proceeded northerly six miles to a well two miles beyond Shahdad-ka-gote. The well, the water of which is tepid, is about 70 feet in depth, and is bored through the conglomerate, which is met with at about twelve feet from the surface. From this I proceeded to Ali-Morad-ka-gote, about 4½ miles north-east. The country passed over is sandy and tolerably level, being a plain of from one to two miles in breadth, widening towards the north, and situated between the outer range of mural cliffs and the more elevated Hala Mountains. The low hillocks near this are composed of various coloured clays like those at Shah Hussan, passing downwards into sandstone, and often crowned with conglomerate, the pebbles of which are small. The beds here, owing to some local disturbance, dip at an angle of about 12° to the west. Hence to Johee, fourteen miles, no water was to be had at any intermediate point, the roads for the most part passing over a naked and barren desert. At this place the villagers informed me that a small river came through the Hala Range by the "Kaphooee" Pass, and was to be found in a north-westerly direction from Thulvee. I accordingly pushed on for the latter place, about twenty miles; and thence north-west across the tail of the desert and by Gool Mahommed-ka-gote, about eighteen miles, to the gorge whence the "Gauj" river debouches on the plain. This river is not laid down in any map that I have seen. At this dry season it was knee-deep, and about fifteen yards in breadth; but at certain seasons it is subject to great floods. It rises to the westward of the Hala Range, and finds its way by a transverse cleft, known as the Kaphooee Pass, to the plains of Sinde. This place is well-calculated for a canal-head, and is worthy the attention of the authorities in Sinde. Irrigation is now effected to some distance, but under European superintendence much more could be done; and a vast tract of country, now a desert, could be rendered fertile by the judicious use of the water of the Gauj.

The outer range at this place is composed of conglomerate in well-marked beds, dipping into the plain (towards the east) at from 25° to

45°; beneath this there are clay beds and sandstones, with which the conglomerate often alternates. This range, holding the same character, extends north and south of the Gauj river as far as my eye could reach; in some places it attains an elevation of from 600 to 800 feet above the plain. From its base to six, and in some places eight miles, the broken-up conglomerate has been spread out, and exhibits all the characters of an ancient beach.

Fig. 5.



Talus of three and a half miles to Raja Derah.

The valley of the Gauj at first is narrow, being little more than sixty yards in breadth; further on it widens to near a mile, and again contracts, thus forming a basin: this place was overgrown with Tamarisk and Acacia trees, in which I found wild pigs most abundant. The section at page 344, taken from Gaza-Peer to the crest of the Hala Range, sufficiently explains the relative position of the beds at this place, excepting the local modern tufa, which is not found here.

Following the course of the Gauj, I passed through the conglomerate ranges, and at $3\frac{1}{2}$ miles came upon a cliff with a western escarpment, about 400 feet in height and based on the Kurrachee non-nummulitic rock (No. 6). This is on the left bank of the river. I found here fossil bones in vast abundance; the bones (as usual much broken) were at this point chiefly those of the Crocodile. I have remarked that the bone-beds (wherever the fossils abound) are of a deep rubiginous tint. The fossils also partake of the same colour, and as they strongly resemble the bones procured in such abundance at Nahn, I am not without a hope that they will establish a connexion between the conglomerate and sandstone (Sewalik) formations flanking the base of the Himalaya and the conglomerate sandstones and bone-beds of Sinde. The cliff above-noted is crowned with sandstone, about 150 feet in thickness; beneath this there is a bone-bed of the usual colour, about 60 feet in thickness; next, descending, comes a sandstone-bed about the same thickness, and containing some bones; then a bed of clays of various colours, penetrated with veins of gypsum, about 80 feet in thickness; then the lower bone-beds, of the usual rusty colour; beneath this, marly clays containing Turritellæ, and a small bivalve in vast numbers; broken pieces of Placuna were also abundant. From this I crossed to the right bank of the Gauj, and came upon the same formation, which is prolonged in a southerly direction as far as I could see. The cliff is not so high here as on the northern side of the river (to the course of which it stands at a right angle). It is mural towards the west, and I ascended it with much difficulty. The lowest visible rock here is sandstone, upon which a bed of the rust-coloured rock rests, dipping at from 35° to 40° to the east, and showing a strong contrast in colour to the sandstone beneath. In it I found bones most abundant, and at this place I procured some of my best specimens. Many of them were still in their original position imbedded in the rock, the denuded surface of which was here perfectly smooth. At this place I found a jaw-bone lying flat, appearing entire, and as if pressed its own depth into the rock at a time when it was soft. Upon attempting to remove it I found that it was loose, and perceived that the bone had been broken into several transverse portions, resting in juxtaposition in the original mould, where doubtless the bone had been fossilized previous to the disturbance which upraised the formation. Near this jaw-bone, but on the surface, I found a portion of a remarkable tusk about five inches in length; I am unable to refer it to any described animal, and strongly suspect that it originally belonged to the above-mentioned jaw-bone. This tusk, which I believe belonged to the left ramus of the lower jaw?, has a diameter of about an inch (I write from memory), is slightly curved and pointed, the lower portion cylindric, the outer side of the apex trenchant and sharp-edged, with the inner side rounded. The bones found here, though much broken, have not suffered from attrition, the fractures being for the most part acute. Night came upon me while engaged on this spot, and with much difficulty I retraced my steps to my tent.

All my provisions were now expended; and nothing, not even milk, being obtainable from the Belochees of this neighbourhood, I was compelled to return to the plain of Sinde. I intended taking in supplies, and again returning to this interesting locality, but on reaching Raja Derah, about six miles from the outer range and the nearest village where supplies were to be had, I was informed that an army was in the act of assembling at Roree with the intention of moving on the Punjaub. I therefore abandoned my geological excursion, and lost no time in rejoining my regiment at Roree.

From Raja Derah I passed through a belt of low Acacia jungle, recrossed the tail of the desert, and regained the road from Sehwan to Sukkur at a place called Gaza-Peer (not to be confounded with "Peer Gaza," above noticed), and thence to Meher, in all about 35 miles. The latter place is near the borders of the desert; and the next march, $16\frac{1}{2}$ miles in a northerly direction, lies for the most part over the desert, the soil of which abounds with saline matter, crackling as if ice-bound under foot. I remarked several places where saltpetre had been manufactured, but none appeared to have been worked lately. In places where saline matter was less prevalent, I found on the surface innumerable individuals of the genera Vivipara, Planorbis, Melania and Lymnea*. From this to Sukkur nothing but plains of sand and alluvium.

In recapitulation I may state, that during this excursion I examined the Hala Range of mountains from Cape Monze (lat. 24° 50′) as far

* The sandy ground flanking the desert is overgrown by a species of Tamarix, to the branches of which a white translucent manna adhered in great quantities. Three of my servants collected four pounds and a half in an hour, and I remarked that they ate nearly as much as they collected. The Tamarix bore neither flowers nor fruit at the season I saw it (January), so I am doubtful as to the exact species.

north as a point nearly west of Larkhana (lat. 27° 30′), a distance of about 200 miles, my operations being chiefly confined to the eastern aspect of the range. I found the formation uniform, exhibiting everywhere the same tertiary (or infero-tertiary) character.

During February and March 1845, I had an opportunity of seeing, and forwarded a report upon, the mountains of Beloochistan, in which Deyrah and Kahun of the Maps is situated. These mountains are east of Dadur and the Bolan Pass, and belong to the same formation; agreeing thus far with the Hala Range, as above noticed; but the valleys and ranges near Deyrah have nearly an east and west direction; this direction alters towards the north, until these mountains pass into the Sulleemaun Range. I gained some little information with respect to the latter from a kind of clay which is sent in considerable quantities into Hindostan as a colouring substance for walls, &c.; it is well known in India under the name of "Mooltaunee Multee;" in this I found fossils agreeing closely with those of some beds in the Hala Range; I strongly suspect therefore that the formations of Sinde are continued along the base of the Sulleemaun Mountains up to the base of the Himalayas.

Though perhaps out of place, I am anxious to add a few words with respect to my observations at Subathoo during the last rains. Close to the European barracks I found some large masses of rock, which had been removed for the purpose of forming level ground to build upon. In some of them I noticed fossil bones, and I had one large mass, weighing four cwt., conveyed to my house; but the stone is intensely hard, and all my efforts to disengage an entire specimen have failed. On inquiry, the Hill-men pointed out several other localities where fossil bones were found, viz. in the Hurreepoor valley between Subathoo and Simla, and a part of the valley separating Subathoo from Kussowlee. I hope to be able to visit these places after my return to Subathoo. In the meantime, the existence of fossil bones at Subathoo is certain. Some thin beds of a very hard blue limestone abounding with fossil shells pass directly through the station. Further down the hill there are beds of a pale-yellow slaty rock in a fissured and decomposing state, in which I found nummulites abundant, and the casts of one species of mollusk. My observations at Subathoo were limited, as I only remained a few months, and that during the rainy season. All my Sinde specimens are at Subathoo, and I am consequently unable to give any account of them at present, but hope to do so shortly after the return of my regiment to that station.

I trust that my slender geological knowledge will be a sufficient apology for all errors in the above notes. The little I know has been learned in this country, and for the most part in the field of nature. If these rough notes add ever so little to the geological history of our globe, I shall be delighted, and seek no better reward.

I am, Sir, your obedient servant,

N. Vicary,
Captain 2nd Bengal Europ. Regt.

Jullunder,
10th February, 1847.

May 12, 1847.

R. E. A. Townsend, Esq., J. Nicol, Esq., and W. A. Provis, Esq., were elected Fellows; M. C. H. Pander, of St. Petersburg, and M. Vicomte D'Archiac, were elected Foreign Members of the Society.

The following communications were then read:—

1. *On the Nomenclature of the Fossil Chimæroid Fishes.* By Sir Philip Grey Egerton, Bart., M.P., F.R.S., V.P.G.S. &c.

In a former communication to the Geological Society in 1843, I endeavoured to show that the fossils described by Dr. Buckland in his paper of November 1835, and referred by him to the genus *Chimæra,* presented differential characters of sufficient importance to warrant their separation from that genus. It was proposed to arrange them under three genera,—viz. *Ischyodus,* of which *Chimæra Townshendi* was the type; *Elasmodus,* typified by *Chimæra Hunteri*; and *Ganodus,* by *Chimæra Colei.* These generic distinctions were sanctioned and adopted by Professor Agassiz with the further elimination of certain species with falciform lower mandibles, such as *Chimæra Mantelli,* under the generic name *Psittacodon.* At that time I had not had an opportunity of examining the specimens discovered by Mr. Sibthorpe at Goldworth Hill, and described by Dr. Buckland in 1838 under the generic names *Edaphodon* and *Passalodon,* but having some fragments of the former genus, from Bracklesham Bay, I noticed the close resemblance of these to the other fossil Chimæroids, especially in structure, and alluded to it in the description of the upper maxillary bone of *Chimæra Agassizi,* and more pointedly in a subsequent paragraph referring to the general affinities of the recent and fossil Chimæroids. In the course of the present year I have not only seen the casts of Mr. Sibthorpe's specimens, from which the figures in the 'Poissons Fossiles' were drawn, but, through the kindness of Mr. Dixon, have had an opportunity of studying a series of specimens of these genera, in a very perfect state of preservation, from Bracklesham Bay. This examination has satisfied me that no distinction, of generic value, can be detected between *Edaphodon,* and *Chimæra Mantelli* of Dr. Buckland; consequently, if the latter be a true *Chimæra,* the former genus should be cancelled. The arguments I formerly advanced seem now to be generally accepted as warranting the exclusion of all the fossil species, hitherto discovered, from both the recent genera of Chimæroid fishes: indeed Professor Owen considers the distinctions of sufficient importance to exclude these fossils from the *family* to which the recent forms belong, and has added to Professor Müller's order *Holocephali,* a new family under the title *Edaphodontidæ,* for the reception of the fossil genera. I have before stated that Professor Agassiz subdivided the genus *Ischyodus,* ranging the species with falciform mandibles under the title *Psittacodon.* This is a natural and well-characterized division, but as these are the forms which so closely resemble the Bracklesham

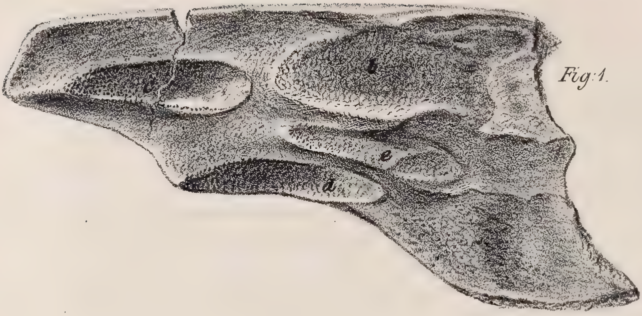


Fig: 1.

Fig: 2.

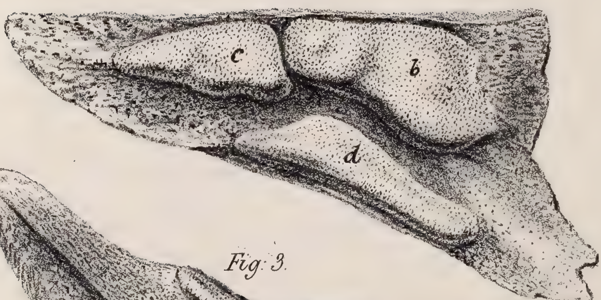


Fig: 3.

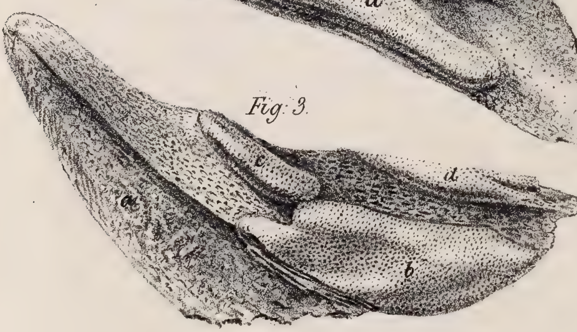
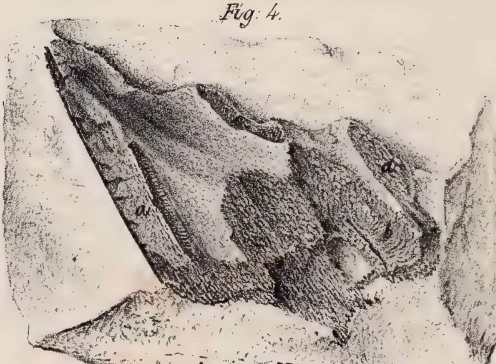


Fig: 4.



J. De C. Sowerby lith.

Hullmandel & Walton Lithographers.

and Goldworth Hill specimens, I propose to place them under Buckland's genus *Edaphodon*, and to cancel the more recent name *Psittacodon*. The validity of this arrangement will be apparent by the following distinctive characters of the two genera. The lower maxillary of *Edaphodon* (Pl. XIII. fig. 3) differs from the corresponding part of *Ischyodus* (Pl. XIII. fig. 4) in being produced anteriorly into a falciform beak. The symphysial facet (fig. 3 *a*) is broad at the base, and contracts gradually forwards until the margins meet at the apex. In *Ischyodus* the lower jaw is deeper, less produced anteriorly, and the margins of the symphysis (fig. 4 *a*) are parallel until abruptly truncated at their extremities. The upper maxillary of *Ischyodus* (Pl. XIII. fig. 1) is easily distinguished by the occurrence of a fourth triturating surface (Pl. XIII. fig. 1 *e*), situated between the large tubercle *b* and the marginal one *d*. This is wholly wanting in the corresponding bone of *Edaphodon* (Pl. XIII. fig. 2). The premaxillaries are comparatively rare in the fossil state, only three species having been found since the original Shotover specimens which first led Dr. Buckland to the discovery of the true affinities of these enigmatical fossils. I have assigned these forms to *Ischyodus Townshendi*, *Edaphodon Mantelli* and *Edaphodon gigas*, characterizing the two latter as being (compared with the former) broader, more compressed and less robust in antero-posterior diameter, and more hooked at their extremities. On looking over Mr. Bowerbank's collection of Bracklesham fossils not long since, I was led to imagine that the genus *Passalodon* might prove to be the premaxillary apparatus of *Edaphodon*. In favour of this idea the following reasons suggested themselves. The two genera have in every case been found associated together in the same strata, yet although both the upper and lower maxillaries of several species of *Edaphodon* have been discovered, the premaxillary has been hitherto a desideratum, while only one form of *Passalodon* has ever been brought to light. This form has a striking resemblance to the premaxillaries of the two species of Chimæroids now transferred to the genus *Edaphodon*. As to structure, the arrangement of the dental substance in distinct columns separated by septa of bone, is precisely that which occurs in the corresponding parts of the other fossils of this family. Upon communicating these views to Mr. Dixon, he wrote to me as follows: "I can bring forward very strong geological evidence in support of your opinion that *Passalodon* is part of *Edaphodon*, for I have found them together. The double upper jaw of *Edaphodon* which I possess, had portions of *Passalodon* with it." Since the receipt of this letter, Mr. Dixon has forwarded me a specimen of *Passalodon* which fully establishes the fact, for at the posterior extremity of the bone a flat articulating surface is preserved, corresponding accurately with the anterior articulating surface of the upper maxillary bone of *Edaphodon*.

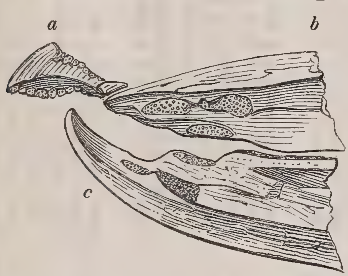
Since my former communications on the Chimæroid fishes, the anatomical details of the dental apparatus of *Elasmodus* have been completed by the discovery at Sheppy and Bracklesham of the upper maxillaries and premaxillaries of *Elasmodus Hunteri*. The remarkable laminated structure which suggested the generic name, obtains

Subclass. ELASMOBRANCHII, *Bonap.*
Order. Holocephali, *Müller.*
Family. Edaphodontidæ, *Owen.*

Genus and Species.	Description.	Synonym.	Reference.	Stratum.
Ganodus, *Egerton.*				
—— Bucklandi, *Egert.*	Lower maxillary		Proc. Geol. Soc., vol. iv. pt. 1. p. 153.	Stonesfield Oolite.
—— Colei, *Buck.*	Upper and lower maxillaries	Chimæra Colei, *Buck.*	Agass., vol. iii. p. 346. Feuilleton 116	Stonesfield Oolite.
—— curvidens, *Egert.*	Lower maxillary		Proc. Geol. Soc., vol. iv. pt. 1. p. 154.	Stonesfield Oolite.
—— dentatus, *Egert.*	Lower maxillary		Supra	Stonesfield Oolite.
—— emarginatus, *Egert.*	Lower maxillary		Proc. Geol. Soc., vol. iv. pt. 1. p. 154	Stonesfield Oolite.
—— falcatus, *Egert.*	Lower maxillary		Proc. Geol. Soc., vol. iv. pt. 1. p. 154	Stonesfield Oolite.
—— neglectus, *Egert.*	Lower maxillary		Proc. Geol. Soc., vol. iv. pt. 1. p. 153	Stonesfield Oolite.
—— Oweni, *Buck.*	Upper and lower maxillaries	Chimæra Oweni, *Buck.*	Agass., vol. iii. p. 347. Feuilleton 116	Stonesfield Oolite.
—— psittacinus, *Egert.*	Lower maxillary		Proc. Geol. Soc., vol. iv. pt. 1. p. 153	Stonesfield Oolite.
—— rugulosus, *Egert.*	Lower maxillary		Proc. Geol. Soc., vol. iv. pt. 1. p. 154	Stonesfield Oolite.
Ischyodus, *Egerton.*				
—— Agassizi, *Buck.*	Lower maxillary	Chimæra Agassizi, *Buck.*	Proc. Geol. Soc., vol. ii. p. 206	Greensand and chalk-marl.
—— Beaumonti, *Egert.*	Upper maxillary		Proc. Geol. Soc., vol. iv. pt. 1. p. 155	Kimmeridge clay, Boulogne.
—— brevirostris, *Agass.*	Lower maxillary	Chimæra brevirostris, *Agass.*	Agass., vol. iii. p. 344.	Gault, Folkestone.
—— Dutertrei, *Egert.*	Upper and lower maxillary		Proc. Geol. Soc., vol. iv. pt. 1. p. 154	Kimmeridge clay, Boulogne.
—— Dufrenovi, *Egert.*	Lower maxillary		Proc. Geol. Soc., vol. iv. pt. 1. p. 155	Kimmeridge clay, Boulogne.
—— Egertoni, *Buck.*	Upper & lower max. & premax.	Chimæra Egertoni, *Buck.*	Proc. Geol. Soc., vol. ii. p. 206	Kimmeridge clay, Oxford.
—— Johnsoni, *Agass.*	Upper & lower max. & premax.	Chimæra Johnsoni, *Agass.*	Agass., vol. iii. p. 344.	Lias, Lyme Regis.
—— Tessoni, *Buck.*	Lower maxillary	Chimæra Tessoni, *Buck.*	Agass., vol. iii. p. 342. Feuilleton 116	Oolite, Caen.
—— Townshendi, *Buck.*	Lower maxillary	Chimæra Townshendi, *Buck.*	Proc. Geol. Soc., vol. ii. p. 206	Portland beds, Milton.
Edaphodon, *Buckland.*				
—— Bucklandi, *Agass.*	Upper and lower maxillaries	E. latidens, *Buck., sp. inedit.*	Proc. Geol. Soc., vol. ii. p. 687 Agass., vol. iii. p. 351	Bagshot sand and Bracklesham.
—— eurygnathus, *Agass.*	Premaxillary Upper maxillary	Passalodon, *Buck.*	Proc. Geol. Soc., vol. ii. p. 687 Agass., vol. iii. p. 352	
—— gigas, *Egert.*	Premaxillaries		Proc. Geol. Soc., vol. iv. pt. 1. p. 211	Chalk, Worthing.
—— helveticus, *Egert.*	Lower maxillary		Proc. Geol. Soc., vol. iv. pt. 1. p. 154	Molasse, Switzerland.
—— leptognathus, *Agass.*	Upper and lower maxillary	E. angustidens, *Buck., sp. inedit.*	Proc. Geol. Soc., vol. ii. p. 687 Agass., vol. iii. p. 351	Bagshot sand and Bracklesham.
—— Mantelli, *Buck.*	Lower maxillary	Chimæra Mantelli, *Buck.*	Proc. Geol. Soc., vol. ii. p. 206	Chalk, Lewes and Worthing.
—— Sedgwicki, *Agass.*	Lower maxillary	Chimæra Sedgwicki, *Agass.*	Agass., vol. iii. p. 349. Feuilleton 116	Greensand, Cambridge.
Elasmodus, *Egerton.*				
—— Greenovi, *Agass.*	Lower maxillary	Chimæra Greenovi, *Agass.*	Agass., vol. iii. p. 350.	Unknown.
—— Hunteri, *Owen*	Lower maxillary		Odontography, p. 66	Sheppey and Bracklesham.
—— ———, ——	Premaxillary	Scaphodus, *Buck., inedit.*	Odontography, p. 66	Sheppey and Bracklesham.

in the upper as well as the lower jaw. The upper maxillary is provided with three triturating tubercles, as in *Edaphodon,* but the dentine of which they are composed is confluent, being rolled round like a scroll in the substance of the bone, one edge forming the margin of the tooth, the other buried deep in its centre. The premaxillary has long been known to Dr. Buckland, who, I believe, gave it the provisional name *Scaphodus.* It is a thin, incurved, scalpriform denticle rounded at the cutting edge. It has the lamelliform structure characteristic of the genus, but corresponds with the premaxillaries of the other members of the family in the columnar arrangement of the plates, although they are in juxtaposition and not separated by septa of bone.

Dental Armature of Edaphodon.



a. Passalodon.
b. Edaphodon.
c. Chimæra.

The alterations which will be required in the arrangement and nomenclature of the fossil Chimæroids are shown in the opposite table. I have added a species to the genus *Ganodus,* under the specific name *dentatus.* It is about the size of *Ganodus rugulosus,* but differs from that and the other species of the genus in having the cutting edge distinctly notched.

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2. *On* Kent's Cavern *near* Torquay. By Edward Vivian, Esq.

In this paper an account was given of some recent researches in that cavern by a committee of the Torquay Natural History Society, during which the bones of various extinct species of animals were found in several situations.

May 26, 1847.

The following communication was read:

On the main points of Structure and the probable Age of the Bagshot Sands, *and on their presumed equivalents in Hampshire and France.* By Joseph Prestwich, Jun., Esq., F.G.S.

[In consequence of the intimate connexion between the two following papers, the publication of the first, read 3rd February 1847, (see Proceed. vol. iii. p. 234) was delayed, at the author's request, in order that it might appear together with the paper read this day.]

1. *On the probable Age of the* London Clay, *and its Relations to the Hampshire and Paris Tertiary Systems.* By J. Prestwich, Jun., Esq., F.G.S. &c.

It is not intended on the present occasion to enter generally upon the subject* of the London clay, nor yet to describe its structure and fauna further than may be necessary to prove the argument of this paper, which is, that the London clay of Highgate, Sheppey, and other places in the neighbourhood of London, apparently is not, as it has hitherto been considered, synchronous with the Calcaire grossier of Paris, nor yet with the clays of Barton, and the clays and sands of Bracklesham; but that it is of older date than these, and consequently occupies a lower position in the Eocene series.

* For previous descriptions (Mr. Webster's especially) of the *Hampshire Tertiaries*, see my paper in the Journal of the Society for August 1846, pp. 224 to 226. Since then Mr. Searles Wood has contributed some important information to our knowledge of Hordwell Cliff. His list of the organic remains from its freshwater and fluvio-marine strata is far more complete than my own.

The following are the additional species given by Mr. Wood:—

Marine Beds.

Acteon.
Arca elegans, *S. Wood, MS.*
Cæcum.
Cancellaria muricata, *S. Wood, MS.*
—— elongata, *S. Wood, MS.*
Cardium.
Cerithium terebrale, *S. Wood, MS.*
Chemnitzia, 2 species.
Cristellaria.
Cyrena cycladiformis, *Desh.*
Cytherea obliqua, *Desh.*
Cytherina.
Gastrochæna.
Lucina pulvinata, *S. Wood, MS.*
Melania angulata, *S. Wood, MS.*
—— muricata, *S. Wood, MS.*
Melanopsis minuta, *S. Wood, MS.*
Natica epiglottina, *Lam.*
Odostomia subulata, *S. Wood, MS.*

Freshwater Beds.

Cyclas exigua, *S. Wood, MS.*
Cyrena obliquata, *Desh.*
—— pisum, *Desh.*
Dreissena Brardii, *Faujas.*
Helix labyrinthicus, *Say.*
—— striatella, *Anthony.*
Lymnea strigosa, *Brong.*
—— elodes, *Say.*
Melania carinata, *S. Wood, MS.*
—— subulaspira, *S. Wood, MS.*
Melania circincta?, *Lea.*
Paludina unicolor, *Swainson.*
—— ? impurata, *S. Wood, MS.*
Planorbis hemistoma?, *Sow.*
—— planulatus, *Desh.*
—— platystoma, *S. Wood, MS.*
Potomomya subangulata, *Sow.*
Potamides funatum, *Sow.*
Succinea imperspicua, *S. Wood, MS.*

Besides these, Mr. Wood found a magnificent lower jaw of an *Alligator*, for which he proposes the specific name of *Hantoniensis*; also remains of the following Vertebrata—*Dichobune, Palæotherium, Seal, Lepidosteus fimbriatus*, S. Wood,—two new genera, for which he proposes the names of *Microchœrus erinaceus* and *Spalacodon*, and a Rodent allied to *Anomalurus* and *Sciurus*. (See Charlesworth's London Geol. Journal, Nos. 1 and 3, 1846–47.)

To the Marchioness of Hastings we are also indebted for some valuable palæontological discoveries in the freshwater beds of Hordwell Cliff, including a new species of extinct *Pachyderm*, which Prof. Owen has named *Paloplotherium*, and a Crocodile, named by Prof. Owen *Crocodilus Hastingsii*. (See Report of the Meeting of the Brit. Assoc. for 1847, in the 'Athenæum' of the 3rd of July.)

These further observations confirm the views expressed in my last paper, that these strata are not the equivalents of the freshwater formations of Paris, but are rather of the age of the Upper Calcaire grossier. The evidence however is yet far from being sufficiently positive.—*September* 1847.

Old terms are altered with difficulty; they have the sanction of usage and weight of successive authorities, and are in geology occasionally apt, by their theoretical signification, to stand in lieu of proof. In the case before us, considering up to a late period the contemporaneity of the marine strata of London, Bracklesham, Barton, and Paris well established, I thought it scarcely necessary to investigate the data on which their identification rested; or rather, proceeding under the full impression of its correctness, I yielded to it facts, and endeavoured to conform to it phænomena, which, had I allowed them their due influence, would have earlier led to independent inferences. The differences known to exist in the fauna of these groups had been attributed solely to changes of condition and distance—causes, which as they produce effects whose limits are not easily assignable, sometimes prevent inquiry by offering an apparently available solution to anomalies in the faunæ, that might otherwise lead to further and more correct investigation.

I allude more particularly to this point, because in my paper on the Tertiaries of the Isle of Wight, following the usually received nomenclature, I applied the term "*London clay*" to the clays of Barton, the sands of Bracklesham, and their associated strata, and designated the group below them the "*Bognor beds,*" in consequence of the typical fauna of the Bognor rocks occurring in this portion of the Hampshire series. If however the evidence which I shall lay before the Society this evening be conclusive, these terms must be changed.

Either the clays of Barton and Bracklesham are the *London clay*, and the clays of Highgate and London are not the *London clay*; or else we must restrict the term to the marine clay of the neighbourhood of London and its equivalent elsewhere: in which case its application to the clays of Barton and the clays and sands of Bracklesham must, as I shall endeavour to show, be discontinued.

With this exception, I adhere to the arrangement introduced in my former paper. In lieu of the term *London clay* in the sections of Alum and White-Cliff Bay, I propose that the terms *Barton clays* and *Bracklesham sands* be used. Below these divisions are the *Bognor beds,*—the strata which I conceive to be the sole equivalent of the London clay; and then the *mottled clays and sands,* the latter resting immediately upon the chalk. (See tabular arrangement of the strata at the end of these papers, and Plate XIV.)

Comparison with the "Calcaire grossier."

Let us first examine the present received hypothesis, that the beds of Barton, Bracklesham and London are synchronous with one another as well as with the *Calcaire grossier,* and see upon what grounds it is established.

In the immediate neighbourhoods of Paris and of London the tertiary series commences with variable strata of sands and clays reposing upon the chalk; these are for the most part unfossiliferous, but contain occasionally subordinate beds with fluviatile and estuary shells*.

* In France, and more especially in England, these are only local conditions; the lowermost beds of the series are as frequently marine.

To these succeed around Paris, whence the first points of comparison were obtained, a deposit of a soft light-coloured calcareous freestone abounding in marine exuviæ; whilst in the vicinity of London we find, in resembling superposition, a thick mass of tough, tenacious, brown and dark grey clays, also with marine remains, but in far less abundance, and not so well preserved. Measuring the strata by their relative importance and general bearing, there appears to be an analogy of position and condition. As masses they are equivalent; but our question is with time, and that has but a very uncertain relation to masses.

From the frequent and almost constant variations of thickness which tertiary strata so generally exhibit, and from the comparatively local and limited expansion of many divisions, we ought to examine carefully the thinner as well as the thicker beds of the singularly-varied series of the Paris tertiaries; to trace the thinner ones in their greater development, and the thicker ones in their decreasing importance, and to note the variations and progress of their faunas. In all cases where considerable differences present themselves at distant points in beds of the same presumed age, we may most usually expect to meet at intermediate localities with intermediate characters, providing always that we have reason to suppose any connexion of original sea-bottom, such as probably existed at the first tertiary period. Thus the thick argillaceous deposit of *London clay*, at London, on the one hand, and the nearly pure calcareous deposit of *Calcaire grossier* at Paris, on the other hand, might be expected to show in their range towards each other, provided they were synchronous, some indications of a common origin. At the same time, the groups of organic remains should, notwithstanding the difference of chemical and mechanical conditions, exhibit some of the analogies dependent upon like conditions of age and of approximate geographical position.

Passing over for the present the beds between the *chalk* and the *London clay*, we will confine ourselves to the examination of the question of the latter being the equivalent of the *Calcaire grossier*. To understand how it came to be so considered, we must begin with the excellent work which first brought the fossils of this period prominently under notice.

Long before any systematic arrangement of the English and French tertiaries was attempted, the abundance and good state of preservation of the fossil shells found in the clay-cliffs of Barton had attracted the attention of Brander, by whom figures and descriptions of them were published in 1766*. When next, in 1803, Lamarck examined the shells of the *Calcaire grossier* of Grignon, he met with many which agreed with those figured by Brander from Barton, and with these he inferred them to be coeval†. In 1811, Parkinson‡ examined the fauna of the London clay of London and Sheppey; and in the same year the cutting of the Highgate tunnel enabled Mr. Sowerby and Mr. Wetherell to add considerably to the list of the London clay fauna.

A general resemblance of lithological character between the strata

* Fossilia Hantoniensia. † Annales du Muséum, tome i.

‡ Trans. Geol. Soc. 1st Ser. vol. i. p. 324.

of Barton and Highgate, and the discovery of several species common to the two localities, led to the belief that they were contemporaneous. The more material differences in the fauna were then and afterwards attributed to differences dependent upon distance, and on the separation of the two seas at the period of the deposition of the strata; and the finding, at Kew, of several species common, some to Highgate, and others to Barton, was supposed to remove any doubts as to the identity of the two groups.

Having thus associated the London clay with the Barton beds, and afterwards, by the same reasoning, with the beds at Stubbington and Bracklesham, the organic remains occurring at these various places were taken as belonging to one and the same deposit; and they were then compared "*en masse*" with those of the *Calcaire grossier*. The consequence was, that the supposed relation of the *London clay* and the *Calcaire grossier* appeared to be confirmed by the discovery of a considerable number of French species at Barton and at Bracklesham: the beds at these localities were therefore supposed to present an intermediate fauna corresponding with their intermediate geographical position, and thereby gave some verisimilitude to the hypothesis of the synchronism of those divisions of the London, Hampshire, and Paris groups. Let us now inquire how far, independently of the aid it has received from Barton and Bracklesham, the *London clay* of the London district* agrees in its organic remains with the *Calcaire grossier*.

The Testacea of the *Calcaire grossier* have been variously estimated at from about 800 to 1000 species; whereas the *London clay* proper, apart from *Barton* and *Bracklesham*, exhibits apparently less than 250 species†. I am however inclined to think that the number of the Testacea of the *Calcaire grossier* has been over-estimated, from the circumstance of specimens from beds both above and below it, and cropping out at the same localities, having been, before the distinction of the beds was well ascertained, quoted indiscriminately as *Calcaire grossier* fossils. There is unfortunately no complete recent list published; and the same fact, which causes doubt as to the number of species, renders also their chronological value problematical.

We have however the excellent, but only local, lists of the Eocene fossils of the Département de l'Aisne given by M. D'Archiac‡, and his shorter but more general lists in his paper on the relations of the French, Belgian and English Tertiaries§. There are also numerous papers by Constant Prevost, Elie de Beaumont, M. C. D'Orbigny

* I have used the terms *London* or *Hampshire tertiary districts*, in preference to *London basin* or *Hampshire basin*, as denoting the areas occupied by the tertiary deposits. The map in Plate XIV. shows the relative position of the two districts.

† Of these not three-fifths are described. (See list at the end.)

‡ In this district M. d'Archiac enumerates from the Sables et Grès moyens, or

Grès de Beauchamp		61	species of Testacea.
Calcaire grossier	Upper	101	"
	Lower	239	"
Lits Coquilliers		190	"
Etages des Lignites		40	"

All these divisions have many species in common.—Mémoires de la Société Géologique de France, vol. v. part 2.

§ Bulletin de la Société Géologique de France, vol. x. p. 168.

and others in the 'Mémoires' and 'Bulletin' of the French Geological Society. The fine work of Deshayes is the standard for the organic remains*, and for general descriptions and details the works of Cuvier and Brongniart.

Taking the number of described *Calcaire grossier* species at a moderate estimate of 600, I can only, after carefully excluding all the Barton and Bracklesham fossils, determine the following 20 as occurring also in the *London clay* of the London district †:

Anomia lineata, *Sow.* (A. striata, *Desh.*)
Beloptera belemnitoidea ??, *Blainv.*
Cassidaria carinata, *Desh.*
Fusus bulbiformis, *Lam.*
Infundibulum trochiforme, *Sow.* (Calyptræa trochiformis, *Desh.*)
Globulus depressus, *Sow.* ?
Natica glaucinoides, *Sow.*
Nucula similis, *Sow.* (N. margaritacea, *Lam.*)
—— minima, *Sow.* ?
Ostrea flabellula, *Lam.*
Pecten corneus, *Sow.* ?
Pseudoliva obtusa, *Sow.* ?
Rostellaria macroptera ?, *Lam.*
Sigaretus canaliculatus, *Sow.*
Solarium canaliculatum, *Lam.*
—— patulum, *Sow.* (? patulum of *Desh.*)
Triton viperinus, *Desh.*
Teredo personata ?, *Lam.*
Turritella imbricataria, *Desh.*
—— sulcifera, *Lam.* ?

Thus it appears that not quite four per cent. of Testacea of the *Calcaire grossier* are found in the *London clay* of London: and even this small number is of little chronological value; for, with few exceptions, all these species have a wide vertical range in the Eocene series of France, twelve of them descending to the "*Sables inférieurs* et *Lits coquilliers*," and several of them ranging upwards to the "*Grès de Beauchamp*," and scarcely any of them being of characteristic *Calcaire grossier* species ‡. (See the works of Deshayes and D'Archiac.)

In the general character of the Testacea of the *London clay* and *Calcaire grossier*, the differences observable are as great as in the species. Thus in the former, Cephalopoda, Phytophagous Gasteropoda, and Lamellibranchiate Dimyaria preponderate; and in the latter, Zoophagous Gasteropoda and Lamellibranchiate Monomyaria.

If we compare the fishes, the plants, the Foraminifera, the Crustacea, and the Zoophytes of the *London clay* and *Calcaire grossier*, the same marked distinctions between them are traceable throughout. The *Calcaire grossier* abounds in *Foraminifera*, and possesses many *Zoophytes*. The former are almost unknown, and the latter very scarce, in the *London clay*, which however exhibits fine groups of *Fishes* §, *Reptiles* and *Crustacea*, together with a *Flora* || of remarkable variety and beauty, whilst in the *Calcaire grossier* ¶ such fossils

* Coquilles Fossiles des Environs de Paris.

† Future comparisons of the organic remains will, no doubt, considerably modify this list.

‡ This can only, from the want of revised lists and more complete descriptions, be a rough approximate estimate. An exact value must not be attached to it.

§ Agassiz's Report on the Fossil Fishes of the London Clay.—Reports of the Brit. Association for 1843 and 1844.

|| Bowerbank, Fossil Fruits of the London Clay.

¶ A local case will exemplify the general bearing.

	Foraminifera.	Zoophytes.	Fishes.	Reptiles.	Crustacea.	Plants.
Calc. gross. dep. de l'Aisne (D'Ar.)	45	15	1	0	0	2
London clay (Morris, Brit. Foss.)	1	3	53	16	4	107

The number of undescribed species of London clay *Crustacea* is very considerable. Alex. Brongniart enumerates thirteen species of plants from the *Calcaire grossier*, and Agassiz but 12 species of fishes.

are extremely rare. The per-centage of species in all these classes common to the two deposits will not, I think, average more than in the Testacea.

Where therefore is the affinity of these formations? Where the proofs of their synchronism? Are we to be satisfied with an assumed analogy of position,—with a community of apparently not more than forty or fifty species of organic remains, out of probably 1000 to 1200 or more, and attribute so wide a variation of fauna merely to geographical position and differences of conditions?—or is not rather the *primâ facie* evidence sufficient to render it probable that they differ in age as well as in origin, and to lead us to investigate more closely their relative superposition? If then the hypothesis which has referred them both to the same period is insufficiently grounded, the question arises, in what relation do they stand one to the other?

For an answer to this question, it is necessary to recur to the Hampshire tertiary series, and to search there for the intermediate and connecting types, without which it would be difficult to institute a comparison.

Divisions of the Tertiary Series.

Lowest—Sands and Mottled Clays.

In determining the synchronism of any portion of the London and Hampshire series, we should endeavour to establish by a good base-line the earliest point of contemporaneity. The lower part of the Hampshire tertiaries presenting at first sight considerable apparent differences from those of London, has caused the base-line, if it may be so termed, to be placed near the top of the series, viz. in the *clays of Barton*, making them parallel with the *London clay*, and thus forcing the strata above and below into an order bearing the same relation to the one as to the other*.

* The following is a sketch of the present arrangement of the Tertiary series of England and France, with the order of superposition and co-relation of the strata.

London Basin.	*Hampshire Basin.*	*Paris Basin.*
Feet[1]. ? Bagshot sands: Position with regard to the Hampshire series uncertain.	Feet. 200. Upper freshwater formation[2]. 20. Upper marine formation[2]. 170. Lower freshwater formation[2].	Feet. 40. Calcaire lacustre supérieure. 80. Sables marins supérieurs. 150. Calcaire lacustre inférieure. 50. Grès de Beauchamp[3].
00. London clay: Highgate, Sheppey.	350. London clay: Barton, Bracklesham and Bognor.	100. Calcaire grossier.
80. Plastic clays: pebble-beds, fluviatile beds of Woolwich, and sands below them to the chalk.	1100. Sands and plastic clays[4]: variegated sands and clays, and lignites, forming the central and lower strata of Alum Bay, including the fossiliferous brown clay[5] (stratum "*d*" of Mr. Webster), and the red clays below it.	100. Lignites and Argile plastique.

[1] These numbers refer to a roughly approximate average thickness of the deposits.
[2] These three formations have of late generally been considered as one.
[3] M. d'Archiac and others refer the Grès de Beauchamp to the thick stratum of sand immediately overlying the London clay at Alum Bay, and which they also consider the equivalents of the Bagshot sands.
[4] Sometimes this distinction has not been admitted, and the series from the freshwater beds to the chalk has been considered as all belonging to the London clay series.
[5] The presumed marine equivalents of the fluviatile beds of Woolwich.—*Sept.* 1847.

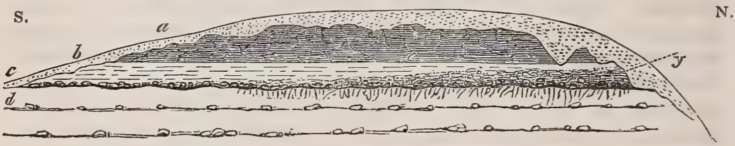
In that portion of the London tertiaries which lies to the west of London, one of the most characteristic features exhibited in the beds immediately overlying the chalk, is the frequent occurrence of a band of the *Ostrea bellovacina*, with a few sharks' teeth, imbedded usually in a clayey greensand, and generally separated from the chalk only by a bed, two or three feet thick, of greensand and clay, full of slightly-rolled green-coated flints. Sometimes, however, the *Ostrea* band descends to the chalk.

These strata, with their associated *mottled clays*, are well known from Dr. Buckland's description * of them at Katesgrove Pits, Reading, whence westward they may be traced to the extremity of the London tertiary district at almost all the points where these lowest strata are exhibited.

In the Hampshire basin this bed has not hitherto been known; but I had the satisfaction last summer of meeting with an excellent exhibition of it in a cutting of the Southampton and Salisbury railroad at Kembridge, about three and a half miles north of Romsey.

The agreement of this section with those exhibited in the neighbourhood of Newbury and Hungerford is striking, and is not confined to the layer of the *Ostrea bellovacina*, but extends to the associated beds of *mottled clays*. At the south end of the cutting at Kembridge the section is identical with that in immediate junction with the chalk at Alum Bay †, both in the arrangement of the strata and in the absence of fossils; but in proceeding northward, a band of oysters gradually appears, and at the further end of the cutting attains a thick-

Fig. 1.—*Section on the Railway near Kembridge.*



a. Ochreous flint gravel.

b. Red clays mottled with grey, dark plum-colour, and yellow at its base. No fossils. (Identical with the mottled clays No. 2 of Alum Bay and of Reading.) .... 15 feet.

c. Clayey yellow and greenish sand, with the usual layer of slightly-rolled, large green-coated flints at the bottom; mixed also with a few small round flint pebbles, and imbedded in an impure ochreous and argillaceous greensand. Above the flints, and partly intermingled with them, there is at the point "*y*" a layer about two feet thick of large *Ostrea bellovacina*. Towards the south end of the cutting it gradually thins out, and disappears altogether about midway in the section. The shells of these oysters are mostly very thick and large, and much corroded .... 4 feet.

d. Chalk with flints. Its upper surface is rather uneven, and irregularly bored into from the greensand layer above, the substance of which now fills the tubular holes.

* Transactions of the Geological Society, 2nd series, vol. ii. part 1. p. 119.

† Excepting that the rolled flints on the chalk are at the latter place imbedded in a rather whiter and purer sand.

ness of two feet, forming a section agreeing perfectly with those of Newbury and Hungerford, where also the band of oysters is far from persistent. (See Plate XIV. Comp. Sec. figs. 5 & 7, points "ε.")

The structure of the south end of the Kembridge cutting is that which commonly prevails throughout the Hampshire tertiary series south of this locality; whereas, as modified at the northern end, it represents that of a large portion of the London tertiary district. This section therefore affords, in conjunction with those of Alum and White-Cliff Bays, Southampton, &c., some stratigraphical and zoological evidence that this lowest division, both in Hampshire and west of London, commenced contemporaneously under very similar conditions, and in apparent connexion.

This point thus probably indicating the early co-relations of these two districts, affords a good base-line from which to measure their progressive development.

Overlying the sands with *Ostrea bellovacina*, or rather in further development of the same series, are the *mottled clays* with intercalated sands. These are seen in their greatest expansion, and in their most argillaceous condition, at Alum and White-Cliff Bays, and reappear, I infer, in lesser thickness and more sandy, but in similar superposition, throughout the western portion of the London tertiary district (see Plate XIV. Comp. Sec. fig. 2 to 11). It may be objected here, that the more variable beds of sands and *mottled clays* of the London district do not well represent the purer *mottled clays* of Hampshire; that the preponderance of sands mark them as a different group, referable rather to the great central mass of variegated sands and clays at Alum Bay, with which they have been hitherto grouped. Against this it can be shown that the *mottled clays* and associated sands are subject to great and rapid variations of thickness and structure, both from having been deposited on the inequalities of the chalk, and from their apparently irregular original drift. At Alum Bay they are 86 feet thick; at White-Cliff Bay, 140 feet; at Southampton, 100 feet; at Clarendon Hill, near Salisbury, apparently not more than 50 or 60 feet; at Pebble Hill, near Hungerford, 45 feet; whilst at Tilehurst, near Reading, they are said to be 150 feet thick.

The variation in the mineral character is of little importance. At Pebble Hill we see them subordinate to the beds of sand; at Newbury the sands and mottled clays are about of equal thickness, and form two beds only; at Reading we have five beds of mottled clays alternating with seven beds of sand; at Sonning Hill the sands have almost thinned out, and at Twyford we again have 40 or 50 feet of pure mottled clays, whilst near London they are frequently 80 to 100 feet thick. In fact, they present a remarkably uniform mineral type of beds of red mottled clay and of siliceous light-coloured sands, merely subject to variations of proportions.

They are also characterized throughout the Hampshire and London districts, whether they are formed of clay beds only, or consist of alternating beds of clays and sands, by the same remarkable absence of animal remains.

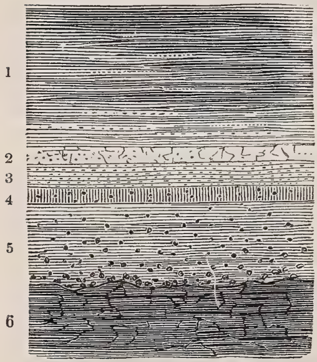
This therefore forms a well-marked and characteristic division, which will aid materially in taking the next and more debateable step.

London Clay.

Immediately overlying these *mottled clays,* or separated from them only by a thin subordinate bed of sand, there is found in the Hampshire district a thick and important mass of fossiliferous brown and grey clay, well-exhibited in the sections at Alum and White-Cliff Bays, and proved to exist in the same position in the well at Southampton (see Plate XIV. Gen. Sect. fig. 2 to 4). This deposit is well-marked and persistent in its lithological characters. At Alum Bay it is 200 feet thick, and at White-Cliff Bay and Southampton about 300 feet, apparently therefore thickening gradually in its range northward and eastward. Its local composition at the former two places I have described in my last paper: it is there termed "*the Bognor beds.*" I will therefore now confine myself to its more permanent and characteristic features.

In the first place it is almost uniformly preceded by a thin seam of sand, frequently green, and containing small rounded black flint pebbles, and occasionally also, when the underlying mottled clays have been sufficiently hard, rolled and water-worn pebbles of the *mottled red clay* itself, pointing to, as I have before observed, a sudden alteration of hydrographical conditions, and a change in the ancient sea-bottom. This fact is particularly noticeable in White-Cliff Bay.

Fig. 2.—*Junction of the London Clay* (1 *to* 5) *and mottled clays at White-Cliff Bay**.



1. Dark grey and brown clay at top; in descending becomes much mixed with greensand; few fossils in this part of it.
2. Tabular Septaria (4 inches thick) with greensand; full of shells; amongst them the most abundant are, *Pyrula tricostata, Pectunculus brevirostris, Cardium* (*Plumsteadiense ?*), *Natica glaucinoides, Ostrea,* and a few *Ditrupa plana.*
3. Similar to (5), but finer grained ...... 6 inches.
4. Dark green sand, *full* of the *Ditrupa plana*; a few flint pebbles..................... 6 inches.
5. Brown sandy clay much mixed with greensand, and passing downwards into a conglomerate with rounded pebbles of *flint, chalk,* and *red clay.* A few *Ditrupa plana* are dispersed throughout .... 2 feet.
6. Dark red *mottled clays* (upper part of).

I dwell upon this fact, because it indicates a well-marked commencement of a different order of things from that which previously existed. (See also Plate XIV. Comp. Sec. 3 to 11, point "δ.")

The lowest beds of the London clay are generally more or less sandy, but the sand gradually disappears, passing into tough brown clay with layers of Septaria (and concretionary conglomerates at Southampton),

* This is best exhibited on the shore between high and low water level.

and a few subordinate sandy beds, the whole forming a total thickness of 300 feet. Sometimes the clays are of a dark grey, but brown is the predominating colour. As a mass the mineral character is almost entirely argillaceous, carbonate of lime though present being in comparatively very limited quantity, and the admixture of green and yellow sands occurring chiefly at the top and bottom of the deposit.

Another lithological character is the presence of two or three layers of round black flint pebbles, as well as their occasional dissemination, denoting an increased transporting power of water, but no change of condition. They are more numerous at Alum Bay than at White-Cliff Bay, and still more so at Southampton.

We will now pass over to the London district, and examine the strata there superimposed to the *mottled clays.* Commencing at Basingstoke and Odiham, we meet with in this position a thick and well-marked deposit of brown and bluish grey clays. To their lithological characters we will first confine ourselves, and ascertain whether these present any discrepancies with the Bognor beds of Hampshire. So far from this being the case, their agreement is remarkable,—far greater than could have been expected.

This great argillaceous deposit commences here, as in the Isle of Wight, with a mineral character different from that of the beds below it. At its base, a bed of sand with rolled flint pebbles almost invariably occurs, indicating therefore, along with other phænomena, that the London tertiary district probably underwent at this period a change of condition similar to that we have shown to have occurred in Hampshire.

Thus at Chinham near Basingstoke, we find the mottled clays and sands overlaid by a yellow clayey sand, with a few pebbles and patches of green sand, passing upwards into the mass of the London clay; at Itchingwell, near Kingsclere, by a thin band 9 inches thick of pebbles, over which is a brown sandy clay passing upwards into a tough brown clay, forming the lower part of the London clay; at Pebble Hill the same layer of pebbles, overlaid by dark sandy clays with London clay fossils. At Reading also the mottled clays are capped by brown clays and sand, with pebbles and patches of green sand, and again at Sonninghill: so also at various places along the southern edge of the London district, as at Guildford. A similar mechanical structure prevails at the base of the London clay at Hampstead, where however the sand and pebbles are cemented by carbonate of lime, a character of not unfrequent occurrence, forming in such instances large tabular masses, as at Hedgerly, Sonning, and various other places around London, and in Hampshire at Alderbury near Salisbury, and Southampton. In all these places this conglomerate band is usually very fossiliferous. (See Pl. XIV. Comp. Sec. 6, 7, 11. point δ.)

Further, the peculiar water-worn and irregular surface of the mottled clays and sand exhibited at their junction with the brown clay deposit in the Isle of Wight is also distinctly visible in the London district. This was very apparent in the long railway cutting at Sonning near Reading. The whole line of junction was there uneven and wavy, forming depressions and curves as much as 1 or 2 feet deep. This structure is also observable in a lesser degree at Chinham near Basingstoke, Pebble Hill, and Guildford.

At all these places in the London district where the superposition can be traced, these pebble beds are subordinate to sands chiefly yellow, but sometimes green and dark grey, laminated with brown clays, passing upwards into beds of the same colour and entirely argillaceous, with subordinate portions of a dark bluish grey colour, frequently very sandy. These strata constitute the great bulk of the *London clay*. Its upper beds are again generally brown, and near the top usually mixed with light-coloured sands in sufficient quantity to form a good brick clay without any further addition of sand.

Layers of Septaria occur irregularly throughout the *London clay*. At the western end of the district the clays frequently contain black flint pebbles, sometimes forming thin layers in the clay, at other times occurring, slightly dispersed, throughout considerable vertical masses. Nearer London these pebbles are of less frequent occurrence.

If, further, we compare the development and thickness of the *London clay* of London and the *Bognor beds* of Hampshire, we find the analogy continued; and as this is a point of some importance to the argument, we will confine ourselves to the few sections where we have positive and complete data.

We have already seen that at Southampton these clays are nearly 300 feet thick. The first measurement we can obtain in the London district is at Dogmersfield, near Odiham, where a well has shown these clays to be 320 feet thick,—a very close approximation to the Southampton section; and at both places they are equally well defined and limited by the *sands* above and the *mottled clays* below. Proceeding towards London the clays gradually become thicker; measuring 400 feet at Chobham, and at Highgate and Hampstead about 400 feet*; the same beds above and below, as at Odiham, serving as limits of vertical range. (See Plate XIV. Gen. Sec. fig. 1 to 11.)

We thus have, in mere physical conditions, a fair "*à-priori*" case for placing the *London clay* of the neighbourhood of London on a level with the *Bognor clay* in the Hampshire series. Their structure is analogous, their superposition alike, and their accumulation was apparently nearly coeval in time and equal in mass; while so far as these conditions are concerned, the presumed synchronism of the Barton clays and Bracklesham sands with the London clay would present great anomalies.

Organic Remains.

The foregoing hypothesis of structure, if correct, ought to be corroborated and proved by an examination of the organic remains.

We will commence with an estimate of the total number of species found in the Hampshire and in the London series, and then consider separately the numbers occurring respectively at Barton, Bracklesham, and London; examine their affinities, and see if any and how many species are peculiar to each of these groups of strata; and investigate the validity of the palæontological evidence upon which their corelation stands†.

* At some places around London they are occasionally thicker than this.

† In the determination of the species occurring in the several localities, the Catalogue of British Fossils of Mr. Morris was of the most essential assistance. I

Limited in the number of its Testacea as the whole of the marine tertiary series of London and Hampshire long appeared to be, as compared with the French series, there now appears a prospect, thanks to the zeal of Mr. Bowerbank, Mr. Wetherell, Mr. Edwards and others, of finding the English fauna far richer than was anticipated. The number of described species of Testacea already known in the London and Hampshire systems taken together amounts to nearly 400; and from information given me by Mr. F. C. Edwards of Hampstead, I am led to believe that, including undescribed species, we may estimate them at between 600 and 700. There is little doubt, I think, that they will shortly exceed even this number, especially as new lines of railway intersect the London clay, our research in which has been much limited by the extreme scarcity of permanent sections.

We will confine ourselves however to the 390 described species: of these 133 occur in the *London clay* of the neighbourhood of London, 193 in the strata at *Bracklesham Bay*, and 209 in the strata at *Barton Cliffs*. Out of the whole number only 35 species are common to all the three localities. Further, 8 are common to London and Bracklesham, 11 to London and Barton, and 55 to Bracklesham and Barton. (See list of species and table of distribution at the end.) It is possible that even the small number of species now given as common to these three groups of strata may yet be reduced as analogues are compared. It must also be borne in mind that some species, although common to all these groups, form, in each of them, distinct varieties. Granting however that the localities* of the described species have been correctly given, and that they have been sufficiently compared, the number of *London clay* shells (*i. e.* of the London district alone) occurring at *Barton* and *Bracklesham* only amounts to 55, out of the total number of 133, thus leaving 79 as peculiar to the London district. When to this fact we add the occurrence of the numerous distinct species of crustacea, fishes, reptiles and plants peculiar to the London district, have we not reason to doubt the contemporaneity of the clays of London with the strata of Barton and Bracklesham?—especially if we can show that the *London clay* has a much closer representative in the Hampshire system in strata distinctly below the Barton and Bracklesham series.

But if the clay of London be not synchronous with those of Barton and Bracklesham, in what relation does it stand to them?

The similarity of structure and physical conditions may indicate, as we have suggested, that the thick and extensive strata of *London clay* of the neighbourhood of London, and the lowest fossiliferous beds of

may here take the opportunity to state the great advantages which the valuable illustrated copy of this Catalogue, arranged by Mr. Morris, recently presented to the Geological Society by our President, Mr. Leonard Horner, will afford to the geologist. It will be a standard work of reference and authority, as the illustrations are mostly from the original works, many of which are of difficult access and very expensive.

* Some few palpable errors, where by mistake a fossil from the Barton clay has been quoted as found in the clays of the neighbourhood of London, or where distinct species from Hampshire and London have been considered as the same, are corrected.

clay immediately overlying the *mottled clays* of the Isle of Wight, have had a like and coeval origin, and that the *London clay* is consequently lower in the series than the *Bracklesham Bay beds*, and still more so than those of *Barton*. It is certainly possible that by greater rapidity of formation the London clay and the so-called Plastic clay of London might have expanded in the Hampshire district, so as to have had for their equivalents the whole of the strata from the chalk to the Freshwater series, including the Barton and Bracklesham beds. Here however the organic remains come to our assistance, and tend to strengthen our view, that the synchronism of the *London clay* extends only to the limits pointed out by similarity of structure.

Owing to the want of sections intermediate between the Isle of Wight and London, there has existed some little difficulty in establishing a satisfactory co-relation of the faunæ of this division in the neighbourhood of London with that which we take as its presumed equivalent in Hampshire, but some recent railway cuttings have materially facilitated the inquiry.

To render the palæontological evidence as clear and decisive as the subject will admit of, and to show that each portion of it is in unison with the whole, it will be desirable to study the organic remains in groups, as they are developed in different places in each system, so as to eliminate any modifications which they may undergo as they approximate in geographical distribution, and to ascertain to what extent the forms and species correspond.

Commencing with the Isle of Wight we have the following group:

Fossils of the Bognor beds of White-Cliff and Alum Bays.*

Anomia lineata, *Sow.*
Cassidaria carinata, *Lam.*
Cardium Plumsteadiense?, *Sow.*
Corbula pisum?, *Sow.*
Cyprina planata, *Sow.*
Cytherea obliqua, *Desh.*
Ditrupa plana, *Sow.*
Dentalium.
Fusus tuberosus, *Sow.*
—— angusticostatus, *Mell.*
Infundibulum trochiforme, *Sow.*
Nucula lunulata?, *Nyst.*
—— amygdaloides, *Lam.*
Natica glaucinoides, *Sow.*
Ostrea flabellula, *Lam.*
Panopæa intermedia, *Sow.*
Pectunculus brevirostris, *Sow.*
Pholadomya margaritacea, *Sow.*
Pholadomya virgulosa, *Sow.*
Pinna affinis, *Sow.*
—— n. s.—a large one, same as at Bognor and Cuffell.
Psammobia compressa?, *Sow.*
Pyrula tricostata, *Desh.*
—— Smithii, *Sow.*
Pleurotoma.
—— (small species resembling one from Southampton and Newnham).
—— four or five other n. sp.
Rostellaria Sowerbii, *Mant.*
—— lucida, *Sow.*
Teredo antenauta, *Sow.*
Turritella imbricataria, *Desh.*
Venericardia Suessonensis, *d'Archiac.*
Vermetus Bognoriensis, *Sow.*

* Mr. Edwards, who has just returned from the Isle of Wight, informs me that he has, in addition to most of the specimens above mentioned, found the following ones in Stratum No. 4 of Alum Bay:—

Acteon simulatus, *Sow.*
Buccinum junceum, *Sow.*
Cassidaria striata, *Sow.*
Cultellus affinis, *Sow.*
Fusus Koninckii, *Nyst.*
Marginella.
Modiola depressa, *Sow.*
Nucula minima, *Sow.*
Solarium patulum, *Sow.*
Typhis muticus, *Sow.*
——
Desmophyllum.

All these are species which tend to confirm my views.—*Oct.* 1847.

Of these the *Cyprina planata, Ostrea flabellula, Panopæa intermedia, Pyrula tricostata, Venericardia Suessonensis, Teredo antenauta* and *Ditrupa plana,* are common at White-Cliff, and comparatively scarce at Alum Bay, where however all the other species are far more abundant. From the latter place I have also several undescribed species of *Pleurotoma* and *Corbula.* Of other organic remains we have the *Cancer Leachii,* teeth of *Lamnæ,* and carbonized wood frequently pierced by the Teredo.

Our next point is the artesian well on Southampton Common; whence also the series is from beds as fully developed as those of the Isle of Wight.

The following is a list, chiefly from specimens in the collection of Mr. R. Keele of Southampton, who has had the kindness to give me the free use of all his Southampton fossils.

Fossils from the Bognor beds at the Artesian well, Southampton.*

Anomia lineata, *Sow.*
Cancellaria læviuscula, *Sow.*
Cardium Plumsteadiense ?, *Sow.*
Cyprina planata, *Sow.*
Cytherea obliqua, *Desh.*
—— suberycinoides, *Desh.* var.
Ditrupa plana, *Sow.*
Fusus bulbiformis, *Lam.*
—— angusticostatus, *Mell.*
—— complanatus, *Sow.*
—— tuberosus, *Sow.*
—— Koninckii, *Nyst.*
—— n. sp.: same as one found at Highgate.
Infundibulum trochiforme, *Sow.*
Natica glaucinoides, *Sow.*
—— Hantoniensis, *Sow.*
Nautilus (either imperialis or Sowerbii).
Ostrea flabellula, *Lam.*
Panopæa intermedia, *Sow.*
Pectunculus decussatus, *Sow.*
—— brevirostris, *Sow.*
Pholadomya margaritacea, *Sow.*
—— virgulosa, *Sow.*
Pinna affinis, *Sow.*
Pleurotoma rostrata, *Sow.*
—— two new species.
Pyrula tricostata, *Desh.*
Rostellaria Sowerbii, *Mant.*
—— (a small species resembling the *Sowerbii*, and occurring also at Clarendon Hill and Cuffell).
—— lucida, *Sow.*
Turritella imbricataria, *Lam.*
—— sulcifera, *Lam.*
Typhis muticus, *Sow.*
Teredo antenauta, *Sow.*
Venericardia Suessonensis, *d'Archiac.*
Vermetus Bognoriensis, *Sow.*
Voluta elevata, *Sow.*

The species of *Turritella, Panopæa, Pholadomya, Natica, Ostrea* and *Infundibulum* are very common. Carbonized wood occurs abundantly.

Proceeding northward, no opportunity offers of observing the organic remains of these beds until we reach the railway cutting at Clarendon Hill, three miles south of Salisbury, where however a depth of only about 40 feet of the lower beds of the Bognor clays are exposed. But in this limited extent we meet with precisely those fossils which are of the most typical species.

Fossils from the Bognor beds at Clarendon Hill.

Anomia lineata, *Sow.*
Cancellaria læviuscula, *Sow.*
Cardium Plumsteadiense ?, *Sow.*
Corbula.
Cyprina Morrisii, *Sow.*
Cytherea obliqua, *Desh.*
Ditrupa plana, *Sow.*
Fusus Koninckii, *Nyst.*
Fusus tuberosus, *Sow.*
Infundibulum trochiforme, *Sow.*
Natica glaucinoides, *Sow.*
—— Hantoniensis, *Sow.*
Nucula.
Ostrea (very large species, same as at Old Basing).
—— flabellula, *Lam.*

* See fig. 5. stratum *c*, *postea*, p. 388.

Panopæa intermedia, *Sow.*
Pectunculus brevirostris, *Sow.*
Pinna affinis, *Sow.*
Pholadomya margaritacea, *Sow.*
Pleurotoma (same species as at Newnham).
Psammobia compressa ?, *Sow.*
Pyrula tricostata, *Desh.*
—— Smithii, *Sow.*
Rostellaria (small species resembling the *Sowerbii*; same as occurs at Southampton and Cuffell).
Rostellaria lucida, *Sow.*
Turritella imbricataria, *Lam.*
Teredo antenauta, *Sow.*
Venericardia Suessonensis, *d'Archiac.*
Flustra.
Desmophyllum (same species as at Highgate).

The small undescribed *Rostellaria*, the *Natica glaucinoides*, *Panopæa intermedia*, *Pinna affinis*, *Pectunculus brevirostris* and *Venericardia Suessonensis* here occur in the greatest abundance. The *Panopæa* is beautifully exhibited in its normal position, as when living and boring downwards into the soft mud: its shell is preserved, but in a very friable state, as it also is at Southampton and in the Isle of Wight. The shells of the *Pinna* and *Pholadomya* are likewise very tender, and difficult to be obtained entire; they still however retain some of their lustre. The other shells are in a tolerably good state of preservation, especially the *Natica*, which usually exhibits a bright untarnished surface.

The thin conglomerate masses of rock before-mentioned as here occurring at the base of these clays are full of *Corbula*, *Cyprina Morrisii*, *Ditrupa plana*, *Natica Hantoniensis*, *Nucula*, *Fusus tuberosus*, *Pectunculus brevirostris*, *Cytherea obliqua* and *Pleurotoma*. (Point δ in fig. 6. Comp. Sect. Plate XIV.)

On comparing the foregoing lists of fossils, we find that of the 37 known species which form a very typical and distinctive group in these beds in the Isle of Wight, 25 occur again among the 32 found at Southampton; and of the 23 species from Clarendon, 20 are of forms common at Southampton and the Isle of Wight.

We are warranted therefore, both by structure and organic remains, in regarding these strata of this portion of the Hampshire tertiaries as synchronous. It is also evident that they possess a peculiar and distinct fauna, since, out of the 49 species which they contain, only 18 range upwards into the Bracklesham and Barton beds*.

If we now pass over to that portion of the London district nearest to the Hampshire tertiary district, we shall find a fauna perfectly ana-

* The limited supplies of specimens furnished by the well at Southampton, and the short examination hitherto made of these beds in the Isle of Wight, renders our knowledge of their fauna no doubt defective, and restricted probably to the most abundant species. A careful search in these beds at Alum Bay would doubtless produce a considerable addition to the number of organic remains now known: but even from our present knowledge of them it is apparent that they are, wherever exhibited in Hampshire, characterized by a peculiar group of fossils.

In addition to the species enumerated in the foregoing lists, there are a few others which occur at Bognor, and which, as we shall have to take them into account in our comparison of the Hampshire with the London series, are given below:

Conus.
Modiola elegans, *Sow.*
Nautilus Sowerbii, *Sow.*
Pholadomya Dixoni, *Sow.*
Pseudoliva semicostata, *Desh.*
Thracia oblata, *Sow.*
Venericardia Brongniarti, *Mant.*
Xiphidion quadratum, *Sow.*

logous to that just described, and only differing from it in proportion as it advances eastward, and the series of beds becomes more expanded.

At Pebble Hill, near Hungerford, which is distant about thirty-five miles north from Clarendon Hill, we find in some abundance in the clays over the mottled clays—

Panopæa intermedia, *Sow.*	? Pinna affinis, *Sow.*
Pectunculus brevirostris, *Sow.*	

In the pebble bed in junction with the mottled clays, at various places in the neighbourhood of Newbury and Kingsclere, *Ditrupa plana* abounds. These are fossils characteristic of the lower beds of the *London clay*; but no opportunity offers for obtaining any considerable variety of organic remains until we reach the vicinity of Basingstoke. At Chinham, one mile north of that town, a cutting on the Reading railway shows the *mottled red clays* overlaid by laminated sands and brown clays mixed with green sand, and with patches of

Cytherea obliqua,	Natica glaucinoides,
Ditrupa plana,	Cardium Plumsteadiense ?, and
Pectunculus brevirostris,	Teeth of Lamnæ;

(point δ in fig. 8 of Comp. Sections, Plate XIV.). At a further distance of two miles on the same line, in a considerable clay cutting at Cuffell, we find a section very similar, both lithologically and zoologically, to that at Clarendon Hill*. In both localities there is the same remarkable abundance of the *Panopæa* imbedded in the clays, in a vertical position similar to that which the recent species assume in their living habitats at the present day, proving the quiescent deposition of these portions of the strata†. The *Pholadomya* and *Pinna*, the latter of which attains an unusually large size at Cuffell, exhibits also there the same peculiarity of position.

The fauna here becomes much more varied, comprehending nearly 60 species, in the determination of which I am much indebted to Mr. Morris. He has visited with me Cuffell and Newnham; and as this and most of the other lists have been revised by him and Mr. Edwards, I give them with much more confidence.

Fossils from the London Clay at Cuffell‡, three miles north of Basingstoke.

Arca impolita ?, *Sow.*	Cardium nitens, *Sow.*
Bulla.	Cassidaria striata, *Sow.*
Cancellaria læviuscula, *Sow.*	Cerithium.

* The Cuffell cutting is however rather higher in the series than that at Clarendon Hill. Possibly between 100 and 200 feet above the *mottled clays.*

† Dr. Fitton has called my attention to the occurrence of the same interesting exhibition of present habits in past states, exhibited by the *Panopæa* and *Pinna* in the lowest beds of the *lower greensand.*

‡ Mr. Edward Cole, one of the under-engineers on that line of railway, has, on the several occasions that I have visited this section, afforded me every assistance. Having superintended this portion of the work, he has had a favourable opportunity, which he has not allowed to pass, of making a complete collection of the organic remains occurring at Cuffell. He has given me many specimens which I had not met with, and I am glad to say has recorded many good geological facts connected with the dip, thickness, &c. of the strata.

Corbula (small new species).
Cultellus affinis, *Sow.*
Cyprina planata, *Sow.*
Cytherea obliqua, *Desh.*
Ditrupa plana, *Sow.*
Dentalium nitens, *Sow.*
Fusus tuberosus, *Sow.*
—— angusticostatus ?, *Mell.*
—— carinella, *Sow.*
—— trilineatus, *Sow.*
—— (two new species).
Modiola depressa, *Sow.*
—— subcarinata, *Sow.*
Murex cristatus, *Sow.*
Natica Hantoniensis, *Sow.*
—— glaucinoides, *Sow.*
Nautilus imperialis, *Sow.*
—— Sowerbii, *Sow.*
Nucula amygdaloides, *Sow.*
—— lunulata ?, *Nyst.*
Ostrea (large species).
Pecten corneus, *Sow.*
Pectunculus brevirostris, *Sow.*
Panopæa intermedia, *Sow.*
Pholadomya margaritacea, *Sow.*
Pholadomya Dixoni ?, *Sow.*
—— virgulosa, *Sow.*
Pinna affinis, *Sow.*
—— (n. s., a very large one).
Pleurotoma rostrata, *Sow.*
—— elegans, *Mell.*
—— (four new species).
Pyramidella —— ?
Pyrula Smithii, *Sow.*
—— tricostata, *Desh.*
Ringicula turgida, *Sow.*
Rostellaria lucida, *Sow.*
—— Sowerbii, *Mant.*
—— (small n. s., same as at Clarendon).
Solarium patulum, *Sow.*
? Scalaria undosa, *Sow.*
—— (new species, large).
Serpula trilineata ?, *Sow.*
Teredo antenauta, *Sow.*
Trivia (Cypræa, *Sow.*).
Turritella imbricataria, *Sow.*
—— sulcifera, *Lam.*
Typhis muticus, *Sow.*
Venus (small species).

With these occur rarely, *Flustra*, *Pennatula*, apparently of the Highgate species, teeth of *Lamna elegans*, and defensive bones of *Myliobates*.

Four miles north of Cuffell, in the cutting at Clewett's Green, we have nearly the summit beds of the *London clay*. In parts they are very fossiliferous, containing numerous individuals of the following species :—

Anomia lineata, *Sow.*
Cassidaria carinata, *Lam.*
Corbula.
Cyprina planata, *Sow.*
Cytherea obliqua, *Desh.*
—— suberycinoides, *Desh.* var.
Fusus tuberosus, *Sow.*
Lingula tenuis, *Sow.*
Modiola elegans, *Sow.*
Nautilus imperialis, *Sow.*
Natica glaucinoides, *Sow.*
Ostrea flabellula, *Lam.*
Panopæa intermedia, *Sow.*
Pseudoliva obtusa, *Sow.*
Pyrula tricostata, *Desh.*
Turritella imbricataria, *Lam.*
Teredo antenanta, *Sow.*
Venericardia.
Voluta elevata.
Palates of Myliobates.
—— Ætobates.
Teeth of Lamna elegans.

On the line of the London railway at Old Basing, the *mottled clays* are immediately succeeded by a bed of dark brown clay with—

Ditrupa plana, *Sow.*
Cyprina.
Astarte donacina, *Sow.*
Turritella.
Nucula similis, *Sow.*
Pholadomya.
Fusus tuberosus, *Sow.*
Cytherea.
Pectunculus decussatus, *Sow.*
Vermetus Bognoriensis, *Sow.*

And at the Plantation one mile further eastward, in a tough brown clay, are found—

Ostrea (same large sp. as at Clarendon Hill). Vermetus Bognoriensis.

On the same line, six miles from Basingstoke, at Newnham near Winchfield, a deep cutting in the *London clay* afforded me the following specimens :—

Fossils from the London Clay at Newnham, between the Winchfield and Basingstoke stations.

Anomia lineata.
Acteon simulatus, *Sow.*
Avicula media, *Sow.*
Ancillaria (same sp. as at Highgate).
Buccinum junceum.
Cardium nitens, *Sow.*
—— Plumsteadiense ?, *Sow.*
Cancellaria læviuscula, *Sow.*
Cassidaria carinata, *Lam.*
Cyprina planata, *Sow.*
Cytherea obliqua, *Desh.*
—— suberycinoides, *Desh.* var.
Ditrupa plana, *Sow.*
Fusus bulbiformis, *Lam.*
—— errans, *Sow.*
—— tuberosus, *Sow.*
Globulus depressus, *Sow.*
Lingula tenuis, *Sow.*
Modiola elegans, *Sow.*
—— subcarinata, *Sow.*
Nautilus imperialis, *Sow.*
Natica glaucinoides, *Sow.*
—— Hantoniensis, *Sow.*
Ostrea flabellula, *Lam.*
—— Cymbula ?, *Desh.*
Panopæa intermedia, *Sow.*
Pholadomya margaritacea, *Sow.*
Pinna affinis, *Sow.*
Pleurotoma rostrata, *Sow.*
—— (two new species).
Pseudoliva obtusa, *Sow.*
Pyrula Smithii, *Sow.*
—— tricostata, *Desh.*
Rostellaria Sowerbii, *Mant.*
—— lucida, *Sow.*
Ringicula turgida, *Sow.*
Solen affinis, *Sow.* (Cultellus).
Teredo antenauta, *Sow.*
Terebratula striatula, *Mont.*
Turritella imbricataria, *Lam.*
—— sulcifera ?, *Lam.*
Vermetus Bognoriensis, *Sow.*
Venericardia.
Voluta elevata, *Sow.*
Serpula extensa, *Brand.*
Teeth of Lamnæ.

These fossils are imbedded in a dark grey sandy clay, frequently containing numerous small round black flint pebbles. The shells are well-preserved, and most of them have attained a large size. The *Cyprina planata* especially are very large. Some of the Septaria are full of *Modiola* and *Cardium*. These three, together with the *Turritella imbricataria, Ostrea flabellula, Cytherea obliqua,* and the two species of *Natica,* are the common shells. Fossil wood pierced by the Teredo is plentiful.

In the small number of sections which have been exposed between Newnham and London, the fossils have been found to agree either with those of the above, or with others occurring at Hampstead or Highgate. But we need not, for our object, go further than Newnham, since from thence to Highgate the *London clay* ranges uninterruptedly. This point can therefore be taken as a fit term of comparison between the fauna of these beds in the neighbourhood of London* and those in Hampshire†.

* Mr. Wetherell has found at the base of the London clay at Hampstead a conglomerate bed similar to that of Clarendon, and analogous to the unindurated layers at Chinham, and containing like them the *Rostellaria Sowerbii, Natica glaucinoides, Cytherea obliqua,* and *Pectunculus brevirostris* (Trans. Geol. Soc. 2nd Series, vol. v. p. 133). Mr. Warburton also gives an analogous group of fossils from a similar position at the base of the London clay at Holyport, near Maidenhead (Trans. Geol. Soc. 2nd Series, vol. i. p. 52). Mr. Rolfe has the same from Reading (Trans. Geol. Soc. 2nd Series, vol. v. p. 130). I have the same species from Sonning near Reading, and many other places; in all of them, as a group, there is a perfect identity.

† From Newnham to Old Basing the *London clay* can be followed, with little interruption, to the mottled clays over the chalk, and in the opposite direction it dips under the Bagshot sands at Winchfield. Newnham seems to occupy a place rather high in the middle of the series. From Old Basing, however, west-

Position of the London Clay in the Hampshire Tertiaries.

The question of the relative age of the *London clay* and the Hampshire series depends materially upon the evidence afforded at Newnham, Old Basing and Cuffell. If the London clay embraces in its synchronism the Bracklesham and Barton beds, then ought we to find some evidence of this expansion as it ranges westward and south-westward, in the gradual preponderance of forms peculiar to these latter beds. If, on the contrary, the equivalent of the London clay is, as I believe, restricted to the lower fossiliferous clays of the Hampshire system, then ought we to find at Newnham and Cuffell a fauna equally related to that of these lower clays and to that of Highgate, and distinct from that of the deposits of Bracklesham and Barton*.

Notwithstanding, however, the intermediate geographical position, and the favourable stratigraphical place, high in the series of the *London clay*, of the *Newnham* and *Cuffell beds*, the following table will show that the proportion of Bracklesham and Barton species is no greater there than in the *London clay* at Hampstead and Highgate (*ante*, p. 365). It will also appear that the strata at Cuffell and Newnham contain a fauna very closely allied to that of the *London clay* of the neighbourhood of London; whilst it is evident that the species which occur in the Bognor beds in Hampshire bear an equally near relation to those of Newnham and Cuffell as well as to those of Highgate and Hampstead, and exhibit no greater number than do the latter of Bracklesham and Barton forms. In fact, the relative proportion to the species of these latter two localities is maintained in each with much uniformity.

ward to Pebble Hill, the range of these clays cannot be so easily followed. The Reading line of railway gives some good sections; and at various points from thence to near Hungerford, the lower beds can be detected at intervals by their organic remains, leaving but little doubt that they are all members of the same series as at Newnham, as the fauna is the same throughout.

* At first sight this seemed to be more doubtful, some forms appearing which have hitherto been confined to Bracklesham and Barton, such as the *Globulus depressus*, *Fusus bulbiformis*, *Psammobia compressa*, and *Pseudoliva obtusa*. Two or three of these have however been found in the Bognor beds of Hampshire (see Lists). The Newnham group of fossils being also from beds rather high in the London clay, may possibly yield a larger proportion of fossils belonging to the overlying series than we find at Clarendon Hill, or even Cuffell, which occupy, I think, a lower position. In the list of fossils at the end of this paper it is the object to show that the three divisions of London, Bracklesham and Barton possess each, as groups, a distinct fauna, and therefore each group is taken as a whole, irrespective of subdivisions; and the distribution in the several divisions of the respective faunas, according to vertical range or to locality, is a question only casually touched upon. They are all however, the *London clay* especially, capable of zoological subdivisions. The *London clay* exhibits a typical group at the bottom of the series: in ascending several new species appear. Then again, many of the early species reappear in considerable numbers at the top of the series. But this is a wide field, on which I do not purpose here to enter, as it may form part of a fuller investigation into, and detail of, the Tertiary Geology of London. For our present object it suffices to consider the *London clay* as a whole.

Table showing the range of the Fossils given in the foregoing lists into other parts of the Eocene series of London and Hampshire.

Localities.	Number of identified and described species found at each locality.	Species common to Highgate or Hampstead.	Species common to Bognor*.	Species common to Bracklesham.	Species common to Barton.
Isle of Wight	37	29	19	14	13
Southampton	33	24	17	12	12
Clarendon Hill	23	16	14	11	11
Cuffell and Clewett's Green	51	39	24	18	16
Newnham and Old Basing...	43	30	21	19	19

From this examination it appears that the per-centage of species common in each locality to Highgate, Hampstead and Bognor is far greater than to Bracklesham and Barton†, and that the Highgate and Hampstead forms exist in nearly as large a proportion in these strata in Hampshire as they do in the western portion of the London district.

It is therefore fair to assume, both from strict analogy of structure and a near similarity of organic remains, that the *London clay* is represented in Hampshire by the lowest fossiliferous beds, which in my last paper I had termed the *Bognor beds,* and that consequently it is older than the *Bracklesham beds,* and still older than the *Barton beds.* I should also propose that the term *London clay* be applied and restricted to this its equivalent in Hampshire instead of the term of *Bognor beds,* as being the better-known designation, and the more important section of this formation (see table at end, and Plate XIV. Comp. Sect.).

I have previously stated‡ the probability that the *Bognor beds* are at or near the base of the *London clay*; but the same genera which at Bognor form a distinct and typical group, associated within narrow vertical limits, are found in the Isle of Wight in greater dispersion and isolation through a vertical range of 200 to 300 feet. (Strata 3 to 6 of Alum Bay, and 3 and 4 of White-Cliff Bay—see Plate XIV. Comp. Sections, figs. 2 and 3.) At Highgate, and elsewhere in the neighbourhood of London, we find the *Bognor group* of fossils chiefly congregated in great abundance at the base of the *London clay.* I

* The number of species found at Bognor amounts at present to about 32.

† I believe it likely that the proportion of species common to *London, Barton* and *Bracklesham* will be materially reduced as our knowledge of the Highgate, Hampstead and Sheppey forms extends. In the fine collection of Mr. Wetherell of Highgate, many of the numerous undescribed species from Highgate and the neighbourhood are of common and characteristic forms. If these were added to the list of *London clay* species, we should probably find, as at Newnham and in Hampshire, that the London clay of Highgate would exhibit a larger proportion of Testacea peculiar to it. The large work upon which Mr. Dixon of Worthing is engaged will also, I hope, shortly make known a more complete list of the organic remains from the productive locality of Bracklesham Bay, and also of those of Bognor.

‡ Journal of the Geol. Soc. for August 1846, page 236.

am however inclined to think that we need not restrict the synchronism of the *Bognor beds* of Hampshire to the lower part only of the *London clay*, but that we may consider that the conditions, which in the Isle of Wight were favourable to the prolonged existence of the characteristic Bognor fossils throughout the whole of the London clay, were altered as we approach the site of London by a greater depth of sea, whereby the shallow water and littoral fauna of Bognor had its character modified by the introduction of new forms, as the *Nautilus*, *Pentacrinites*, and other deep-sea animals which abound in the central beds of the *London clay* around London. The groups of organic remains in the intermediate localities bear corroborative evidence. At Alum Bay and Southampton we find a considerable number of Highgate forms, but still with a general prevalence of the Bognor group*. In the western portion of the London district we meet with a distribution of the fauna approximating closely to that of Hampshire, and showing a high range in the *London clay* of the Bognor group. At Newnham and Cuffell the fauna begins to exhibit the lower range of the Bognor group, and the introduction of a greater variety of Highgate forms; and in the neighbourhood of London we find the Bognor group, although largely preponderating in the lowest beds, but faintly represented in the greater bulk of the middle beds, whilst in the highest beds some species of the group reappear in the greatest abundance.

This is a phænomenon of considerable interest, inasmuch as it indicates that that prolonged and gradual subsidence of the sea-bottom, which I have before† endeavoured to show prevailed during the formation of the London clay (Bognor beds) in the Isle of Wight, extended in a nearly equal degree to the western portion of the London district. Over all this area the increasing depth caused by the subsidence appears to have been constantly neutralized by an accumulation of sediment, equal, or nearly so, to the amount of depression. By the joint and counteracting effects of these two causes, a nearly uniform and moderate depth was maintained throughout the seas then covering these districts, enabling the *Panopæa*, *Pholadomya*, *Pinna*, and other shallow-water genera, to exist all through this geological period, to the exclusion of the more varied fauna which greater changes of depth would have produced. But we have indications, as we proceed further eastward in the London district to Highgate and Sheppey, of a departure during part of this period from these uniform zoological conditions; for, as we have just mentioned, we here find various species of *Cephalopoda*, *Echinodermata*, some *Brachiopoda*, and of a generally deeper sea testacea, superadded in considerable abundance to the more limited fauna of the same age in the Isle of Wight. As the deeper sea forms here predominate, so do those of

* The typical species of this (if we may so term it) rudimentary group are, *Cytherea obliqua*, *Cardium Plumsteadiense*, *Infundibulum trochiforme*, *Natica glaucinoides*, *Panopæa intermedia*, *Pectunculus brevirostris*, *Pholadomya margaritacea*, *P. virgulosa*, *Pinna affinis*, *Pyrula tricostata*, *P. Smithii*, *Rostellaria Sowerbii*, *Turritella imbricataria* (var.), *Teredo antenauta*, *Venericardia Suessonensis*, *Vermetus Bognoriensis*, and the *Ditrupa plana*.

† Journal of the Geol. Soc. for August 1846, page 237. The reasoning upon which this hypothesis is founded is there given, and need not therefore be repeated here.

the shallower waters gradually disappear. At the end of this period the latter again prevail to the near exclusion of the former.

From these more varied conditions, and from the operation of more numerous zones of depth, adapted to the existence of more numerous classes of Testacea, results probably the more diversified and abundant fauna of Hampstead, Highgate and Sheppey.

Comparison of the London Clay with the French Tertiaries.

In my paper on the Tertiary Geology of the Isle of Wight, I expressed an opinion that the *Bracklesham Bay beds* were of the age of the *lower Calcaire grossier* and the *Glauconie grossière*. Since then I have had the opportunity of examining the large and valuable collection from Bracklesham of Mr. Edwards, and am confirmed in this view of their synchronism. The number of French species found at Bracklesham amounts to about 140 out of the total number of 193 described species. Of these 140 about 120 occur in the *lower Calcaire grossier* and the *Glauconie grossière*; about 40 descend to the *Lits Coquilliers*; and still fewer are peculiar to the *upper Calcaire grossier* and bed above; thus showing a far more intimate connection with the first-named divisions than with any of the others*.

There are a few anomalies, but they are overbalanced by the stronger coincidences. Thus, among the few characteristic fossils of the *Lits Coquilliers* in France, we find foremost the *Bifrontia Laudunensis* and *Nummulites planulatus* (*elegans*, Sow.). Both these species occur in considerable abundance at Bracklesham, but associated with them we have a large proportion of the characteristic species of the *lower Calcaire grossier* and *Glauconie grossière*, including with many others,

Cerithium giganteum†, *Lam.*	Pecten squamula, *Lam.*
Conus deperditus, *Brug.*	Pleurotoma granulata, *Desh.*
Fusus Noæ, *Lam.*	Voluta spinosa, *Lam.*
Lucina gigantea, *Desh.*	—— cithara, *Lam.*
—— concentrica, *Lam.*	Venericardia planicosta, *Lam.*
Melania costellata, *Lam.*	—— acuticosta, *Desh.*

Of the 209 species of Testacea found at Barton, about 100 are identical with species occurring in France, of which 30 are found in the *Lits Coquilliers*, about 60 in the *Calcaire grossier* and *Glauconie grossière* (more particularly the *lower Calcaire grossier*), and probably 20 in the overlying beds. The number of French analogues is here much less than in the Bracklesham series, and with a larger proportion of species of the *Lits Coquilliers*. This is peculiar, as from superposition there can, I think, be little doubt that the Barton series are higher than the Bracklesham Bay series. Before however

* At Chaumont, between Rouen and Beauvais, the *Glauconie grossière* literally abounds with fine specimens of the *Venericardia planicosta*. It is the same species which constitutes so typical and common a form at Bracklesham, and in the beds of the same age at White-Cliff Bay and Southampton. From lithological character and superposition, it is more particularly with these beds that I should associate the Bracklesham sands and clays. I have not however visited Chaumont, nor have I been able to meet with any full account of its sections and fossils.

† A French author, in speaking of the *lower Calcaire grossier*, refers to it as "l'époque du *Cerithium giganteum*, cette coquille-reine qui est devenue une date géologique." This however may be doubtful.

we can reason upon this fact, we require a more extensive determination of the organic remains*.

We have before (*ante*, p. 358) shown that the *London clay*, so far from presenting the same large proportions of forms common to the *Calcaire grossier*, at present shows only about four per cent. of French analogues.

It is in the beds, therefore, of *Brackleshaм* and *Barton*, and not in those of *Bognor* or *London*, that we have the approximate representatives in time of the *middle* and *lower Calcaire grossier*. The *London clay* itself is most probably, as I have before stated the *Bognor beds* to be, of the age of some of the subdivisions of the group of "*Sables inférieurs*" of M. d'Archiac,—possibly near the position of the *Lits Coquilliers*; but its exact parallel in this series cannot at present be clearly determined. At all events, the fossils of the *Lits Coquilliers* present a greater analogy to those of the London clay than do those of the *Calcaire grossier*. Still the number of species common to the two deposits is only about 33; or if we take the number of species found in the *Lits Coquilliers* and *Sables inférieurs* at 200, the proportion will be but sixteen and a half per cent. on that number. The following is a list of them†:—

Anomia lineata, *Sow.*
Cassidaria carinata, *Sow.*
Conus concinnus, *Sow.*
(bicoronatus, *Mell.*)
Cytherea tenuistriata, *Sow.*
(obliqua, *Desh.*)
Fusus porrectus, *Sow.*
(unicarinatus, *Desh.*)
—— bulbiformis.
—— angusticostatus, *Mell.*
—— regularis, *Sow.*
Globulus sigaretinus, *Sow.*
(Natica sigaretina, *Def.*)
Infundibulum trochiforme, *Sow.*
(Calyptræa trochiformis, *Desh.*)
Murex spinulosus, *Desh.*
Natica glaucinoides, *Sow.*
(labellata, *Lam.*)
Nautilus zic-zac, *Sow.*
Corbula striata, *Lam.*
Rostellaria macroptera, *Lam.*
Ostrea flabellula, *Lam.*
Cardium semistriatum ?, *Desh.*
Solarium canaliculatum, *Lam.*
Nucula similis, *Sow.*
(margaritacea, *Lam.*)
? Pectunculus pulvinatus, *Lam.*
(? P. brevirostris, *Sow.*)
Panopæa intermedia, *Sow.*
(Corbula dubia, *Desh.*)
Pholadomya margaritacea, *Sow.*
Pinna affinis, *Sow.*
(margaritacea, *Lam.*)
Pleurotoma colon, *Sow.*
—— elegans, *Mell.*
Pseudoliva semicostata, *Sow.*
(Buccinum semicostatum, *Desh.*)
Pyrula tricostata, *Desh.*
Ringicula turgida, *Sow.*
(Auricula ringens, *Lam.*)
Sigaretus canaliculatus, *Sow.*
Teredo personata, *Lam.*
Turritella imbricataria, *Lam.*
Venericardia Suessonensis, *d'Archiac.*

As in "London clay," *Foraminifera* and *Zoophytes* are comparatively scarce in the "Lits Coquilliers," whilst remains of *Reptiles* are not uncommon.

* The more exact relations of these two divisions will be discussed in the next paper.

† It is to be observed, however, that if we confine ourselves to a comparison of these fossils of the *Lits Coquilliers* with the fossils of the *London clay* at the intermediate geographical position of Hampshire, we shall find the analogy much stronger. Thus, out of the 42 Hampshire species, 26 are analogues of the *Lits Coquilliers*. But the difficulty is, that although this typical Hampshire fauna ranges on the one side into the Paris system, and on the other into the London system, yet it becomes respectively associated in each case with faunas in other respects dissimilar. At the same time we have good geological horizons both above and below, restricting to within tolerably narrow limits the superposition

It may however be observed that the *Lits Coquilliers* bear a much closer relation to the *Calcaire grossier* than the *London clay* does to the *Bracklesham sands* and *Barton clays*; since the proportion of species common to the two former is about 90 per cent., whereas in the latter it is only about 40 per cent.

We can thus for the present only approximate to the relative superposition of the *London clay*, and place it below the *Calcaire grossier*; for, notwithstanding we cannot assign it an exact equivalent, it is evident that it contains a rudimentary fauna (see lists, *ante*, p. 366–371), which may be considered, as a group, to indicate a synchronism with the lowest eocene division of M. d'Archiac (Groupe des Sables inférieurs).

We must not, however, at present draw too close a parallelism between the tertiary formations of the two countries. We appear in this country to have an important and larger development of strata of the age of the lower portion of the French series, and that to an extent which would constitute them the type of the period rather than a subordinate variation thereof.

A few of the more general conclusions derivable from the foregoing observations may here be mentioned.

It is probable that the tertiary sea at first extended uninterruptedly over the London, Hampshire and Paris tertiary areas;—that, at a period coeval with the change of conditions, both in structure and fauna, which is evident at the base of the *London* and *Bognor clays*, a separation took place between the Paris and Hampshire areas, leaving the latter one however still connected with that of London during the deposition of the *London clay*;—that, after this period, the communication between the French and English tertiaries was restored, as evinced by the introduction in the Bracklesham beds of so many French species, and that this connexion was probably in part prolonged until the completion of the Isle of Wight series,—the London district in the meantime assuming a more isolated position, and emerging sooner from beneath the sea.

This leads to an inquiry into the age and structure of the *Bagshot Sands*, which will be found to be in perfect conformity with, and to corroborate, the hypothesis advanced in this paper. I hope shortly to have the honour of laying some remarks on this subject before the Society.

of these deposits. Possibly the *London clay* may have been formed during a period unrepresented, or only very partially so, in the French series. Perhaps the presence of the typical group of Bognor fossils in the *Lits Coquilliers* is the result of migration, at the conclusion of the London clay period, into more recently formed seas wherein the *Lits Coquilliers* were deposited. I am almost inclined to adopt this view, and to consider that the *London clay* period immediately preceded that of the *Lits Coquilliers*;—that it synchronises with some older portion of the *Sables inférieurs*.

The list of fossils, tables and sections accompanying this paper are placed at the end of the following one.

2. *On the main points of Structure and the probable Age of the* Bagshot Sands, *and on their presumed equivalents in Hampshire and France.* By Joseph Prestwich, Jun., Esq., F.G.S.

In continuation of the paper I had the honour of reading before the Society on the 3rd of February last, I purpose now to examine another division of the Eocene series, frequently incumbent upon the *London clay* in the neighbourhood of London, and commonly termed the "*Bagshot Sands*."

Forming usually barren sandy districts, and rising, over great part of their area, into ranges of heath-covered hills, the *Bagshot sands* have attracted but little attention, having, although so near London, remained comparatively unexplored since Mr. Warburton described them in 1821 *.

Without any permanent natural sections, and with few artificial ones beyond an occasional sand or clay-pit, and the curious grave-shaped excavations often scattered over the surface of the gravelly heaths on some of the hills, where they are formed in the process of digging out of the sands the occasional masses of concretionary sandstone, the almost only opportunities for studying the structure of the *Bagshot sands* are afforded by fresh roadside sections and railway cuttings.

The fossils are as rare as the sections. The three genera † (for the species were not distinguishable) of testacea found by Mr. Warburton at Chobham, and the subsequent notice by Dr. Buckland in 1838 of the remains of fishes (including the determination of three new genera) at Goldsworthy, near Woking, comprise I believe all ‡ at present known of the palæontology of the Bagshot sands §.

Notwithstanding however the scantiness of their recent flora and the poverty of their ancient fauna, the *Bagshot sands* present many features of much interest. Superimposed on the more fertile *London clay*, from whose rich and well-wooded valleys they frequently rise in abrupt hills and steep slopes, they often command views of much beauty and considerable extent, and in striking contrast with their own uncultivated and open but fresh and healthful tracts. Of this the rich and varied prospects from St. George's Hill near Weybridge, St. Anne's Hill and White Hill near Chertsey, Cooper's Hill near Egham, Hungary Hill near Farnham, and Farley Hill near Swallowfield, are well-known examples ||. Nor are the Bagshot sands them-

* Trans. Geol. Soc. 2nd Series, vol. i.

† Casts of *Crassatella*, a *Pecten*, and what appears to have been a *Trochus* (Trans. Geol. Soc. 2nd Series, vol. i. p. 51).

‡ Indistinct traces of vegetable remains have also been noticed in some of the blocks of concretionary sandstones.

§ With the exception of a few occasional specimens, rarely collected, I am not aware of the existence of any regular collection of the "*Bagshot-sand*" fossils, even of a local nature. I shall be glad to be informed of any.

|| The general average height above the level of the sea of the "massif" of the *Bagshot sands* varies from 100 to 200 feet. From above this general level the ranges of hills which constitute so large a portion of the area of these sands, rise from 150 to 200 feet. St. Anne's Hill is 240 feet high, Goldsworthy Hill 185 feet; Farnborough station 200, Winchfield station 250, and Bagshot Heath 463. In the section No. 2 the heights are taken from the railway levels. For the heights of many places in this and the adjacent districts see Dr. Fitton's useful list (Geol. Trans. 2nd Series, vol. iv. p. 369).

selves always barren and bare. In many parts of the lower Bagshot sands more particularly, some of the most pleasing scenery in the neighbourhood of London is to be met with. On their eastern border they form a belt of country frequently of considerable beauty and interest*, comprising the well-known parks and grounds of Claremont, Esher, Painshill, Burwood, Oatlands, Woburn, Botley, St. Anne's Hill, Virginia Water, Sunninghill, Sillwood, and further westward those of Easthampstead, Brainshill, Heckfield, and the eastern and higher part of Strathfieldsaye. Between these more prominent localities, and mostly just on the borders of the clays and sands, are many pleasant villages† embosomed in woods, in which the oak and elm of the clays are interspersed with the firs and larches of the sands‡. This is the general character of the country in most parts of the zone of outcrop of the lowest strata of the *Bagshot sands* at their junction with the *London clay*. Even the upper sands themselves, although generally barren, exhibit here and there a few cultivated spots, and these are gradually extending§; but as a mass, the district covered by them is bleak and wild enough for a mountain moor‖. There are however, between the upper and lower sands, a few green sand and argillaceous strata, whose outcrop in the transverse valleys intersecting the ridges of the upper sands is marked by areas of considerable fertility, well-wooded and beautifully verdant¶. Such spots as these are like oases in a desert, and viewed from the higher grounds around form scenes of much beauty, heightened by the contrast of the surrounding heath-clad hills, with their clear and well-marked outlines, broken only by occasional conspicuous clumps of firs on the highest levels.

Range and Structure.

The *Bagshot sands* have a far wider range and more important development than has hitherto been assigned to them. The main mass extends on the east from Esher and Claremont, with little interruption, westward to Heckfield and Strathfieldsaye, and from near

* A walk from the Great Western at Slough, through Windsor and Virginia Water, to the South-Western at Weybridge, and another from Weybridge over St. George's Hill, by Cobham, Ockshot, Claremont, to the Esher station, leads through a great part of this district. The walk from Windsor to Woking, through Sunninghill and Chobham, is interesting and characteristic. The more peculiar features of the *Middle* and *Upper Bagshot sands* may be seen by walking from the Woking station over Goldsworthy and Knap Hills, through Bisley to Bagshot; thence over Penny Hill, along the Devil's Highway to Finchampstead, and over Farley Hill to Reading.

† Esher, Ockshot, Weybridge, Byfleet, Addlestone, Englefield, Eversley, Hazely, Winchfield, Ewshot, Aldershot, Ash, Littlefield, Ripley and others.

‡ An agreeable character of these mixed sandy and argillaceous lands is their rapid absorption of excessive wet, their general freshness (from the underlie of clay), and good by-roads.

§ Especially in the neighbourhood of Farnborough and Frimley.

‖ Romping Downs, Chobham Ridges, Fleet-pond Heath, Hartford Bridge Flats, Sandhurst Heath and Bagshot Heath are examples of this.

¶ As at Goldsworthy, Knap Hill, Pirbright, Bisley, Ottershaw, Windlesham, Bagshot, Elvetham, the valley of the Blackwater, and of various other small streams. The first two localities are celebrated for their nursery-grounds.

Farnham on the south to Wokingham on the north*. They also form numerous outliers both to the westward and eastward of this main mass, appearing on the summits of Harrow, Hampstead and Highgate hills; and I have further traced them on some of the hills near Epping, at Havering-atte-Bower, Brentwood, Langdon, and as far as the hills around Rayleigh, near Southend.

These sands are everywhere in distinct and conformable superposition to the *London clay*, but nowhere, that I have yet seen, is there any other deposit incumbent upon them.

A wanderer amongst formations, without determined age or superposition—by some considered the equivalent of our most recent tertiary series, the *Crag* †,—by others referred to the sands superimposed upon the *Freshwater strata* of Hampshire ‡; frequently placed rather lower than this §, and (as its lowest assigned position) sometimes grouped with the *sands* overlying the *Barton clays* at Alum Bay, and forming the base of Headon Hill (see Pl. XIV. Gen. Sec. fig. 2, No. 30): on the continent sometimes placed in co-relation with the *Grès de Fontainebleau* ||, but more usually with the *Grès de Beauchamp* ¶,—the deposit known as the *Bagshot sands* still presents a problem in geological chronology and stratigraphical structure**.

In investigating this question I have traversed the Bagshot sands in every direction, from Southend to Newbury, and yet have collected but a small number of positive facts. Few however though they are, they all give concurrent testimony, and being supported by a mass of negative evidence, possess I think greater weight than numerically they would be entitled to.

As with the *London clay* in my previous paper, I do not now intend to enter minutely into the details of structure, but to restrict myself merely to such a general view as will suffice for a comparison with the strata which I hope to prove to be their equivalents in Hampshire and the Isle of Wight.

The *Bagshot sands* have been described as an irregular mass of unfossiliferous siliceous sands, with occasional subordinate beds at their base of fossiliferous green sands and marls. Of the relative superposition and range of their component strata; of their comparative development, persistence and thickness, and of the distribution of the fauna, further details are however yet required before their age and structure can be well determined. To these points we will therefore direct our attention.

Notwithstanding the apparent indistinctness and irregularity of these sands, their structure is far more regular and persistent than could be anticipated at first sight. The sandy heaths of Woking, Ascot, Cob-

* For further details of the range of outcrop of these sands, see Mr. Warburton's paper. See also Dr. Mantell's Geology of Surrey, in Brayley's 'Surrey,' and Conybeare's and Phillips's Geology. † Bakewell's 'Introduction to Geology.'

‡ Warburton's paper before quoted; and in most Geological maps.

§ In Conybeare's and Phillips's Geology of England it is placed as the *Upper Marine Formation*, an arrangement since very generally followed.

|| Brongniart's 'Tableau des Terrains.'

¶ D'Archiac, Bulletin de la Soc. Géol. de France, vol. x. p. 200.

** See note, *antè*, p. 359.

ham, Frimley and Hartford, similar as they are in general appearance, can all be placed in their relative geological divisions with as much certainty as though situated in the well-marked divisions of the cretaceous system. Instead of forming one mass of unfossiliferous sands, with irregular subordinate beds of green sand and marls, the *Bagshot sands* can be divided into three distinct and persistent divisions, severally characterized by peculiar groups of organic remains and by differences of lithological characters.

Lower Bagshot Sands.

This division, which reposes* conformably on the *London clay*, consists mainly of whitish and light yellow fine siliceous sands, frequently micaceous and occasionally argillaceous, with a few seams of pebbles and mere traces of organic remains. It varies in thickness from 100 to 150 feet. Thus in the well at Chobham Place (Pl. XIV. Comp. Sec. fig. 10), after sinking through a portion of the upper sands and the whole of the central green sand beds "*b*" (fig. 4. p. 384), there was found about 100 feet of light-coloured sands "*c*," and below them the *London clay*†. At the Woking station 100 feet of light-coloured sands were pierced through before reaching the *London clay*, and if we then follow these sands, from the station to Goldsworthy Hill (fig. 3. p. 382), where the outcrop of the central green sands "*c*" is very distinct, we shall have a total thickness of about 130 feet to this lower division. Again, at Knap Hill, at a short distance from the outcrop of the central green sands, the borings passed through 100 feet of light-coloured sands before arriving at the *London clay*. At St. George's Hill near Weybridge, the sands may be traced from the London clay at the base of the hill to the outcrop of the green sands about halfway up it, a thickness of about 130 feet. At Shapley Heath, adjoining the Winchfield station, the green sand beds are seen resting upon the lower sands, which may be followed down the hill to the *London clay*, giving an estimated thickness of about 100 feet (see Pl. XIV. Comp. Sec. fig. 9).

Numerous other wells and many small road-side sections occur in the lower sands, but the bulk of them are only of a very partial and limited character; still they are important, inasmuch as they show the uniformity of structure of this division of the Bagshot sands. Thus in Virginia Water Park, around Woking, at Claremont, Cobham, Ripley, Ascot, and wherever else exposed, these lower sands exhibit no traces of green sands. Thin and finely laminated subordinate and irregular beds of whitish, light yellow, brown and liver-coloured fine clays with sands are of not uncommon occur-

* This was well exhibited in the railway cutting through St. George's Hill. At the end, near the Walton station, I traced the *London clay* for a distance of several hundred feet passing conformably below the *lower Bagshot sands*. Again near Egham and elsewhere, as mentioned by Mr. Warburton.

† The well was continued through the London clay 400 feet; then through about 50 feet of mottled clays and sand, and into the chalk to a depth of 150 feet, making a total depth of about 800 feet. These measures were given me from recollection by an old man who had worked at the well, and are therefore liable to error; I however believe them to be tolerably exact.

rence, in the upper part especially. This structure is best exhibited around Woking, Horsley, and White Hill near Egham. A peculiar local instance in these *lower Bagshot sands* of their sudden transition into, or rather of the sudden substitution of clays, occurred at the railway-cutting at Goldsworthy Hill near Woking. Immediately under the central green sands, the upper part (for a depth of five or six feet, which was as far as it was exposed) of the underlying fine white siliceous sands were there seen passing horizontally and abruptly into a dark grey laminated clay (see Fig. 3. at point marked "*y*").

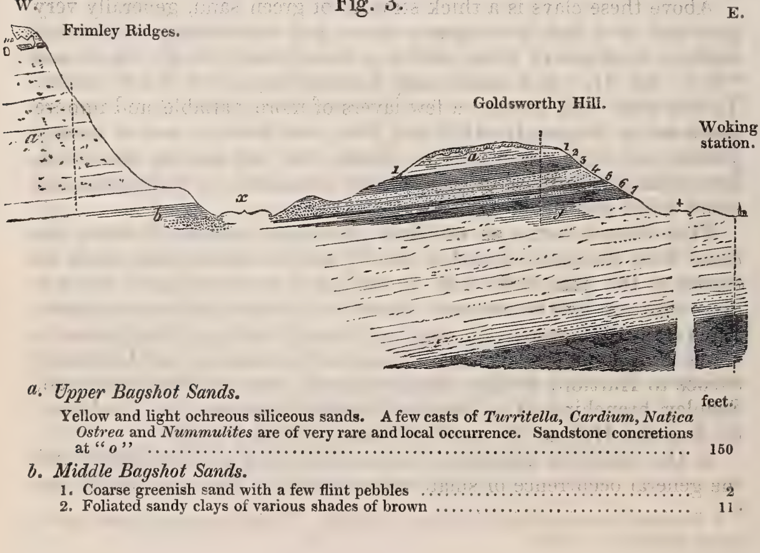
This variation of structure is of very local character, as this bed of clay does not even appear at the outcrop of the same sands on the south side of the hill at less than a quarter of a mile distant. To the north however it is apparently more persistent, and it is probable that part of the neighbourhood of Chobham, which stands on the upper beds of the lower sands, is in some measure indebted to the occasional presence of this bed for its good supply of water and general fertility.

In the western districts of the Bagshot sands this lower division again becomes very argillaceous, passing into light brown loams. Their lowest beds remain however usually the most sandy.

Amongst the subordinate lithological characters is the frequent presence in the sands of small plates of mica (especially where slightly laminated with clays), of large grains of yellow and transparent quartz, pebbles of black rolled flints, thin layers and nodules of iron sandstone, and a few concretionary masses of saccharine sandstone, which are more compact and harder than those in the upper sands, and by no means so abundant.

The following section exhibits the details of the divisions and the general structure of the Bagshot sands:—

Fig. 3.



a. Upper Bagshot Sands. feet.

Yellow and light ochreous siliceous sands. A few casts of *Turritella, Cardium, Natica Ostrea* and *Nummulites* are of very rare and local occurrence. Sandstone concretions at "*o*" 150

b. Middle Bagshot Sands.

1. Coarse greenish sand with a few flint pebbles 2
2. Foliated sandy clays of various shades of brown 11

		feet.
3.	Grey clay with traces of lignite	1
4.	Green sand; upper part light-coloured and clayey, the lower part pure and dark-coloured. Numerous teeth and bones of fishes and turtles, casts of *Turritella sulcifera* and *Venericardia planicosta*, &c. (see List, p. 390)	16
5.	Compact lignite	1
6.	Light-coloured compact sandy clay, passing downwards into dark grey clay. The upper part is irregularly pierced with green sand-tubes	6
7.	Light and dark brown and liver-coloured very compact foliated clays, with traces of vegetable impressions	8

c. Lower Bagshot Sands.

	feet.
Light yellow siliceous sands with irregular light-coloured argillaceous beds. Traces of vegetable impressions	130

d. London Clay (upper part of).

x Interval of three miles. † Interval of quarter of a mile.
In both these spaces the strata are continuous.
...... Portions of strata proved.

The section at Shapley Heath, adjoining the Winchfield station, is almost an exact counterpart of this one.

Middle Bagshot Sands.

Overlying the *lower sands* are a few beds of white, yellow, sulphur-coloured, brown, liver and cream-coloured laminated clays, and one or two beds of green sands. Their thickness altogether does not exceed from forty to sixty feet; they nevertheless form a division, not only of distinct mineral character, but also of extremely persistent range and structure. The lowest part usually consists of light-coloured and dark brown, very compact or impalpable foliated clays, frequently laminated with light-coloured sand, and occasionally with subordinate beds of lignite ("*b.* 6 to 7," fig. 3). These clays are most extensively developed around Addlestone and Chertsey, where they attain a thickness of ten to twenty feet. In their range westward they gradually diminish to a thickness of five feet at Shapley Heath (Pl. XIV. Comp. Sec. 9 and 10).

Above these clays is a thick stratum of green sand, generally very pure and of a dark bottle-green colour, and maintaining a tolerably uniform thickness of about twelve to twenty feet ("*b.* 4," fig. 3, and "*b.* 2," fig. 4). It is occasionally fossiliferous, but of this hereafter. To this main bed succeed a few layers of more variable and impure green sands, frequently exhibiting false stratification, and of brown, yellow, and light greenish clays, usually, but not always, laminated. Intercalated with these green sands are occasional layers of large and small rolled flint pebbles.

This division forms an excellent geological horizon, dividing the *lower* from the *upper Bagshot sands*; and its outcrop may easily be traced on the sides of the hills by the line of small springs to which it gives rise, or by the frequent presence of marsh- and water-plants. Thus from Goldsworthy it may be followed through Worplesdon to above Normandy; is again visible east of Crookham, near Crondall; thence to Hartford Bridge, Shapley Heath, round to Finchampstead, Swinley, branching off to Bagshot, passing thence north of Chobham, by Knowles Hill, to the south of Sunninghill and Ascot*.

In the valleys its presence is indicated by their greater fertility and the general occurrence of small water-courses. This has led to the

* Its exact course can only be given on a map. These are merely a few of the places where it is visible.

supposition that the *London clay* cropped out in these valleys, as for instance in the valleys of Chobham and Blackwater. Such however is apparently not the case. On the level of the first of these valleys, the upper part of the *lower sands* and lower part of the *central green sands* outcrop, and in the second the *upper part of these green sands* is at or near the surface. In both cases the *London clay* is still covered by the 100 to 130 feet of *lower Bagshot sands.*

The following section shows the relation of these strata:—

S. Valley of Chobham. Fig. 4. N. Chobham Place.

a. Upper Bagshot Sands.
Yellow siliceous sands .... 100 feet.

b. Middle Bagshot Sands 45
1. Clays; brown, yellow and greenish.
2. Clayey green sands, full of impressions of *Ostrea, Corbula, Turritella, Venericardia,* &c. (See List of Fossils, p. 390.)
3. Foliated white, brown and yellow clays, with traces of vegetable impressions.

c. Lower Bagshot Sands.
Light yellow siliceous sands.. 120 feet.

d. London Clay (upper part of). See Pl. XIV. Gen. Sec. fig. 10.

- - - - - Section where proved.

Upper Bagshot Sands.

Incumbent on these green sands is the upper and main mass of the *Bagshot sands.* Having fewer distinct argillaceous beds than occur in the lower sands, the stratification of this division is not so well marked and appears more confused, and the sections in it are also rarer.

This division consists of irregular-bedded sands of a light yellow colour, occasionally slightly tinged green, red, or ochreous, and as a whole rather darker in its tint than the lower sands.

Its superposition on the central green sands is in every instance, where the latter are visible, very apparent. This structure is tolerably apparent on the range of hills two miles north of Chobham, on the side of which the green sands, in some places very fossiliferous, may occasionally be seen outcropping (see fig. 4).

Small ironstone concretions are common in this division, and amongst these concretions may sometimes be detected traces of organic remains. The well-known blocks of light-coloured, or nearly white, saccharine sandstone are met with chiefly in the upper beds of these sands, generally just below the gravel. They are found by sounding the sands and gravel with iron rods. Some of these concretions attain a size of ten to twelve feet across, and three to four feet thick. Flint pebbles, sometimes only slightly rolled and angular, at other times perfectly rounded, occur in them. The sandstone is friable when first excavated, but hardens by exposure. This upper division of the *Bagshot sands* is best exhibited in the ridges of Frimley and Chobham, which are formed entirely of it, and in the heaths of Bagshot, Hartford Bridge and Sandhurst. Its thickness in the first of these localities appears to be as much as 250 to 300 feet. These sands are usually very barren, but the lower beds near the central green sand become more fertile, and the cultivation of them is gradually extending.

Position of the Bagshot Sands.

Such are the subdivisions of the *Bagshot sands*, and such their general lithological structure. As a mass they are almost entirely siliceous, and rarely exhibit even a trace of carbonate of lime. The contrast with the preceding nearly pure argillaceous series of the London clay is marked.

As it will be necessary to bring forward all the organic remains as evidence of the age of the *Bagshot sands* in another part of this paper, we will for the present pass them over, and proceed to the discussion of the main question, viz. with which of the Hampshire and French tertiary strata are the *Bagshot sands* synchronous*?

From a careful examination of all the phænomena, I am convinced that they cannot be associated with the Hampshire *Freshwater strata*, or with the *sands* above or immediately below them, nor yet with the *Grès de Fontainbleau* or the *Grès de Beauchamp*; but that, however anomalous it may appear at first sight, they must be considered as the equivalent of that group to which the rich fossiliferous beds of *Bracklesham* belong; that they are synchronous with the central vertical strata at White-Cliff Bay, and with the great central mass of variegated and light-coloured sands of Alum Bay (see Pl. XIV. Comp. Sec. fig. 3 to 11), including possibly the *Barton clays*. At all events these *Bagshot sands* are older than the Freshwater or Fluvio-marine series.

Such being their position in England, they would I think be represented in the French tertiaries by the lower part of the *Calcaire grossier* and the *Glauconie grossière*. They would thus occupy a low position in the *Eocene series*, following in uninterrupted sequence the formation of the *London clay*, and being in perfect conformity with the progressive development of the marine strata of the Hampshire tertiaries.

In instituting a comparison of superposition, mineral structure and fauna between the *Bagshot sands* and the *Bracklesham series*, we must take as our Hampshire type that section which best exhibits the sequence of the strata and the range of organic remains. For

* I am aware that I am here deviating from the usual plan, but I am following the course of my own investigation, in which I was chiefly guided by a study of superposition and physical conditions. It was only at a very late period that I obtained any decided corroborative evidence by organic remains.

this object the section at White-Cliff Bay is best suited (see White-Cliff Bay section, fig. 3, Pl. XIV.).

From the great changes exhibited in the equivalent strata at Alum Bay, the sequence is not so easily traced. We will therefore reserve the comparative examination of that section to the end of the paper, and confine ourselves at first to the one point where the evidence is strongest.

Comparison of the structure and physical conditions of the Bagshot Sands and of the Bracklesham Bay series.

We have shown that the *Bagshot sands* may be separated into three divisions, of which the lower and upper ones are characterized by loose light yellow siliceous sands, and the central one by dark green sands and foliated brown and liver-coloured clays—the whole reposing conformably on the *London clay*. This structure is subject to but little variation throughout the London district. Now let us take the central vertical strata Nos. 5 to 20 (see Pl. XIV. Comp. Sec. fig. 3) of White-Cliff Bay* and resolve them into their simplest elements, and it will result that as a whole they may be classed into a lower mass of light yellow unfossiliferous sands (stratum No. 5), to which succeed thick beds of brown laminated clays and fossiliferous green-sands (strata Nos. 6 to 13), more or less calcareous and argillaceous, followed by sands and light brown and yellow sandy clays (strata Nos. 14 to 20). This section exhibits a greater development of strata and more complexity of structure than we find in the *Bagshot sands*. In other respects the analogy of mineral structure is strong. This we will now proceed to examine more in detail and at successive sections.

In the preceding paper I showed that the *London clay* at White-Cliff Bay was probably limited to the 300 feet of argillaceous strata (fig. 3, strata Nos. 3 & 4) which immediately succeeds the mottled clays (No. 2). Conformably overlying this London clay is a mass of light yellow siliceous sands without fossils, and 100 feet thick. At the Southampton artesian well we again find that the sixty to seventy feet of strata overlying the London clay consist of similar unfossiliferous sands, but rather more argillaceous (see fig. 5. p. 388, stratum "*b*").

Proceeding to the London district we find these sands there continued, and forming a nearly exact counterpart to those of Hampshire. Thus at Shapley Heath there is incumbent on the *London clay*, and underlying the *central green sands*, about 100 feet of light yellow unfossiliferous *sands*. At Goldsworthy, Chobham and Weybridge, where the thickness of these sands can again be ascertained, they exist in but slightly increased expansion (see Pl. XIV. Comp. Sec. figs. 4, 3, & 1).

Over these *sands* (No. 5) at White-Cliff Bay are 100 feet of *foliated brown clays* and green and yellow sands, succeeded by 150 feet of impure green sands and brown and grey clays, with layers of lignite and pebbles, and then 60 feet of pure *dark green sands* very

* For fuller details of this section see Journal of the Geol. Soc. for August 1846, p. 252–255.

fossiliferous, and then again 50 feet of *laminated green sands and brown clays,* making a total thickness of about 360 feet, and including the equivalents of the Bracklesham Bay beds.

This division I consider to be represented in the *Bagshot sands* by the fifty feet of central, brown, and liver-coloured clays and green sands. As a question of synchronism, this difference of thickness between the supposed equivalent strata of Hampshire and Bagshot is not essential; for in a distance of forty to fifty miles, the varying action of the tides and currents of the sea of that period renders conceivable a greater accumulation of sediment in one place than in another*, especially as it is probable that it was derived from some point south-west of the site of the Isle of Wight. But although the accumulation of sediment may in these ancient seas have varied in quantity, from this or any other cause, still, if originating in the degradation of the same land and spread by the same waters, we ought to find in its mineral characters traces of its common origin; and these more important conditions we shall in this case find perfectly fulfilled. Thus we have in both districts the same peculiar brown and liver-coloured clays—in the *Bagshot sands* usually very finely foliated, and in Hampshire more coarsely laminated with fine sands. The occurrence of green sands is very distinctive, as in no other part of the English tertiaries do they of themselves form entire and persistent strata.

In the Hampshire series this division is characterized by occasional beds of lignite and by frequent layers of rounded flint pebbles, denoting stronger temporary drifts; so in the Bagshot series at Shapley, Worplesdon and Goldsworthy, one or two thin, but well-marked and persistent layers of round flint pebbles occur, and at the latter place a compact bed of lignite ten inches thick immediately underlies the main stratum of green sand (see "1 of *a*," fig. 3, p. 382).

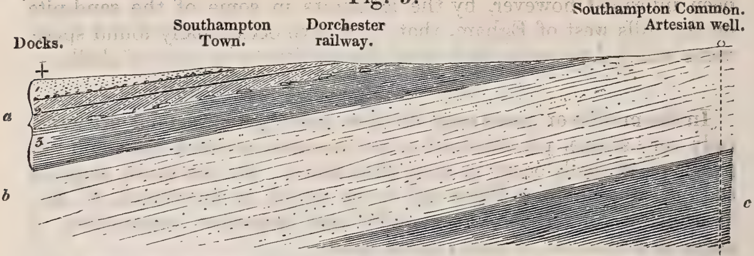
There is however one element almost entirely wanting in the *Bagshot sands,* and that is the carbonate of lime, which enters, though in small proportion, into the composition of many of the strata of this portion of the Hampshire series†. With this exception, the mineral character of this division in the Hampshire and in the London districts is identical; it is the measure only which is different.

At Southampton we have lately had an opportunity of observing the development of these two divisions corresponding with the *lower* and *middle* Bagshot sands both in structure and organic remains. With the exception of the section at the artesian well, the superposition of the other strata is not exhibited. From dip and range I however believe it to be as follows:—

* I am rather inclined to attribute it however chiefly to variations in the rate of subsidence during the formation of these strata.

† It there frequently forms irregular flattened concretions, sometimes of a very large size, and consisting usually of a light green-coloured calcareous sandstone slightly argillaceous. At Southampton however many of them have been found bearing a curious resemblance in shape and appearance to large cannon-balls. Unlike the septaria of the London clay, the interior of these concretions is solid and compact.

Fig. 5.



a. Bracklesham Bay beds (middle Bagshot sands) .... 100 feet ?

1. Green sands—*Venericardia planicosta, Turritella sulcifera*, and teeth and bones of fishes, &c. (*as at Goldsworthy*). (For a fuller list of the organic remains see pages 391 and 392.)
2. Dark clayey sands passing down into yellow clays and sands—*Nummulites lævigatus, Sanguinolaria Hollowaysii, Cardium porulosum*. (The relative positions of No. 1 and 2 is rather uncertain.)
3. Foliated brown clays. (*The thickness and extent of this bed is extremely uncertain.*)

b. Light yellow sands, more or less argillaceous .... 100 feet ?
(*Lower Bagshot sands.*)

c. London clay (upper part of).

The thickness of the Bracklesham Bay beds has not here been ascertained. An approximate one is given. The artesian well is about two miles distant from Southampton. For particulars of it see Mr. Keele's paper (Report of the British Association for 1846, p. 52).

The strata (No. 14. Pl. XIV. Comp. Sec. fig. 2) above this division at White-Cliff Bay are very indifferently exhibited. They appear to consist of about 100 feet of very sandy light brown and yellow clays, with traces of green sands. On the opposite coast of Hampshire are strata apparently the same, but lighter in colour and more sandy. To these beds succeed 200 to 260 feet of brown and yellow sandy clays, sands, and impure green sands (Nos. 16 to 19), which are probably the equivalents of the *Barton beds*; but all this portion of the section was extremely obscure when I examined it in 1839, and it requires further investigation. It is probable that, although continuous, these 300 to 400 feet of strata, including the Barton beds, become less argillaceous and more sandy as they proceed northward, and they may possibly be represented more or less by the upper division of the *Bagshot sands*. To this we shall refer again. At present we can only approximate to a determination of equivalents in this last division. This partial uncertainty will not however materially affect the main argument.

The comparative sections (Pl. XIV.) exhibit the presumed range of the Bracklesham Bay series from the Isle of Wight to the neighbourhood of London, and show the relative position of the Barton series.

Organic Remains.

In examining the evidence afforded by the fossils, we will first direct our attention to the fauna alone. The flora will be considered apart.

The lower division of the *Bagshot sands* appears marked by its negative evidence; not a single specimen have I been able to obtain in it either in the Isle of Wight or in the London district. I have been informed however, by the labourers in some of the sand-pits on the hills west of Egham, that they have occasionally found specimens which I presume from their description to be casts of shells.

In the middle or green sand division also organic remains are generally very scarce, yet there are a few localities in which casts and impressions of shells occur in some abundance. On the south slope of the hill at Chobham Place are to be found, as mentioned by Mr. Warburton, numerous, but generally very imperfect, impressions of shells in a stratum of clayey green sand.

Very perfect and solid casts of a large *Venericardia*, and of a few other bivalves, are abundant in the green sand beds exposed in a slight cutting in a descent of the road midway between Bagshot and Chertsey*, and again at Knowles Hill†. It was however in the railway cuttings at Goldsworthy and Shapley Heath near Winchfield that I obtained the best specimens (see fig. 3. p. 382, stratum "4. *b*").

The well-preserved specimens above-named from near Long Cross, although numerous, being with scarcely an exception interior casts, I was long unable to determine any of the species. The exceptional case is a specimen given to me by Dr. Stanger. In this instance one valve of the shell remains attached to the cast. Although much eroded, it is sufficiently perfect to determine its species‡ (*V. planicosta*).

At Chobham Place, the stratum being more clayey and compact, many of the impressions of the exterior of the shells are preserved with a few casts of the interior. Of these some few are sufficiently well-marked to be identified. At Goldsworthy the specimens were in the state of pyritical casts of the exterior of the shell. I have been enabled to recognize three species. At Shapley Heath, however, the shells were in most instances preserved, but in so friable a state that it was extremely difficult to obtain perfect specimens.

The evidence supplied by these few determinable species, although so limited, is for its extent the strongest which could have offered; for amongst the most abundant and typical fossils of Bracklesham Bay, and of the corresponding beds at White-Cliff Bay and Southampton, stand the *Venericardia planicosta, Turritella sulcifera* and *Nummulites lævigatus*, and these are precisely the species best determined in the above-mentioned specimens from the middle division of the *Bagshot sands*. The shell of which the cast occurs the most abundantly in the green sands at the places above-named is, there is little doubt, the *Venericardia planicosta*.

The genus, and sometimes the species of a few other specimens, are also determinable. The following list exhibits all the organic remains that I have been able to collect, with their localities in the Bagshot district, and their position in the Hampshire series:—

* Three-quarters of a mile west from a spot called Long Cross. Mr. D. Mumford of Chobham pointed out this locality to me.

† Four miles west of Chertsey.

‡ I have worked out a large number of specimens, but not a trace of shell remained on any of them. The one named above was, I believe, found by the Rev. Mr. Jerome of Chobham.

Fossils of the Middle Bagshot Sands.

	Locality.	Position in the Hampshire series*.
Arca (very small undescribed species)....	Shapley Heath.	Bracklesham†.
Avicula (species not determinable)........	Chobham Place.	
Cardium semistriatum?, *Desh.*	do.	Bracklesham.
Corbula gallica, *Lam.*	do.	do.
—— plicata, *Edwds.*........................	Shapley.	do.
—— striata, *Desh.*..........................	do.	do. and Barton.
Cytherea (small undeterminable species)	do.	
Nucula, possibly the *similis*..................	do.	
Nummulites lævigatus, *Sow*................	Chobham Place.	Bracklesham.
Ostrea flabellula, *Lam*......................	do. and Shapley and Windlesham.	do. and Barton.
Pecten (smooth species, possibly the *corneus*)	Shapley.	
Turritella sulcifera, *Lam*....................	Goldsworthy.	Bracklesham.
—— (species not determinable)............	Shapley.	
Venericardia acuticosta, *Lam.*	Goldsworthy and Shapley.	Bracklesham.
—— elegans, *Desh*..........................	Shapley and Windlesham.	Bracklesham.
—— planicosta, *Lam.*	Heaths N. of Chobham, Goldsworthy and Shapley.	Bracklesham.
Teeth of Lamna elegans, *Agas*.............	Goldsworthy and Shapley.	Bracklesham, Barton and Sheppey.
.... —— compressa, *Agas*..........	Goldsworthy.	Sheppey.
.... Carcharodon megalotis, *Agas*..	do. and Shapley.	Bracklesham.
.... Pristis acutidens, *Agas*.........	do.	do.
.... Otodus obliquus, *Agas*.........	do. and Shapley.	Bracklesham and Sheppey.
Palatal teeth of Myliobates ‡..............	do.	do. do.
.... Ætobates	do.	do. do.
.... Edaphodon Bucklandi, *Agas*...	do.	Bracklesham.
.... —— leptognathus, *Agas*.......	do.	do.
.... Passalodon § rostratus, *Agas*...	do.	do.
Vertebræ of Lamna and of Myliobates....	do.	do. and Sheppey.
Bones of Turtles..............................	do.	do. do.
Part of the claw of a Crustacean..........	do.	

This gives a total of sixteen species of Testacea, of which ten are of determinable and described species, and one is determinable but not described. Now, of these eleven species every one occurs at *Bracklesham*, and most of them are very typical forms. One species only, or at most two, occur in the *London clay* proper of London

* I have included the Sheppey analogues for the fishes. There are more Barton fishes, but as there is an uncertainty about them, I have omitted the references.

† For the Bracklesham Bay fossils see list at end.

‡ Of these palates there are several varieties. None of them agree exactly with those figured by Agassiz. One specimen is identical with one from the Bracklesham beds of Southampton. Sir Philip Egerton informs me however, that notwithstanding these remains of the *Myliobates* differ considerably, it is probable that they must be referred to one or two species.

§ Sir Philip Egerton has since shown that the specimens referred to this genus belong to *Edaphodon*.—Oct. 1847.

and Hampshire, and but two or perhaps three are found in the *Barton clays*.

If we turn to the fishes, we shall find the same coincidence as in the Testacea. The fossil ichthyology of Bracklesham has not yet received the same attention as that of Sheppey. We believe, however, the number of species* found in the Bracklesham beds to be far less than in the clays of Sheppey, although the individuals are frequently numerous. Singularly enough (considering the rarity of its fossils), we have in this instance to reason from Bagshot to Bracklesham, for it is in the curious group found by Dr. Buckland† at Goldsworthy that we obtain some of our best analogues for Bracklesham. It will be observed that most of the species can be recognized in specimens from Bracklesham.

Out of eight determinable species, three have a wide range in the Eocene series, and are found in equal abundance in strata above and below it. The other five are forms characteristic of the Bracklesham Bay series. The fine large serrated teeth of the *Carcharodon*, the peculiar long, flat, shapeless teeth of the *Pristis*, and the singular palates of the *Chimæroid fishes*, are as a group very distinctive of this period.

At the partly-intermediate locality of Southampton we have already seen that the geological structure of the upper strata (fig. 5, p. 388) is, as far as it goes, conformable on the one hand to that of the *Bracklesham series* at White-Cliff Bay, and on the other, to that of the *Bagshot sands*; and also, that the organic remains of the 300 feet of brown and grey clays which underlie them agree with those of the *London clay*.

We can now further show, that not only is the structure similar, but that the organic remains of these strata overlying the *London clay* are in perfect agreement with the Bracklesham group. In the 100 to 150 feet of yellow sands (stratum "*b*," fig. 5, p. 388) immediately overlying the *London clay*, no fossils have been found. The foliated brown clays (3 of "*a*") succeeding these sands are not well exhibited. Above them are probably the beds of light yellow and greenish calcareous and clayey sands (2 of "*a*"), with occasional large calcareous concretions, from 1 to 6 feet in width and 1 to 2 feet in depth, and full of fossils. In a pit by the side of the old canal, 1¼ mile W.N.W. from Southampton, several weathered blocks of these concretions may be seen.

Fossils of part of the Bracklesham beds‡, near Southampton.

Anomia lineata, *Sow.*
Bulla, n. s. (the common Bracklesham one).
Cardium porulosum, *Brand.*
—— turgidum ?, *Sow.*
Cassidaria coronata ?, *Sow.*
Corbula globosa, *Sow.*
—— rugosa ?, *Lam.*
—— pisum ?, *Sow.*
—— striata, *Lam.*

* Many genera occurring at Sheppey are wanting at Bracklesham.
† Proceedings of the Geol. Soc. vol. ii. p. 687.
‡ I apply the term of *Bracklesham beds* to the strata of clays and green sands forming the central division of the arenaceous series, the whole of which I designate as the *Bracklesham sands*.

Cytherea nitidula, *Desh.*
—— elegans, *Lam.*
Dentalium, n. s. (the common Bracklesham one).
Fusus bulbiformis, *Lam.*
Globulus Willemettii, *Desh.*
Infundibulum trochiforme, *Sow.*
Natica.
Nummulites lævigatus, *Sow.*
Panopæa corrugata, *Sow.*
Rostellaria rimosa?, *Sow.*
Sanguinolaria Hollowaysii, *Sow.*
Solen obliquus, *Sow.*
Tellina donacialis, *Lam.*
—— tenuistriata, *Desh.*
Turritella imbricataria, *Lam.*
—— sulcifera, *Lam.*
Venericardia acuticosta?, *Lam.*
Voluta.

Apparently overlying these beds are a series of dark grey sandy clays and impure green sands, which were visible for a time in the cutting of the Dorchester railway crossing the London road at the entrance to Southampton. They there contain extremely few fossils, and those few very friable and imperfect. They consist of the *Corbula striata*, *Venericardia elegans*, and a small *Turritella*. Some small semi-indurated masses full of these shells, most of them mere impressions and mixed with numerous fragments of carbonized wood, could hardly in hand specimens be distinguished from specimens from Shapley.

To these strata succeed dark green sands, which underlie part of the town. The docks are excavated in them. The following very typical group of fossils were then found*. (See "*a.* 1," fig. 5, p. 388.)

Fossils from part of the Bracklesham beds, Southampton Docks.

Turritella sulcifera, Lam.
Venericardia planicosta, Lam.
Teeth of *Lamna elegans*, Agas.
——— *Otodus obliquus*, Agas.
——— *Carcharodon megalotis*, Agas.
——— another species, same as at Goldsworthy.
——— *Pristis acutidens*, Agas.
Palatal teeth of *Edaphodon Bucklandi*, Agas.
——————— *Ætobates.*
——————— *Myliobates punctatus*, Agas.?
——————— ——— *jugalis*, Agas.?
——————— ——— *goniopleurus*, Agas.?
——————— und. spec., same as at Goldsworthy.
Vertebra of *Lamna* and *Myliobates.*
——— *Serpent.*
Bones of *Turtles.*
Bone, apparently of a *Mammal.*
A beautiful undescribed palate of a fish.

The large *Venericardia* and *Turritella* are here, as at White-Cliff Bay, very abundant. They present, with the associated fishes, a group of fossils singularly analogous to that just described from the Middle Bagshot sands at Goldsworthy Hill.

In the upper division of the *Bagshot sands* organic remains are extremely rare, and where they exist they are not easy to find. The great mass of these sands contain no traces of fossils. Here and there

* We are indebted to Mr. Keele of Southampton for the preservation of the very interesting group of fossils found here, and which he has had the kindness to place in my hands.

however, in the thick and nearly uniform mass of loose siliceous sand, are small ferruginous lumps and concretions, usually coated with the sand in which they are imbedded. On carefully examining some of these smaller concretions, which are about the size of a large marble and nearly round, most of them, at many places on Frimley Ridge* and Hartford Heath, show traces of organic structure, and prove to be the casts of a small globose species of *Cardium*. In the larger tabular lumps of rough iron sandstone, casts and impressions of shells may also be occasionally detected. Weathered specimens are to be found in the mounds of sand thrown up from the railway cutting at Frimley Ridge. The following list is almost entirely from this locality. Owing to the very imperfect state of the specimens, the species must be considered as determined with some doubt.

Fossils of the Upper Bagshot Sands.

Cardium.
Cytherea?
Cypricardia?
Fusus?
Globulus patulus?, *Desh.*
——— sigaretinus?, *Sow.*
Infundibulum trochiforme, *Sow.*
Melania costellata?, *Lam.*
Nummulites elegans, *Sow.*
Ostrea flabellula, *Lam.*
Tellina scalaroides, *Lam.*
Turritella (apparently the *sulcifera* or *terebellata*).
—— (carinated and tuberculated species).
Trochus?
Venericardia (species undescribed).
Voluta.

And of fishes the remains of the
Teeth of Lamna elegans. Cœlorhynchus rectus.

From the limited number of determinable species in this list, it would be difficult to draw any well-founded opinion as to the precise co-relation of these strata. Of the 8 or 9 species two have a range through all the Eocene series; of the remaining 7 three are common to *Bracklesham* and *Barton*, one is chiefly confined to *Barton*, and the remaining four are *Bracklesham* forms. That these sands belong to one or the other of these two divisions I have but little doubt. The evidence, such as it is, would rather approximate them to the latter.

It is possible that, taking as a base the green sands of the *Bracklesham strata* at White-Cliff Bay, where we have over them in ascending order a series of yellow and greenish sands and sandy brownish and yellow clays, followed again by the yellow sands (Nos. 14 to 20, section 6) on which repose the *Freshwater series*, we shall find, in following the development of these upper beds westward from that point, that they become more argillaceous and fossiliferous and in more distinct stratification, ending in their most perfect development at Barton;—that if, on the contrary, we trace them from White-Cliff Bay to the northward and north-eastward we shall find them becoming more arenaceous, the beds not so well defined, and the organic remains less abundant; and consequently, that a continuance of these lithological changes, in proportion as the strata trend in this direction, might result in the nearly entirely arenaceous and unfossiliferous condition ex-

* Between Chobham and Farnborough.

hibited by the *Upper Bagshot sands*;—else we may consider that the upper and less fossiliferous *Bracklesham sands* (Nos. 14 & 15, section 6) expand as they range northward and constitute the *Upper Bagshot sands*;—or again, that the *Barton clays* thin out, and that the *upper sands* (Nos. 14 to 15) of the *Bracklesham beds* then come into juxtaposition with the *sands* (No. 20) overlying the *Barton clays*, viz. the *Headon Hill sands* (see Pl. XIV. Comp. Sec. fig. 2);—further, the *Upper Bagshot sands* may be the equivalents of the *Headon Hill sands*, the *Barton clays* thinning out;—or lastly, they may prove to represent the whole of the upper division of the great arenaceous series of Hampshire included between the Bracklesham Bay beds and the Freshwater series.

The solution of this problem requires however a more detailed examination than I have had time to make of the *Barton clays*, both at Barton and in their range northward and eastward, and also of all the beds between the *Bracklesham sands* and the Freshwater series. My own opinion is rather in favour of the last of the views I have expressed above; still I should be glad of further and more conclusive evidence.

I have not been able to discover anywhere on the Bagshot sands any traces or indications of overlying freshwater strata.

Comparison of the Bagshot and the Alum Bay series.

Having taken the White-Cliff Bay section as a type, we will now proceed to examine how far the structural variations exhibited at Alum Bay agree with the parallelisms sought to be established. The great difference of conditions that prevailed during this geological period at these two localities has produced results, which, had we not good geological horizons both above and below this great arenaceous series, it would be difficult to assimilate.

In the first place, the rich and varied fauna existing at Bracklesham, and which already at White-Cliff Bay shows a very material decrease, has entirely disappeared at Alum Bay. A few unimportant layers of lignite are the only connecting links in organic life between the two sections. Nevertheless, if the *central mass* of variegated sands and clays (Nos. 7 to 28) of Alum Bay is admitted to be synchronous (for I think that the similar relative position in both sections of the *London clay*, in their lower, and *Freshwater series*, in their upper part, proves the synchronism of their intermediate strata) with the central series, including the *Bracklesham beds* of White-Cliff Bay, then it will follow, that this portion of the Alum Bay section is synchronous with the *Bagshot sands*; in confirmation of which hypothesis the evidence, although restricted, is in perfect accordance (see Pl. XIV. Comp. Sec. figs. 2 & 3).

The Alum Bay series affords but one term of comparison in organic remains with the *Bagshot sands*. Of animal life, as we have before said, we have no traces, but remains of a rich and interesting flora exist in great abundance and in excellent preservation in the thin stratum No. 17. In a comparison with the strata at White-Cliff Bay this avails little, as the remains of plants yet found there are far too indistinct for the remotest determination, but with the *Lower Bagshot sands* it serves to establish a connexion rather important in kind although wanting in strength.

When the *Lower Bagshot sands* are entirely arenaceous no distinct traces of plants exist, but where the sands contain subordinate foliated clays, as in the neighbourhood of Woking, and more especially of Chertsey, these clays usually exhibit numerous small and generally indistinct vegetable impressions. In the more important stratum of this description immediately underlying the green sands, and which is worked to some extent in brick-fields about Addlestone, Chertsey and Otter, larger and more perfect specimens may be occasionally obtained*.

The matrix in which these impressions of plants are preserved is of a very similar character and appearance both at Alum Bay and in the Bagshot district; only in the latter it is usually coarser and micaceous, and does not show the impressions so sharply. The Bagshot specimens are also very difficult to preserve; the clay laminating and falling to pieces as it dries. I am not aware that any of the species from Alum Bay have been figured. Some of them somewhat resemble some of the species of *Phyllites* and *Culmites* from the *Calcaire grossier* described and figured by Adolphe Brongniart in Cuvier and Brongniart's Geology of the neighbourhood of Paris, but I have not been able to establish any good identity†. I can only therefore refer to the plants found in the *Bagshot sands* as a group, and state that a comparison of specimens with those found at Alum Bay shows that they are of analogous forms and preserved in a matrix of similar lithological character. The most abundant species is a long lanceolate smooth-edged leaf; another species of like form has the edges dentated.

Conditions of Structure and of Organic Remains.

We have now described the main points connected with the structure and organic remains of the *Bagshot sands*. Their regular stratification and persistent lithological structure are apparent. They form a separate group in the Eocene period, distinct from the *London clay* both in the character of its fossils and in their mineral composition. In this latter however they have many points of resemblance with the *sands* under the *London clay*, as in their blocks of concretionary sandstone, their beds of sand with layers of round flint pebbles, which have frequently led to such beds being mistaken for a part of the *Plastic clay series*.

Notwithstanding the great scarcity of organic remains, I am led to

* The best specimens I obtained from Botley, three miles W.S.W. from Chertsey. These pits have not however been worked for four or five years past, and the section is no longer visible.

† Some of the specimens resemble those figured by Dr. Mantell in his 'Geology of Sussex,' from the Plastic clay of Newhaven. The few species found there have hardly sufficient character to complete a comparison. As a group they are certainly distinct. Besides, those of Newhaven are in beds below the London clay, and those of Alum Bay occur in strata above the London clay.

believe that their absence partly arises, not so much from original causes so entirely unfavourable to the existence of testacea, as from the subsequent operation of chemical agencies; for under favourable circumstances there are, in the central and upper divisions, traces of a fauna far from restricted.

A slight quantity of clay and peroxide of iron has sufficed at Chobham Place enough to consolidate the usually incohesive green sands, so as to form a semi-solid mass full of the casts and impressions of shells. At Knowles Hill and near Long Cross the green sands contain considerable numbers of the solid sandstone casts of the *Venericardia planicosta*. At Goldsworthy the iron pyrites, which occurs in the green sands, has preserved many casts of the entire shell, whilst at Shapley, where in one part the green sands pass into a sandy grey clay, undecomposed, but very friable shells, are in places common. Again, in those parts of the upper sands where concretions of iron sandstone occur in rather more abundance than usual, traces of shells, although indistinct, are, in places, not rare. But in the great mass of the *lower* and *upper Bagshot sands*, where there is a want of any substance to give compactness to the loose and incohesive sands, there is almost or rather a complete absence of organic remains.

Yet, if preserved in remnants, why should they not have existed in masses? why not in the sands as well as in occasional concretions?

It is evident from the exceptional, yet uniform conditions under which the fossils are preserved, that there must have been some general cause in operation to produce so common a result*.

* Supposing there had been a sea-bottom of much regularity of depth and of similar mineral character (muddy green sand), is it probable that the mollusks would have, under such circumstances, fixed their habitats only in many very limited and distant parts of this area? or else supposing them to have existed throughout the whole area, could they have been fossilized in certain localities only, by the oxide of iron, which must have affected them all equally, as it would have been generally diffused over the spaces in which it is now segregated only in occasional masses?

Conditions such as these would, on the contrary, appear to be favourable to an average uniform diffusion of life; for the causes in operation would not be local, such as might give rise to local conditions favourable to local existences, but general. Further, it is improbable that animal life should have been developed in exact measure with the action of a subsequent chemical agency. If an originally limited and local distribution did not prevail, then there must have been a more widely diffused fauna than now appears, of which all but the traces now remaining must have been destroyed by some general cause.

It has been stated that, excepting where the beds were impervious, or nearly so, to the action of water, the original substance of the shell nowhere remains. In all the pervious strata only the impressions and casts, and that rarely, at present exist, and even in this state there are, as before mentioned, favourable mineral conditions which do not generally prevail.

We know that the hydrated peroxide of iron is of common occurrence in the *upper* and *middle Bagshot sands*, both generally disseminated in an earthy state, and in concretions and layers. Now this mineral is readily derived from the carbonate of the protoxide of iron, which by exposure slowly parts with its carbonic acid, and uniting, without change of form, with a further portion of oxygen and a proportion of water, passes into the hydrated peroxide. The consequence of this change would be, that if a carbonate of iron were originally disseminated in the mass of the sedimentary deposit, and segregated in and upon any extraneous organic bodies which may have offered, it would by decomposition

With regard to the Alum Bay section, the difference in mineral composition between the *Bagshot sands* and these their presumed equivalents at Alum Bay, is not so great as might be supposed. They both consist in by far their larger part of loose siliceous sands with some green sands and clays. At Alum Bay these are grouped in many distinct strata; in the Bagshot district on the contrary, with the exception of the central green sands and brown clays, the clays are more intimately mixed and interstratified with the sands. At the same time the clay also probably exists in rather less total quantity.

With regard to the bright and brilliant reds of the Alum Bay section, that is a local condition produced by the more abundant presence of the peroxide of iron. Of this we have some traces even in the *Bagshot sands,* for at West End near Farnham some thin beds of the upper sands are of a bright red colour, whilst the general prevalence of various tints of yellow, ochreous and brown, indicates a like general diffusion of the hydrated peroxide of iron.

The silicate of iron, forming the mass of the beds of green sands, occurs in both; so also do we find in both thin layers of small round flint pebbles and beds of lignite. All these are points of evidence, which though of little importance separately, yet together form, from their general and undivided agreement, a corroborative proof of a like origin in the strata so co-related. For, where the distances are not excessive, and the general evidence points to a probable contemporaneity and continuity, the persistent prevalence of peculiar chemical and mechanical conditions, and of marked and consistent lithological characters, over large areas, affords, I conceive, independently of palæontological evidence, tolerably presumptive proofs of a sediment derived

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gradually evolve its component part of carbonic acid, which, being taken up by the water percolating through these strata, would immediately act upon any carbonate of lime with which it came into contact. And as, from the general siliceous character of the strata, the waters would pass through them without becoming saturated with other substances, and as the solution of carbonic acid could not act upon the siliceous and argillaceous rocks, it would follow that its action as a solvent would be almost entirely confined either to any disseminated traces of carbonate of lime, or to the substance of the shells. In both cases the bicarbonate of lime would be formed, which being readily soluble in water, would by the gradual percolation thereof be entirely removed.

In the cases especially where the carbonate of iron had segregated in the interior or around the exterior of the shell, the liberated carbonic acid would, as the carbonate passed into the hydrated peroxide, at once unite with the carbonate of lime of the shell, converting it into a bicarbonate soluble in and removable by water.

It would result that a solid cast of the hydrated peroxide of iron, in the one instance of the interior of the shell, and in the other instance of the exterior, would remain; in both cases the space left by the removed shell would usually be left unoccupied, and such is the condition of most of the fossils of the *Bagshot sands.*

Where the shells were imbedded in the loose sands free from clay or ferruginous concretions, which could afford them any solidity of matrix, they might be thus removed without leaving a trace of their original presence. With regard to the carbonate of iron, it is a mineral common in many rocks, especially in those below the chalk, whence the materials forming this deposit were doubtlessly derived.

This reasoning may possibly admit of extension to some other formations in which siliceous sands and soft porous sandstones predominate. It is perfectly well known that rain and spring-water will dissolve carbonate of lime, but I doubt whether they are agents sufficiently powerful to produce the extensive effects we have alluded to.

from the same land, suspended in the same waters, and distributed by the same currents. This is naturally modified as the sediment from rivers flowing through different geological districts is swept into these currents, but the characters thereby superadded may be blended so gradually, that by the time they preponderate, and we lose sight of our first guides, we shall recognise and receive these new characters as representative forms, and be able to trust as fully to their guidance in prolonging from distance to distance the synchronism of widely ranging deposits.

Conclusions.

In conclusion, notwithstanding that the palæontological and stratigraphical evidence afforded by the *Bagshot sands* is scanty, still we must decide according to that evidence; and the deficiency in quantity is in some measure compensated for by the strength of most of the proofs and by a singular absence of conflicting testimony.

It has been shown that, commencing with the *lower division* of the *Bagshot sands,* we find them possessing a uniform and regular character in the London district, and exhibiting with the Hampshire presumed equivalent strata, a very close identity both of thickness, lithological structure and organic remains; and that they are both in conformable superposition upon the *London clay.*

The *middle division* of the *Bagshot sands* may, I think, be considered as the attenuated representative of the *Bracklesham Bay beds,* formed as they both are, although in varying quantities, on the same mineral type, and containing organic remains, not only of analogous forms in the two districts, but also of the most distinctive species of the period.

The *upper Bagshot sands* we must place provisionally on a parallel with the strata somewhere between the fossiliferous strata of Bracklesham and the Freshwater series.

As a whole it results, that the interesting and varied succession of strata composing the English tertiaries in Hampshire and to the *west** of London belong entirely to the Eocene period; that they can be divided into three great groups, severally characterized by peculiar mineral structure and organic remains.

The *first and lowest group* is argillaceous, and consists of the *mottled clays* and *London clay,* with a few subordinate beds of sand chiefly confined to the first-named division, and is characterized by a fauna of which a considerable proportion consists of forms confined to it.

Second, the *central group,* constituting the *Bagshot* and *Bracklesham* series, an arenaceous formation with subordinate green sands and laminated clays, separable into three divisions, and exhibiting a very distinctive fauna.

Third, the *upper group,* of green marls, earthy limestones and siliceous sands of freshwater or fluvio-marine origin, and which group is also marked by fossils peculiar to it.

* To the east of London other divisions are developed below the London clay: of these we have not yet completed the investigation.

All these groups are largely developed in Hampshire. Around London only the first two exist, whilst in France there are, in addition to them, several *groups of more recent origin* (see the table of equivalent strata, p. 400). In my previous paper on the Isle of Wight tertiaries I have endeavoured to show that the series of marine and freshwater strata, overlying the *Calcaire grossier* at Montmartre and elsewhere in the neighbourhood of Paris, are not represented by the *Freshwater series* of the Isle of Wight, but that these latter are the fluvio-marine and freshwater equivalents of the *upper part* of the *Calcaire grossier*.

We have further in this paper attempted to prove that the lower beds of the *Calcaire grossier*, with the underlying impure green sands of the *Glauconie grossière*, which, thin in the vicinity of Paris, attain a considerable thickness between Paris, Rouen and Beauvais, and are characterized by the abundance of the *Venericardia planicosta*, *Turritella terebellata* and *sulcifera*, and *Nummulites lævigatus*, range* in considerable development on this side of the Channel, where they form a series characterized by similar fossils and of resembling lithological character. In this synchronism are included the groups of Bracklesham and Barton.

It is with this portion of the French and Hampshire systems that the well-marked fossils above named, combined with a like order of superposition and an analogous structure, have led me to infer that the *Bagshot sands* are contemporaneous. Consequently the central beds of variegated sands at Alum Bay, instead of belonging to the *Plastic clay* series, are of the age of the lower *Calcaire grossier* and *Glauconie grossière* on the one hand, and on the other of the *Bagshot sands*; the *London clay* proper occurring near the base, and not at the top of the sections of the vertical strata of the Isle of Wight.

Notwithstanding the variety and diversity of the phænomena exhibited in each of the above-named geographical and geological centres, there is a harmony in the sequence, a regularity in the formation, and a singleness in the mode of operation, evident throughout the strata of which they are composed, and indicating that, however different the results, they are to be attributed to a few great and uniform agencies acting simultaneously, but not in equal energy, over large and wide areas, rather than to numerous local and often conflicting causes. The latter may frequently suffice for the explanation of a single phænomenon, but we want in Geology, as in the other sciences, that hypothesis which will embrace the greatest number of facts, and reconcile those which, explained separately and independently, might, when we come to adjust the whole, exhibit "*inter se*" irreconcilable discrepancies†.

* With possibly part of the *Sables* and *Grès inférieurs*.

† I had intended to have entered more fully upon the consideration of this subject, but some links of the chain are still wanting. I have not yet been able to obtain information on many points of structure of the north-western portion of the Paris tertiaries, nor am I yet sufficiently well acquainted with the detail of the western part of the Hampshire tertiaries. I am obliged therefore to defer this inquiry to a later period.

1. *Table showing the Superposition and Synchronism of the several Formations constituting the Tertiary Systems of* London, Hampshire, *and* Paris.

LONDON SYSTEM*.	Average thickness.	HAMPSHIRE SYSTEM.	Average thickness.	PARIS SYSTEM †.	Average thickness.
	feet.		feet.		feet.
				Calcaire d'eau douce supérieure	40
				Grès et Sables supérieurs (*Fontainebleau*)	80
				Calcaire d'eau douce inférieure (*Gypseous series*)	150
				Grès et Sables moyens (*Beauchamp*)	50
		Fluvio-marine and Freshwater series	350		
?		Barton clays	300	Calcaire grossier and Glauconie grossière	100
Bagshot sands	400	Bracklesham sands	700		
London clay	350	London clay (*Bognor beds*)	250	*Part of the* Sables inférieurs, *including probably the* Lits Coquilliers	100
Mottled clays and sands	80	Mottled clays and sands	150	*Lower part of the* Sables inférieurs, *more especially the* Argile plastique	60

* This refers to the district west of London only: eastward there are further subdivisions under the *London clay*.

† As in no part of this district is there a complete vertical sequence of the whole of the series, the several deposits overlapping one another from the lowest in the north to the highest in the south, the thickness of the strata varies most materially. A rough approximation of that of each deposit at its point of average development is all that can be given.

2. *Table showing the number of described Species of Testacea found in each of the marine divisions of the English Eocene Series, the proportions in which the Testacea of any one division are distributed in others, and their range in the French Series.*

	Total number.	Peculiar to each.	Species common in the English Series to				* Species common to the French Series in the		
			Barton and Bracklesham.	Barton and London.	London and Bracklesham.	Barton, Bracklesham, and London.	Gres Moyens.	Calcaire grossier.	Lits Coquilliers and Sables inferieurs.
Barton clays	209	108					22	70	30
Bracklesham Bay series	193	95	55	11	8	35	36	126	40
London clay	133	79					7	20	33

* I can only give these as some slight approximation.

Lists of the Testacea of the London Clay *proper, of the* Bracklesham Bay Sands, *and of the* Barton Clays ; *to which are added, the principal Foraminifera and Annelides*†.

SPECIES.	SYNONYMS.	London clay.	Bracklesham sands‡.	Barton clay.
Acteon crenatus, *Sow.*	Tornatella, *Lam.*	*		*
simulatus, *Sow.*		*	*	*
Amphidesma splendens, *Sow.*	*Sow.* as Tellina	*	*	*
Ampullaria acuta, *Sow.*	Globulus, *J. Sow.*			*
ambulacrum, *Sow.*			*	*
depressa, *Sow.*	Natica, *Lam.*	*	*	*
patula, *Sow.*	——, *Desh.*		*	*
ponderosa, *Desh.*			*	
sigaretina, *Sow.*				*
Willemetii, *Desh.*			*	
scalariformis, *Desh.*			*	
Ancillaria subulata, *Sow.*	A. buccinoides, *Lam.*		*	*
olivula?, *Lam.*			*	
Anomia lineata, *Lam.*		*	*	*
Arca appendiculata, *Lam.*				*
barbatula, *Lam.*			*	*
Branderi, *Sow.*			*	*
impolita, *Sow.*		*		
interrupta, *Lam.*			*	
nitens, *Sow.*		*		
Astarte rugata, *Sow.*		*		
donacina, *Sow.*		*		
Avicula media, *Sow.*		*	*	*
arcuata, *Sow.*		*		
papyracea, *Sow.*		*		
Axinus angulatus, *Sow.*		*		
Balanus erisma, *Sow.*				*
Beloptera anomala, *Sow.*		*		
belemnitoidea, *Bl.*		*	*	
Bifrontia laudunensis, *Desh.*			*	
Buccinum junceum, *Sow.*		*	*	*
stromboides, *Lam.*			*	
Bullæa striata?, *Desh.*			*	
Bulla acuminata, *Sow.*			*	*
constricta, *Sow.*		*		*
elliptica, *Desh.*				*
attenuata, *Desh.*	? B. ovulata, *Lam.*	*	*	*
lignaria, *Desh.*	Not the recent B. lign.			*

† In this list I have confined myself to described species only. I believe that many of these will be described in Mr. Dixon's forthcoming work. In Mr. Edwards's collection alone there are probably from 150 to 200 undescribed species from Bracklesham and Barton. In Mr. Wetherell's collection from Hampstead and Highgate the number of undescribed species is also very large, and it is the same with Mr. Bowerbank's collection from Sheppey. I am indebted to Mr. Edwards for many corrections and additions to this list. To Mr. Morris I have to express many obligations for his kind and valuable co-operation in assisting me to draw up the lists of the several local groups of fossils, and for many important suggestions.

‡ Lists of the fossils from Bracklesham Bay and Bognor were given by Dr. Mantell in his 'Geology of the South-East of England.' A more recent list was presented by Mr. Edwards to the British Association at the Southampton meeting. I myself have not had an opportunity of visiting either Bracklesham or Bognor. The lists of fossils of these and the other strata I have compiled chiefly from Sowerby's 'Mineral Conchology,' Morris's 'Catalogue of British Fossils,' and, from the above, only the principal synonyms are given.

Species.	Synonyms.	London clay.	Bracklesham sands.	Barton clay.
Bulla filosa, *Sow.*	?B. striatella, *Desh.*			*
Cancellaria evulsa, *Sow.*				*
Cancellaria costulata, *Desh.*			*	
læviuscula, *Sow.*		*		
quadrata, *Sow.*				*
Cardium nitens, *Sow.*		*		
porulosum, *Brand.*			*	*
turgidum, *Sow.*				*
semigranulatum, *Sow.*		*		*?
Plumsteadiense, *Sow.*		*		
discors, *Lam.*				*
hippopæum, *Desh.*			*	
Cassidaria coronata, *Desh.*			*	
carinata, *Sow.* and *Lam.*		*	*	*
striata, *Sow.*		*		
Cerithium cornucopiæ, *Sow.*			*	
geminatum, *Sow.*	C. pleurotomoides?, *Lam.*			*
giganteum, *Lam.*			*	
hexagonum, *Lam.*				*
rigidum, *Sow.*				*
turris, *Desh.*			*	
unisulcatum, *Desh.*			*	
Chama squamosa, *Brand.*	C. lamellosa, *Lam.*			*
calcarata, *Lam.*			*	
gigas, *Desh.*			*	
Clavagella coronata, *Desh.*			*	*
Corbula ficus, *Brand.*	C. umbonella, *Desh.*		*	*
gallica, *Lam.*			*	
globosa, *Sow.*		*	*	*
pisum, *Sow.*		*	*	*
rugosa, *Lam.*			*	
revoluta, *Sow.*		*	*	*
striata, *Lam.*		*	*	*
cuspidata, *Sow.*				*
Crassatella compressa, *Lam.*			*	
plicata, *Sow.*			*	*
rostrata, *Desh.*			*	
sulcata, *Brand.*	var. C. lamellosa, *Lam.*			*
Conus concinnus, *Brand.*	C. bicoronatus, *Mell.*	*		
corculum, *Sow.*			*	
deperditus, *Brug.*			*	
diversiformis, *Desh.*			*	
lineatus, *Sow.*	? C. stromboides, *Def.*			*
scabriculus, *Sow.*				*
velatus, *Sow.*			*	
dormitor, *Sow.*				*
Cultellus affinis, *Sow.*	Solen affinis, *Sow. M. C.*	*		*
Cypræa oviformis, *Sow.*		*		
tuberculosa, *Sow.*	Ovula tubulosa, *Desh.*		*	
inflata, *Lam.*			*	
Cypricardia pectinifera, *Sow.*			*	*
carinata, *Desh.*			*	
oblonga, *Desh.*			*	
Cyprina planata, *Sow.*		*		

Species.	Synonyms.	London clay.	Bracklesham sands.	Barton clay.
Cyprina Morrisii, *Sow.*	....	*		
Cyrena cycladiformis, *Desh.*	....			*
Cytherea elegans, *Lam.*	....		*	*
nitidula, *Lam.*	....		*	
obliqua, *Desh.*	C. tenuistriata, *Sow.*	*	*	*
pusilla, *Desh.*	....			*
rotundata, *Brand.*	....			*
suberycinoides, *Desh.*	....		*	*
? sulcataria, *Desh.*	....		?*	
tellinaria, *Lam.*	....			*
transversa, *Sow.*	....			*
trigonula, *Desh.*	....		*	
Delphinula Warnii, *Desh.*	....		*	
Dentalium acuminatum, *Sow.*	....			*
anceps, *Sow.*	....	*		
eburneum, *Desh.*	....		*	
nitens, *Desh.*	....	*	*	*
striatum, *Sow.*	....		*	*
Ditrupa incrassata, *Sow*	Dentalium, *Sow.*	*		
plana, *Sow.*	....	*	*	*
strangulata, *Sow.*	....			*
Fasciolaria funiculosa, *Desh.*	....			*
Fistulana ampullaria, *Lam.*	....			*
Fusus acuminatus, *Sow.*	F. aciculatus, *Desh.*		*	*
angusticostatus ?, *Mell.*	....	*		
asper, *Sow.*	....			*
bifasciatus, *Sow.*	*an* errans	*		
bulbiformis, *Lam.*	....	*	*	*
canaliculatus, *Sow.*	....			*
carinella, *Sow.*	....	*		*
complanatus, *Sow.*	....	*		
coniferus, *Sow.*	....	*		
curtus, *Sow.*	....	*		
desertus, *Sow.*	Buccinum desertum		*	*
errans, *Sow.*	....		*	*
ficulneus, *Lam.*	....		*	*
interruptus, *Sow.*	....	*		*
intortus, *Lam.*	....		*	
Koninckii, *Nyst*	....	*		
lavatus, *Sow.*	....			*
lima, *Sow.*	....			*
longævus, *Lam.*	....		*	*
porrectus, *Brand.*	F. unicarinatus, *Desh.*	*	*	*
regularis, *Sow.*	....		*	*
trilineatus, *Sow.*	....	*		
tuberosus, *Sow.*	....	*		
Noæ, *Lam.*	....		*	
Gastrochæna contorta, *Lam.*	....			*
Harpa Trimmeri, *Flem.*	....	*		
Hipponyx cornucopiæ, *Def.*	....		*	
squamiformis, *Lam.*	....		*	*
Infundibulum obliquum, *Sow.*	....			*
trochiforme, *Sow.*	....	*	*	*
Isocardia sulcata, *Sow.*	....	*		

Species.	Synonyms.	London clay.	Bracklesham sands.	Barton clay.
Lingula tenuis, *Sow.*		*		
Limopsis granulatus, *Desh.*	Pectunculus, *Lam.*		*	
scalaris, *Sow.*	Pectunculus scalaris, *Sow.*			*
Littorina sulcata, *Pilk.*	Turbo sculptus, *Sow.*		*	*
Lucina divaricata, *Lam.*				*
concentrica, *Lam.*				*
gigantea, *Desh.*				*
Goodhalli, *Sow.*		*		
mitis, *Sow.*			*	*
Menardi, *Desh.*				*
Mactra depressa, *Desh.*			*	
semisulcata, *Lam.*			*	
Marginella dentifera, *Lam.*			*	
eburnea, *Desh.*			*	
ovulata, *Desh.*			*	
Melania costellata, *Lam.*			*	
costata, *Sow.*				*
Melanopsis fusiformis, *Sow.*				*
Mitra parva, *Sow.*			*	*
pumila, *Sow.*				*
scabra, *Sow.*				*
monodonta, *Lam.*			*	
Modiola elegans, *Sow.*		*	*	*
depressa, *Sow.*		*		
subcarinata, *Sow.*		*		
sulcata, *Lam.*				*
seminuda, *Desh.*				*
tenuistria, *Mell.*				*
Murex asper, *Brand.*			*	*
bispinosus, *Sow.*				*
coronatus, *Sow.*		*		
crispus, *Desh.*				*
cristatus, *Sow*		*		
defossus, *Sow.*	? M. sublamellosus, *Desh.*			*
frondosus, *Sow.*	M. rudis, *Desh.*			*
minax, *Brand.*	Fusus minax, *Lam.*		*	*
tripteroides, *Lam.*			*	*
spinulosus, *Desh.*		*		
Neæra dispar, *Sow.*	Corbula, *Desh.*			*
argentea, *Lam.*	Corbula, *Desh.*		*	*
inflata, *Sow.*	Nucula, *Sow.*	*		
Natica glaucinoides, *Sow.*	N. labellata, *Desh.*	*	*	*
Hantoniensis, *Pilk.*		*	*	*
lineolata, *Desh.*			*	
hybrida, *Lam.*			*	
similis, *Sow.*	? N. epiglottina, *Lam.*		*	*
Nautilus centralis, *Sow.*		*		
imperialis, *Sow.*		*		
regalis, *Sow.*		*		
Sowerbyi, *Sow.*		*		
ziczac, *Sow.*		*		
urbanus, *Sow.*		*		
Nerita globosa, *Sow.*				*
Nucula amygdaloides, *Sow.*		*		

Species.	Synonyms.	London clay.	Bracklesham sands.	Barton clay.
Nucula trigona, *Sow.*				*
Bowerbanki, *Sow.*		*		
Wetherellii, *Sow.*		*		
compressa, *Sow.*		*		
deltoidea, *Lam.*				*
ovata, *Sow.*				*
similis, *Sow.*	N. margaritacea, *Desh.*	*	*	*
minima, Sow.	N. striata, *Lam.*	*	*	*
Nummulites lævigatus, *Lam.*			*	
elegans, *Sow.*	N. planulatus, *Lam.*		*	*
variolaria, *Lam.*			*	*
Oliva Branderi, *Sow.*				*
aveniformis, *Sow.*				*
canalifera, *Lam.*			*	*
Salisburiana, *Sow.*				*
Ostrea dorsata, *Sow.*			*	*
elegans, *Desh.*			*	
flabellula, *Lam.*		*	*	*
gigantea, *Sow.*				*
radiosa, *Desh.*			*	
oblonga, *Brand.*				*
Ovulum retusum, *G. Sow.*		*		
Panopæa intermedia, *Sow.*	Corbula dubia, *Desh.*	*		
corrugata, *Sow.*			*	*?
Patella striata, *Sow.*			*	
Pecten carinatus, *Sow.*				*
corneus, *Sow.*		*	*	
opercularis, *Linn.*	Recent		*	
duplicatus, *Sow.*		*		
squamula, *Lam.*			*	
multistriatus, *Desh.*			*	
reconditus, *Sow.*			*	*
Petricola coralliophaga, *Desh.*				*
Pectunculus brevirostris, *Sow.*		*		
decussatus, *Sow.*		*		
pulvinatus, *Lam.*			*	
scalaris, *Sow.*				*
deletus, *Brand.*	P. angusticostatus, *Lam.*			*
Pholadomya margaritacea, *Sow.*		*		
virgulosa, *Sow.*		*		
Dixoni, *Sow.*		*		
Pinna affinis, *Sow.*		*		
arcuata, *Sow.*		*		
margaritacea, *Lam.*			*	*
Pholas conoidea ?, *Desh.*				*
Pleurotoma acuminata, *Sow.*		*		
attenuata, *Desh.*			*	*
brevirostra, *Sow.*				*
cataphracta, *Broc.*				*
colon, *Sow.*		*		*
comma, *Som.*		*	*	*
conoides, *Brand.*				*
dentata, *Lam.*			*	
elegans, *Mell.*		*		

Species.	Synonyms.	London clay.	Bracklesham sands.	Barton clay.
Pleurotoma exerta, *Brand.*	....		*	*
fusiformis, *Sow.*	....	*		
granulata, *Lam.*	....			*
innexa, *Brand.*	....			*
lævigata, *Sow.*	....	?*		*
macilenta, *Brand.*	....			*
prisca, *Sow.*	....	*	*	*
rostrata, *Sow.*	....	*?	*?	*
semicolon, *Sow.*	....			*
turbida, *Lam.*	....			*
Psammobia compressa, *Sow.*	....	*	*	*
rudis, *Lam.*	....			*
Pseudoliva obtusa, *Sow.*	Buccinum obtusum, *Desh.*	*	*	
patula, *Sow.*	patulum, *Desh.*		*	
semicostata	semicostatum, *Desh.*	*		
Pyrula Greenwoodi, *Sow.*	....			*
lævigata, *Lam.*	....		*	
nexilis, *Lam.*	....		*	*
Smithii, *Sow.*	....	*		
tricostata, *Desh.*	....	*	*	
Potamis variabilis ?, *Sow.*	....		*	
Ringicula turgida, *Sow.*	*an* Auricula ringens, *Lam.*	*	*	*
Rostellaria lucida, *Sow.*	....	*		
macroptera, *Lam.*	....	*	*	*
rimosa, *Sow.*	R. fissurella, *Lam.*		*	*
Sowerbyi, *Mant.*	....	*		
Sanguinolaria Hollowaysii, *Sow.*	....		*	
Scalaria acuta, *Sow.*	? S. crispa, *Lam.*		*	*
interrupta, *Sow.*	....		*	*
reticulata, *Sow.*	....	*		*
semicostata, *Sow.*	....			*
spirata, *Nyst*	....		*	
undosa, *Sow.*	....	*		?*
Saxicava vaginoides, *Desh.*	....			*
Sepia longirostris, *Desh.*	....		*	
Seraphs convolutus, *Montf.*	Terebellum convolutum, *Lam.* ...			*
Serpula crassa, *Sow.*	....	*		*
exigua, *Sow.*	....			*
extensa, *Sow.*	....			*
flagelliformis, *Sow.*	....		*	
heptagona, *Sow.*	....		*	*
prismatica, *Sow.*	....	*		
trilineata, *Sow.*	....			*
Sigaretus canaliculatus, *Sow.* ...	....	*	*	*
Solarium canaliculatum, *Lam.* ...	....	*	*	*
discoideum, *Lam.*	....			*
patulum, *Sow.*	....	*	*	
plicatum, *Lam.*	....		*	*
trochiforme, *Desh.*	....		*	
Solenocurtus Parisiensis, *Desh.* ...	Solen strigillatus, *Lam*		*	*
Solen Dixoni, *Sow.*	....		*	
gracilis, *Sow.*	....		*	*
obliquus, *Sow.*	....		*	
Strombus Bartonensis, *Sow.*	S. ornatus, *Desh.*			*

Species.	Synonyms.	London clay.	Bracklesham sands.	Barton clay.
Tellina ambigua, *Sow.*	....			*
Branderi, *Sow.*	....			*
canaliculata, *Edw.*	....		*	
concinna, *Edw.*	....		*	
donacialis, *Lam.*	....		*	*
dis-stria, *Edw.*	....		*	
filosa, *Sow.*	....		*	*
granulosa, *Edw.*	....			*
Hantoniensis, *Edw.*	....			*
lamellosa, *Desh.*	....		*	
lamellulata, *Edw.*	....			*
lævis, *Edw.*	....			*
lunulata, *Desh.*	....		*	
obovata, *Edw.*	....		*	
plagia, *Edw.*	....		*	
reflexa, *Edw.*	....		*	
rhomboidalis, *Edw.*	....		*	
speciosa, *Edw.*	....		*	
squamula, *Edw.*	....			*
subrotunda, *Desh.*	....		*	
textilis, *Edw.*	....		*	
tumescens, *Edw.*	....		*	
scalaroides, *Lam.*	....		*	*
tenuistria, *Desh.*	....		*	
Terebellum fusiforme, *Lam.*	....		*	*
Terebratula striatula, *Mant.*	....	*		
Teredo personata, *Desh.*	....	*		
antenauta, *Sow.*	....	*	*	*
Thracia oblata	Lutraria oblata, *Sow.*	*		
Triton argutus, *Sow.*	....			*
viperinus, *Lam.*	....	*		
Turbo planorbularis, *Desh.*	Adeorbis, *S. Wood*		*	
plicatus, *Desh.*	....		*	
Trochus agglutinans, *Desh.*	....		*	*
extensus, *Sow.*	....	*		
monilifer, *Sow.*	....			*
Benettiæ, *Sow.*	....			*
Turritella abbreviata, *Desh.*	....		*	
brevis, *Sow.*	....			*
fasciata, *Lam.*	....		*	
imbricataria, *Lam.*	....	*	*	*
sulcifera, *Lam.*	....	*	*	
terebellata, *Lam.*	....		*	
multisulcata, *Lam.*	....		*	
Typhis fistulosus, *Broc.*	....			*
muticus, *Sow.*	....	*		
pungens, *Brand.*	Murex tubifer, *Lam.*			*
Venericardia acuticosta, *Lam.*	....		*	
Brongniartii, *Mant.*	....	*		
deltoidea, *Sow.*	....			*?
elegans, *Desh.*	....		*	
globosa, *Sow.*	....			*
mitis, *Lam.*	....		*	
oblonga, *Sow.*	V. cor-avium, *Lam.*			*

Species.	Synonyms.	London clay.	Bracklesham sands.	Barton clay.
Venericardia planicosta, *Lam.*			*	
Suessonensis, *D'Archiac*		*		
Vermetus Bognoriensis, *Sow.*		*		
Voluta ambigua, *Sow.*				*
augusta, *Desh.*			*	
athleta, *Sow.*			*	*
bicorona, *Lam.*			*	
bulbula, *Lam.*			*	
cythara, *Lam.*			*	
costata, *Sow.*			*	*
denudata, *Sow.*		*		
depauperata, *Sow.*				*
elevata, *Sow.*		*		
geminata, *Sow.*				*?
harpula, *Lam.*				*
labrella, *Lam.*			*	
lima, *Sow.*	V. digitalina, *Lam.*			*
luctatrix, *Sow.*	V. musicalis, *Lam.*		*	*
majorum, *Sow.*			*	*
muricina, *Lam.*			*	
nodosa, *Sow.*		*	*	*
protensa, *Sow.*		*		
scalaris, *Sow.*				*
simplex, *Desh.*			*	
spinosa, *Lam.*			*	*
suspensa, *Sow.*				*
tricorona, *Sow.*		*		
Wetherellii, *Sow.*		*		
Volvaria acutiuscula, *Sow.*				*
Vulsella deperdita, *Desh.*				*
Xiphidion quadratum, *Sow.*	Pollicipes quadratus	*		

DESCRIPTION OF PLATE XIV.

Comparative Sections.—In these sections the superposition and thickness of the strata have been proved either in natural sections, wells, or railway cuttings. The lines connecting the sections show the presumed range of the strata they subtend. They have no reference to the surface level. Where the connexion is not completed, there is a doubt as to their probable course. In the horizontal scale the sections are merely placed at their relative geographical distances.

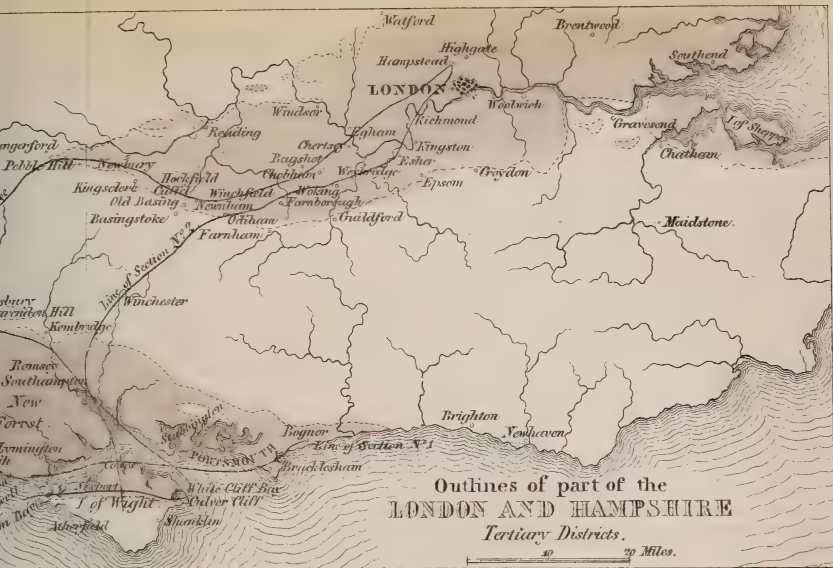
Point α, figs. 1 and 2, shows the base of the Barton clays. The junction beds in both sections exhibit like characters.

Point β, figs. 3 to 10, gives the range of the *Venericardia planicosta*, *Turritella sulcifera* and *Nummulites lævigatus*—typical fossils of the central beds of the Bracklesham Bay series.

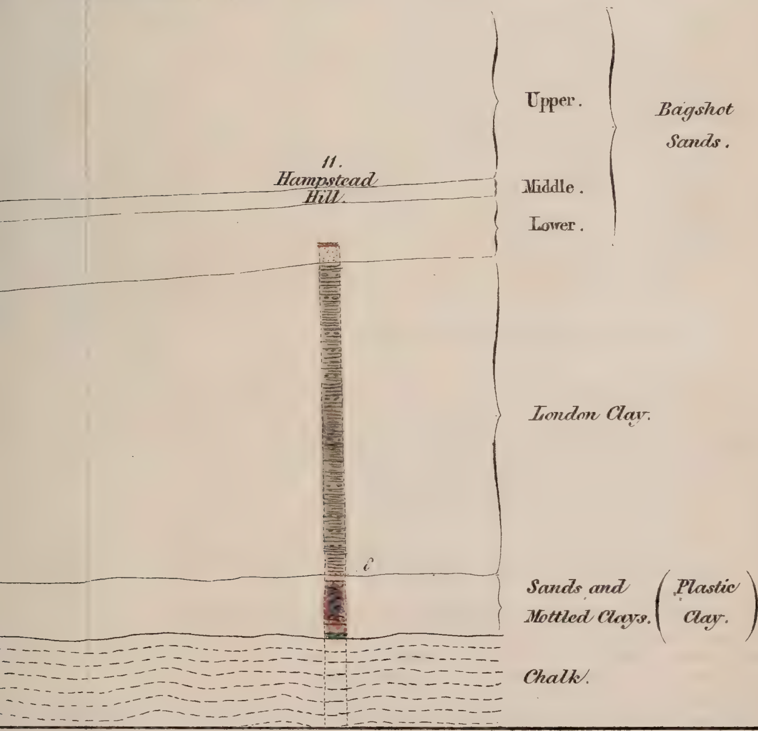
At Point γ, fig. 2, is the thin stratum of light-coloured laminated clays full of very distinct vegetable impressions. In fig. 1. I have shown at γ the probable position of the Bournemouth strata in which similar impressions have been found.

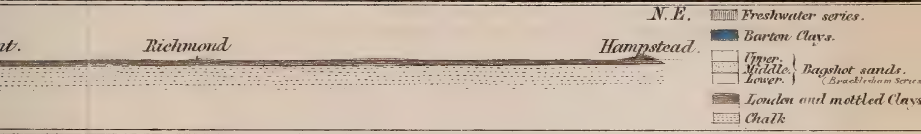
Point δ is at the base of the London clay at those places where we have found the structure to correspond, and where the lowermost stratum abounds with *Pectunculus brevirostris*, *Ditrupa plana*, *Cytherea obliqua*, *Pinna affinis*, *Panopæa intermedia*, *Rostellaria Sowerbii*, &c. and teeth of *Lamnæ*.

Point ϵ exhibits the position of the band of *Ostrea bellovacina.*



Outlines of part of the LONDON AND HAMPSHIRE Tertiary Districts.





on stone Reeve, Broth

Comparative Sections in the LONDON and HAMPSHIRE Tertiary Systems
illustrative of the relative range and synchronism of the strata.
Vertical Scale — 1 Inch = 250 Feet
2. Section from Barton to Bognor.
W.
E.
Barton Cliff
Bracklesham
Bognor
Alum Bay.
White Cliff Bay.
Barton Clays
Sands
Bracklesham Bay Series.
London Clay (Bognor Beds)
Sands and Mottled Clays
Chalk
Southampton
Kembridge.
Clarendon Hill.
Pebble Hill
Cuffell and Ouniham.
Winchfield.
Chobham Place.
Hampstead Hill.
Upper.
Middle.
Lower.
Bagshot Sands.
London Clay
Sands and Mottled Clays.
Plastic Clay.
Chalk.
1 Section from the Isle of Wight to London. Scale 1 Inch = 4 Miles.
S.W.
N.E.
Sea level
Newport
Winchester
Odiham.
Farnborough.
Oddworthy. Woking Station
St. George's Hill
Claremont.
Richmond
Hampstead
Outlines of part of the LONDON AND HAMPSHIRE Tertiary Districts.
LONDON
Winchester
Maidstone
Brighton

In the sections of Alum and White-Cliff Bays the numbers on the side refer to the more detailed sections given in my previous paper (see Journal Geol. Soc. for Aug. 1846). As they are there given in full, only the few portions necessary for the elucidation of the subject are repeated here. The colouring is omitted for the same reason.

The Barton cliff section represents the strata as far as Muddiford near Christchurch. The base of the Barton clays is there exposed reposing upon light-coloured sands without fossil shells, but full of fragments of soft carbonized wood. A break in the strata is then made by Christchurch harbour, on the other side of which the cliffs resume and range uninterruptedly to Poole harbour and the chalk at Studland. The strata, of coarse sands and impure clays, forming these cliffs correspond with the central beds of Alum Bay and the Bracklesham Bay series. No fossils have been found in them except the vegetable impressions at Bournemouth. For a description of these strata see Mr. Lyell's memoir (Trans. Geol. Soc., 2nd Series, vol. ii. p. 279).

The colouring of the sections indicates roughly the most generally prevailing colours of the several formations.

Section 1 shows the superposition and range of the strata composing the Hampshire system, and the relative position of the strata of Barton, Bracklesham and Bognor, from Bognor through Cowes to Christchurch.

Section 2 exhibits the range of the tertiary strata from London to the Isle of Wight; shows the slight curve by which the chalk is elevated, and the continuity of the two tertiary districts interrupted. A few outliers of the lowest tertiary beds (not marked here) occur at intervals on the range of chalk hills separating the two districts.

In both these sections (1 and 2) the horizontal and vertical measurements are on the same scale*. The few faults that occur in these strata are omitted. Of the two systems, that of Hampshire is by far the most disturbed.

The Map shows the relative positions of the Hampshire and London systems. The outline of the latter I can give as the result of my own observations:—that of the former I have taken chiefly from Mr. Greenough's large map.

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* Owing to the minuteness of the divisions this scale has not been well kept in the plate. The vertical proportions are in most parts of it in excess.

In section 2, the strata reposing upon the London clay from near Odiham to Claremont represent the three divisions of the Bagshot sands. The lower division should have appeared again on the summit of Hampstead Hill, which is also made to appear too high.

CORRIGENDUM.

In Table 2, page 400, reckon one more species in addition and common to Barton and Bracklesham.

PROCEEDINGS,

ETC.

POSTPONED PAPERS.

On the Age of the Tertiary Beds of the TAGUS, *with a Catalogue of the Fossils.* By JAMES SMITH, Esq. of Jordan-hill, F.G.S.

[Read June 30, 1841.]

[An abstract of this paper appeared in the Proceedings of the Geological Society, vol. iii. p. 462.]

DURING a recent visit to Portugal my attention was chiefly directed to an examination of the testaceous fossils of the tertiary deposits near Lisbon, with the view of ascertaining their geological age. The result has been to satisfy me that they belong to the second great division in the ascending scale of the tertiary system, the miocene of Lyell, and in particular that they agree more nearly with those of the deposit of the south-west of France, in the environs of Bordeaux and Dax, than with any other which have been hitherto described*. I was at first inclined to consider them to be, strictly speaking, identical and contemporaneous; but a careful comparison of the Portuguese fossils with those described in the catalogues of MM. De Basterot and Grateloup, and also with a collection of shells from Bordeaux in my own possession, shows a greater difference than can be ascribed to geographical distance alone. But whether they are more or less ancient we have no means, in the present state of our knowledge, of determining, and the proportion of recent shells to extinct species does not throw any light upon the subject. M. de Basterot makes the proportion of recent shells in the Bordeaux fossils twenty-three per cent., whilst M. Grateloup makes it thirty-seven per cent.; according to the annexed catalogue, there are twenty-eight per cent. of recent species in the Lisbon fossils, which is somewhat below the mean, and may perhaps indicate an earlier date. But although I am fully convinced of the soundness of the principle by which we infer the age of a tertiary deposit from the proportion of recent species which it contains, yet in practice the difficulty of distinguishing species really different from mere varieties is so great, that in the present state of the

* I have since found the same beds in the south of Spain and Malta. See Proceedings of the Geological Society, vol. iii. p. 452, and Quarterly Journal of the Geological Society, vol. iii. p. 52.

science of conchology we can only expect to arrive at an approximation sufficient perhaps to determine to which of the great divisions of the system a tertiary deposit belongs, but not, as in the present case, to throw any light on the relative antiquity of two formations of nearly the same age.

Professor Agassiz recognized several of the new species as belonging to the Molasse of Switzerland, and is inclined to consider the deposits as being nearly contemporaneous.

I am indebted to Mr. G. B. Sowerby for the descriptions of the new species annexed to the catalogue, and to his son for the figures; the initials G. B. S., with or without a mark of interrogation, indicate his opinion as to the identity of the shells to which they are attached, with their recent or fossil analogues.

The mineral structure of the strata in which they are imbedded has been so fully and so accurately described by Mr. Sharpe, in his communications to the Geological Society*, as to render any details on my part superfluous; I shall therefore only notice them to point out the localities and the place in the series from which the fossils were collected.

The upper beds are composed of loose sand and gravel, and are known as the Golden Sands of the Tagus, from the gold which has occasionally been extracted from them. They are destitute of organic remains, but below them we find a series of beds of yellow sand and calcareous sandstone and blue marl, rich in marine remains. Mr. Sharpe has termed them the Almada beds, from the town of that name on the south side of the Tagus opposite Lisbon, where they are most fully developed, and it was from them that the fossils here described were collected. The number of species is upwards of 150, but many of them are mere casts, or in too imperfect a state to allow their specific characters to be made out. Those which have been determined amount to 124 species; of which 20 are new and peculiar to the deposit, 51 occur in the Bordeaux beds, 17 in the Faluns of Touraine, 15 in the Sub-Apennine and Sicilian beds, 8 in the eocene of the London and Paris basins, and 35 are recent. Several of them also occur in the deposits of Vienna, Switzerland, Turin and the Morea.

Upon the whole, I am inclined to consider this deposit as belonging to the *older* miocene; that is, that it is older than the Touraine beds, and nearly of the same age as those of Bordeaux and Dax.

Dentalium entalis. Recent. Fossil at Bordeaux, and in all the divisions of the tertiary system.

—— *Radula*, Brocchi, p. 262? Nearly straight, with 9 or 10 slender granulated striæ: this is probably the same as that mentioned by Brocchi "à strie granulose." Fossil in Italy.

Serpula vermicularis. Recent.

—— *fascicularis*, Lamk. Recent.

* Proceedings of the Geological Society, vol. iii. p. 29.

Vermilia triquetra. Recent.

—— *bicarinata,* Lamk.? Recent.

Balanus ——? I found at least six species, one of which I am informed by Professor Agassiz is common in the Molasse, another agrees with one from Bordeaux in my possession. As Basterot's catalogue of Bordeaux fossils does not include Balani, it is impossible to say whether any of the others are to be found in that locality.

Fistulana echinata, Brocchi, p. 270. pl. 15. fig. 1.

Pholas altior, n. sp., Pl. XV. fig. 1.

—— *Branderi,* Bast.? pl. 7. fig. 1. Some of the specimens of the *Ostrea longirostris* are perforated by a Pholas agreeing in shape and size with the above, which occurs fossil at Bordeaux and in the Faluns of Touraine.

Solen antiquatus? Recent. G. B. S.

Panopæa Faujasi, Bast., G. B. S. (*P. Menardi,* Dujardin.) M. Agassiz considers it the same as the *P. Agassizii* of Valenciennes. Fossil at Bordeaux, Touraine, and in the Molasse.

Lutraria sanna, Bast. pl. 7. fig. 13; G. B. S. Fossil in the Bordeaux basin.

Corbula nucleus. Recent. Fossil at Dax and Touraine.

—— *porcina,* Lamk. Recent in the Mediterranean. Although the specimen in my possession is only a cast, it agrees so perfectly with that figured by Agassiz, Mém. sur les Moules des Mollusques, 2nd vol. of 'Mém. de la Soc. des Scienc. Nat. de Neuchatel,' pl. 1. figs. 13–17, as to satisfy me that it is the same species.

Lucina columbella, Bast. pl. 5. fig. 11. Recent in Senegal. Fossil in Bordeaux and Touraine.

—— *rotundata,* Turt.? Resembles the *L. lactea,* but is much larger, being an inch and a half in diameter.

—— *dentata,* Bast. pl. 4. fig. 20.

Cyprina æqualis, Sow. Min. Con. pl. 21. (*C. islandicoides,* Bast.) G. B. S. Fossil in Bordeaux, the Crag, &c.

Artemis elliptica, n. sp., Pl. XV. figs. 2, 3. I find this species in my collection of Bordeaux fossils.

Cytherea incrassata, Desh., G. B. S.

—— *erycinoides*?, Bast. A cast. Fossil at Bordeaux, &c.

Pullastra? A cast. G. B. S.

Venus vetula, Bast. pl. 7. fig. 7. Fossil at Bordeaux. This is apparently the same as that figured by Bowdich, 'Excursions in Madeira,' &c., figs. 2, 3.

—— *Brocchii*? G. B. S.

—— *dysera,* Brocchi, pl. 16. fig. 7; Bast. Fossil in Bordeaux and Italy. Recent in the European seas and Indian Ocean.

——. Two other species. Casts.

Cardium hians, Brocchi, pl. 13. fig. 6. Fossil in Italy and Vienna.

—— *echinatum.* Fossil at Bordeaux. Recent.

—— *multicostatum,* Bast. pl. 6. fig. 9; Broc. pl. 13. fig. 2. Fossil in Italy, Bordeaux, Touraine.

Cardium paucicostatum, G. B. S.
—— *pholadiforme,* n. sp., Pl. XV. figs. 6, 7.
—— *latisulcatum,* n. sp., Pl. XV. figs. 4, 5. M. Agassiz informs me that it is common in the Molasse.
Venericardia Jouannetti, Bast. pl. 5. fig. 3; G. B. S. Fossil in Italy, Bordeaux, Vienna. Found by Mr. Sharpe at Adiça.
Arca subrostrata, Sowerb., n. sp., Pl. XV. figs. 8, 9. Agrees with a specimen from Bordeaux in my collection.
Pectunculus pulvinatus, G. B. S. Fossil at Bordeaux and Touraine. Recent.
Nucula ——? A fragment too imperfect to determine the species.
Mytilus ——? A fragment.
Meleagrina. A cast resembling *M. margaritifera.*
Pinna affinis. G. B. S.
Pecten ambiguus, Goldf.? G. B. S.
—— *maximus*? G. B. S. Recent.
—— *squamulosus,* Virlet and Boblaye, pl. 5. fig. 9. Fossil in the Morea.
—— *Pandoræ,* Virlet and Boblaye, pl. 2. figs. 12, 13, 14. Fossil in the Morea. See also Mr. Sowerby's description and figure, Pl. XIX. fig. 22.
—— *multiradiatus,* Bast. Fossil in Italy and Bordeaux.
—— *scabrellus,* Bast. (*P. dubius,* Broc. pl. 16. fig. 16.) Fossil in Piedmont, Bordeaux and Touraine. Recent.
—— *Burdigalensis,* Bast. Fossil at Bordeaux.
—— *striatus,* Sowerb. Min. Con. pl. 394. fig. 2, 3, 4. Fossil in the Crag and Touraine. Recent.
—— *complanatus*? Sowerb. Min. Con. pl. 586. Fossil in the Crag.
—— *Beaudanti,* Bast. pl. 5. fig. 1. A.
—— *tenuisulcatus,* n. sp., Pl. XVIII. figs. 19, 20.
—— *conjux,* Sowerb., n. sp., Pl. XVII. fig. 17.
—— *Josslingii,* n. sp., Pl. XVI. figs. 10, 11, 12. This shell resembles the *P. arcuatus* of Brocchi, pl. 14. fig. 11, but is larger and has fewer ribs. It agrees very nearly with one from the Maestricht beds (*Peigne bombé*), Faujas, and is probably the same as that found in the Molasse by M. Elie de Beaumont, said to be "voisin du *P. arcuatus* de Brocchi, mais plus grand," 'Recherches,' &c., p. 97.
—— *fraterculus,* n. sp., Pl. XVI. figs. 13, 14.
—— *expansus,* n. sp., Pl. XVIII. fig. 21. It agrees with a specimen from Bordeaux in my collection.
——. Fragments of a Pecten resembling the last, but with the ribs elevated externally, which are perfectly smooth in *P. expansus*; about eleven in number. It is transversely striated and subdiaphanous.
—— *acuticostatus,* n. sp., Pl. XVII. fig. 18.
—— *Macrotis,* n. sp., Pl. XVII. fig. 15.
—— *giganteus,* n. sp., Pl. XVII. fig. 16.
Spondylus quinquecostatus, Virlet and Boblaye, pl. 2. fig. 2. Fossil in the Morea.

Ostrea flabellula, Min. Con. pl. 253. Fossil in the London clay, Grignon and Bordeaux.

—— *plicata.* (*Chama plicata,* Brander, pl. 7. fig. 84; *Cymbula,* Bast.?) Fossil in the London clay, and Bordeaux?

—— *Boblayei,* Virlet and Boblaye, pl. 3. figs. 6, 7. Fossil in the Morea.

—— *longirostris,* Goldf. pl. . fig. .

—— *excavata,* Virlet and Boblaye, pl. 5. figs. 5, 6.

—— *crassicostata,* n. sp., Pl. XIX. fig. 23.

—— *hyotis,* G. B. S.

—— *cyathula,* Goldf. pl. 87. fig. 5.

—— *undata,* Bast.? Fossil at Bordeaux.

Anomia ephippium. Recent.

Calyptrea muricata. (*Patella,* M. Brocchi, pl. 1. fig. 2.) Fossil in Italy and Bordeaux.

Ampullaria perusta, Brongn.; G. B. S.; Brongn. Vicent. pl. 2. fig. 17. Fossil in the Vicentine.

Natica sigaretina, Min. Con. pl. 479. fig. 3. A specimen from Bordeaux in my collection agrees with it.

—— *clausa,* G. B. S.

—— *glaucina,* G. B. S.

—— *helicina,* Brocchi, pl. 1. fig. 20.

—— *perpusilla,* n. sp., Pl. XX. fig. 33. *a, b, c.* Specimens in my collection of fossils from Bordeaux agree with this.

Sigaretus canaliculatus, Desh. Coq. Foss. de Paris, pl. 21. fig. 13; Min. Con. pl. 384. fig. . Fossil in the London and Paris basins, and Bordeaux.

Tornatella semistriata, Bast. p. 25; *Voluta tornatilis,* Brocchi, pl. 15. fig. 14. Fossil in Italy and Bordeaux.

Scalaria tenera, n. sp., Pl. XX. fig. 24.

Solarium neglectum, Bellardi; G. B. S.

Trochus agglutinans. Fossil in Bordeaux and Touraine.

—— *patulus*? Brocchi, pl. 5. fig. 19. Fossil in Italy and Bordeaux.

—— *turgidulus*? Of these two last I have only casts, but they perfectly agree with the figures and specimens in my collection from Bordeaux.

——. There are three other species of *Trochus,* but as I have only casts they cannot be made out: one of them is two inches and a half in diameter; another has a flat, depressed spine.

Turritella proto, Bast. pl. 1. fig. 7; G. B. S. Fossil in Bordeaux and Touraine.

—— *cathedralis,* Brongn. Vicent. pl. 4. fig. 6; G. B. S. Fossil in the Vicentine and Bordeaux.

—— *turris,* Bast. pl. 1. fig. 11; G. B. S. Fossil in Bordeaux.

—— *terebralis,* Bast. pl. 1. fig. 14; G. B. S. Fossil in Bordeaux.

—— ——, var. *angustior,* G. B. S.

—— *terebra,* Brocchi, pl. 6. fig. 8. Recent. Basterot considers that this and the *T. terebralis* are perhaps the same. In the Lisbon specimens they are however perfectly distinct, the *T. terebralis* being much larger and the whorls nearly smooth; whilst in the other the spiral striæ are as strongly marked as in the living analogue. Fossil in Bordeaux.

Turritella terebra, var. *b*. Angular in the whorls.

—— *bicarinata*, n. sp., Pl. XX. fig. 25.

—— *imbricataria*, G. B. S.? A cast. Recent. Fossil in the Vicentine, and in the London and Paris basins.

Cerithium pictum, Bast. pl. 3. fig. 6. Fossil at Bordeaux and Vienna.

Pleurotoma ramosa, Bast. pl. 3. fig. 16. Fossil at Bordeaux.

—— *lævigata*, n. sp., Pl. XX. fig. 28.

Turbinella Lynchii, Bast. pl. 7. fig. 10. Fossil at Bordeaux.

Cancellaria acutangula, Bast. pl. 2. fig. 4. Fossil at Bordeaux. Recent in Senegal.

—— *decussata*, n. sp., Pl. XX. fig. 27.

Fasciolaria Burdigalensis, Bast. pl. 7. fig. 11. Fossil at Bordeaux, &c.

Fusus. Casts of three species: uncertain.

Pyrula ventricosa, G. B. S.

—— *condita*, G. B. S.; Brongn. Vicent. pl. 6. fig. 4. Fossil at Bordeaux, Turin, Touraine. Recent in Africa.

—— *clava*? Bast. pl. 7. fig. 12. Fossil at Bordeaux.

—— *rusticola*, G. B. S.; Bast. pl. 7. fig. 9. Fossil at Bordeaux, &c. Recent in the Indian Ocean and Senegal.

—— ——, var. *β*, Bast. Fossil at Bordeaux.

—— *melongena*. Recent. Fossil at Bordeaux.

—— *reticulata*? G. B. S. Recent. Fossil in London and Paris basins, and Italy.

—— *ficoides*, Brocchi, pl. 1. fig. 5. Fossil at Bordeaux, &c. Recent in the Indian Ocean.

Ranella marginata, G. B. S.; Brongn. Vicent. pl. 6. fig. 7. Fossil at Bordeaux and Piedmont. Recent in the Indian Ocean.

—— *leucostoma*, Bast. pl. 4. fig. 6. Fossil at Bordeaux, &c. Recent in the Mediterranean.

Murex trunculus, G. B. S. Recent. Fossil in the Touraine and Bordeaux.

—— *suberinaceus*, Bast. pl. 4. fig. 15. Fossil at Bordeaux.

—— *asper*, Brander, pl. 3. figs. 77, 78; *tricarinatus*, Sowerb. Min. Con. Fossil in the London clay and Bordeaux. Recent in the Indian Ocean.

—— *lingua-bovis*, Bast. pl. 3. fig. 10.

Aporrhais? G. B. S. Casts: uncertain.

Cassis Thesei? G. B. S.; Brongn. Vicent. pl. 3. fig. 7.

—— *Sobaron*, Adanson, Senegal, pl. 7. fig. 8. Fossil at Bordeaux. Recent in Africa.

Dolium rotundatum, Brocchi, pl. 15. fig. 22.

Buccinum Veneris, Bast. pl. 2. fig. 15. Fossil at Bordeaux.

—— *baccatum*, Bast. pl. 2. fig. 16. Fossil at Bordeaux.

——. Casts of three species: uncertain.

Nassa curta, Duj. pl. 19. fig. 17. Fossil in Touraine.

—— *pusio*, n. sp., Pl. XX. fig. 30.

—— *proxima*, n. sp., Pl. XX. fig. 31.

—— *parvula*, n. sp., Pl. XX. fig. 34. *a, b, c*.

Nassa inconspicua, n. sp., Pl. XX. fig. 35. *a*, *b*, *c*.
Eburna spirata? G. B. S. Fossil at Bordeaux. Recent at Ceylon.
Terebra plicaria, Bast. pl. 3. fig. 4. Fossil at Bordeaux. Recent in the Indian Ocean.
Auricula ringens, var. *β*, Bast. *Voluta* (*Marginella*) *buccinea*, Brocchi, pl. 4. fig. 9. Fossil in Bordeaux and Italy.
Voluta spinosa. Fossil in London and Paris basins, and Bordeaux.
—— *spoliata*, n. sp., Pl. XX. fig. 32.
Conus. Casts of several species.

Species of Shells found in Mr. Sharpe's *Collection made near Lisbon, and not in the above lists.*—J. D. C. S.

Panopæa intermedia, of the Bognor rocks. Canneiras, near Lisbon.
Pectunculus. Large species, uncertain what. Poço do Bispo.
Ostrea gigantea? Poço do Bispo.
—— *nodosa*? Lisbon.
Pecten reconditus, Min. Con., not Brander. Poço do Bispo.
Turritella (*Proto*, Def.) *mutabilis*, n. sp. Poço do Bispo.
Pleurotoma tuberculosa. Bordeaux. Poço do Bispo.
—— *denudata*, MSS., n. sp., near to *Pl. tuberculosa*. Poço do Bispo.
Pyrula reticulata. Almada.
Bulla Edwardsii? Dixon, MSS.; or *B. Fortissii*, Brongniart. Like one found at Bracklesham Bay. Poço do Bispo.
Ancillaria inflata. Poço do Bispo.
Conus. Two species. Poço do Bispo.

Fishes.

Oxyrhina xiphodon, Agassiz. Fossil at Bordeaux.
Carcharias productus, Ag.
—— *megalodon*, Ag. Fossil in the London clay.
Galeus aduncus, Ag.
Lamna denticulata, Ag.
Delphinus. Species uncertain.

Echini, &c.

Clypeaster, n. sp. M. Agassiz informs me that this species occurs in the Molasse.
Scutella, n. sp.
Micraster, n. sp.
Echinus, n. sp.
—— n. sp. M. Agassiz has undertaken to describe the above in his work on *Echini*.
Corals, *Flustra*, *Crustacea*. Species uncertain.

Descriptions of Figures, Plates XV.–XX., *by* Mr. G. B. Sowerby.

Pholas altior.

Fig. 1.

Ph. testâ ovato-oblongâ, anticè rotundatâ, lineis incrementi rugulosâ, costellis radiantibus circa 18, distantibus, lineas incrementi decussantibus; posticè lævi; margine dorsali declivi. Long. 3·4, lat. 1·5, alt. 1·6 poll.

This species, as far as we can judge from a single imperfect specimen, comes nearest in its characters to *Pholas candida*; it differs however greatly in its proportions, and also in the circumstance of its posterior part being free from the radiating ribs, which cover about two-thirds of this shell, while the *Ph. candida* is entirely covered with them. It is not without some hesitation that we place this shell among the *Pholades*; still we think the balance of evidence is in favour of our decision.

Artemis elliptica.

Figs. 2, 3.

Art. testâ subellipticâ, rotundato-subtrigonali, tumidiusculâ, inæquilaterali, latere antico brevi, subrostrato, margine dorsali antico, rectiusculo, declivi; latere postico longiore, posticè subtruncato, margine dorsali rotundato-subdeclivi; lunulâ magnâ, ovali, lineâ tenuiter impressâ circumscriptâ; margine ventrali rotundato; superficie læviusculâ, lineis incrementi concentricis acutis solùm insculptâ. Long. 2·5, lat. 1·4, alt. 2·1 poll.

The general form of this species, being similar to that of many *Cytherea*, would, at a first sight, have induced us to place it in that genus: the characters of its hinge, with the fulcrum, to which the cartilage is attached, eroded close to the umbones (as in *Cyprina*), and those of the muscular impressions, compel us to unite it to *Artemis*: it is principally in its more elliptical form that it differs from the other species of that genus. This species resembles greatly, and is certainly congeneric with, *Venus Brocchii* of Bronn (which is put into *Cyprina* by most authors), but which is nearer to *Artemis* than to *Cytherea*, *Venus* or *Cyprina*.

Cardium pholadiforme.

Figs. 6, 7.

Card. testâ oblongâ, tumidiusculâ, anticè obtusâ, subrotundatâ, posticè subattenuatâ, umbone magno, costis radiantibus circa 10, magnis; impressione musculari posticâ circulari, profundè impressâ. Long. 1·9, lat. 0·9, alt. 1·15 poll.

Of this species we have only a single cast of the inside; it is composed of a greenish-grey-coloured fine sand, with very small remains of the shell.

Cardium latisulcatum.

Figs. 4, 5.

Card. testâ subglobosâ, subæquilaterali, costis radiantibus circa 18, interstitiis duplò latioribus. Long. 1·5, lat. 1·3, alt. 1·6 poll.

Casts of the inside alone have been found of this species; it is therefore obviously impossible that we should give the external characters of the shell: the casts are composed of a fine yellowish ferruginous sand.

Arca subrostrata.

Figs. 8, 9.

A. testâ subinæquivalvi, ovatâ, inæquilaterali, costato-radiatâ, latere antico brevi, rotundato, postico longiore subrostrato, costis radiantibus, anticis præcipuè subrugosis; interstitiis concentricè striatis. Long. 1·2, lat. 0·75, alt. 0·8 poll.

Very like *Arca antiquata*, but its general form is different, owing to the posterior part being more acuminated; it is moreover slightly inequivalve.

Pecten Pandoræ, *Desh.*

Fig. nost. 22.

P. testâ subæquivalvi, subæquilaterali, suborbiculari, squamulis minimis confertissimis rugosâ, radiatim costatâ et striatâ, costis alterius valvæ 14–15 majusculis, inæqualibus; alterius 15, subæqualibus; omnibus, interstitiisque longitudinaliter striatis, striis prope marginem ventralem omnibus confertissimè squamulosis; auriculis magnis, radiatim striatis et squamulosis. Long. 3·0, lat. 1·0, alt. 2·8 poll.

This is probably the *Pecten Pandoræ* described and figured in the 'Expédition scientifique de Morée' by Deshayes, but we have thought it necessary to give another representation of it, because our specimens are so much larger than his representation. It is evidently quite distinct from *P. plebeius*, Brocchi.

Pecten tenuisulcatus.

Figs. 19, 20, 20 *a*.

P. testâ inæquivalvi, æquilaterali, tenui, corneâ, lævi, valvâ alterâ plano-convexiusculâ, costis radiantibus 14–15, rotundatis, angustis, interstitiis latioribus; alterâ convexâ radiatim tenuiter sulcatâ, costis interstitialibus leviter elevatis.

This species is nearly similar in general form to *Pecten Beudanti* of Basterot, and it has been thought to be identical with it, though it may very easily be distinguished by the smooth convex valve not being deeply grooved, as in that species. The short character given by Basterot is not sufficient to enable us to form any idea of the species independently of the figure, which may be seen in the 'Mém. de la Soc. d'Hist. Nat. de Paris,' tome ii. pl. 5. fig. 1. A, B, C. His words are: "P. testâ lamellis acutis, transversis, confertis; striis intercostalibus nullis; costis 17–18;" which however are sufficient to prove our *P. tenuisulcatus* to be quite distinct.

Pecten conjux.

Fig. 17.

P. testâ æquilaterali, inæquivalvi, valvâ alterâ planâ, prope umbonem subconcavâ, concentricè tenuissimè striatâ, radiatim costatâ, costis 15–18 rotundatis, interstitiis paululùm latioribus. Long. 3·0, alt. 2·5 poll.

We possess the flat valve alone of this species, which resembles the same valve of *Pecten medius*; the ribs in this species are however more numerous and the interstices nearly equal, whereas in *P. medius* the interstices are much broader than the ribs, and there is moreover, in general, a very small intermediate rib between the principal ribs corresponding to a depressed line on the broad ribs of the convex valve. Judging from the deeply depressed broad ears, the other valve of this species should be very deeply convex.

Pecten Josslingii, *Smith*.

Figs. 10, 11, 12.

P. testâ valdè inæquivalvi, subæquilaterali, valvâ alterâ plano-subconcavâ, costis radiantibus 16, utroque latere angulatis, interstitiis latis; alterâ altè convexâ, umbone recurvo, magno, costis radiantibus 18, latis, rotundato-planulatis, interstitiis angustioribus; auriculis magnis, æqualibus, lævibus. Long. 2·0, lat. 0·9, alt. 2·1 poll.

Like *Pecten fuscatus* of Gray and *Pecten arcuatus* of Brocchi (to both of which this fine species bears some resemblance), one of its valves is remarkably convex; its umbo is very large and recurved, more than in either of those species, so much so, that a single imperfect convex valve has been taken for a Cardium. The interstices of the flat valve correspond in width with the ribs of the convex valve, and *vice versâ*.

Pecten fraterculus.

Figs. 13, 14.

P. testâ inæquivalvi, æquilaterali, lævi, radiatim costatâ, valvâ alterâ convexâ, costis 20, utroque latere rotundato angulosis; interstitiis angustioribus; alterâ subconvexo-planâ, costis 18 angustis, rotundatis, interstitiis latioribus, auriculis mediocribus. Long. 1·9, lat. 0·55, alt. 1·9 poll.

The general form of this species is much like that of *P. maximus*; it appears however to be sufficiently distinguished from that species by the number and form of its ribs, as well as by its being destitute of radiating striæ. From the Almada beds, and also from the blue marl at Adiça, to the south of Lisbon.

Pecten expansus.

Fig. 21.

P. testâ suborbiculari, valdè expansâ, inæquivalvi, æquilaterali, lævi, radiatâ; valvâ alterâ plano-subconvexâ, lateribus paululùm reflexis, alterâ convexiori, lateribus paritèr deflexis; auriculis magnis. Long. 5·5, lat. 1·3, alt. 5·0 poll.

Certainly very different from *P. Pleuronectes* and *Japonicus*, Lam., and much nearer to *P. Laurentii* in general form, as well as in the size of the ears, which are double the size in this and *P. Laurentii* that they are in *P. Pleuronectes* and *P. Japonicus*. In form our shell resembles *P. cristatus* of Goldfuss, t. 99. fig. 13; his expression, "auriculis in margine cardinali valvæ dextræ spinosis," proves that it cannot be the same.

Pecten acuticostatus.

Fig. 18.

P. testâ suborbiculari, valvâ alterâ convexâ, costis radiantibus 20, acutis, elevatis; lateribus costarum interstitiisque concentricè striatis; auriculis magnis, tenuiter radiatim costatis.

A fragment only of one valve of this species has been found; it will however easily be distinguished from the numerous species of this genus by its elevated triangular ribs, broader at their base than the interstices.

Pecten macrotis.

Fig. 15.

P. testâ subinæquivalvi, æquilaterali, radiatim costatâ; costis viginti scabris, dorso acutiusculis, lateribus utroque costellatis, interstitiis angustioribus, costellâ unicâ medianâ; auriculis magnis, radiatim striatis, scabris. Long. 1·5, lat. 0·6, alt. 1·6 poll.

Found at Adiça, south of Lisbon, and near Piedade. This species somewhat resembles *P. opercularis*; it may however easily be distinguished from that species by the great depth of one valve and the much larger ears. In Mr. Sharpe's collection.

Pecten giganteus.

Fig. 16.

Pect. testâ inæquivalvi, valvâ alterâ concavâ, alterâ planulatâ, valvæ concavæ costis radiantibus 16 s. 17, elevatis, supernè subplanulatis, ad latera rotundatis, transversè striatis; auriculis æqualibus. Long. 6·25, alt. 5·75, lat. 2 poll.

In general form and in proportions this species resembles *Pecten maximus*; it may however easily be distinguished by the circumstance of its radiating ridges being destitute of the longitudinal striæ so conspicuous in that species.

Ostrea crassicostata.

Fig. 23.

O. testâ inæquivalvi, inæquilaterali, irregulari, valvâ alterâ plano-concavâ, alterâ convexâ, lævi, costis crassis irregularibus paucis; margine crassè undulato; latere altero alato.

The only species to which this bears the least resemblance is the *Ostrea hyotis*, Linn., which is also found at Almada; we think however that they cannot be confounded together.

Natica perpusilla.

Fig. 31 *a*. mag. nat.—33 *b, c*. auctæ.

Nat. testâ parvâ, subglobosâ, lævi, nitidâ, crassiusculâ, spirâ subconicâ, anfractibus 3½, ultimo maximo, posticè obducto; labio interno incrassato, umbilicum partim tegente; umbilico anticè carinâ obtusissimâ circumdato. Long. 0·25, lat. 0·2 poll.

This species is between *N. Uber*, Val., and *N. conica*, Lam., in general form; its spire is more prominent than that of the first, though less so than that of the latter; it may be distinguished from both by its wanting the umbilical callosity. I believe it is the smallest species known.

Scalaria tenera.

Fig. 24.

Scal. testâ oblongo-pyramidali, tenui, anfractibus septem rotundatis, costellis parvis, paululùm elevatis, rotundatis, posticè mucronulatis. Long. 0·8, lat. 0·35 poll.

A very delicate little shell, somewhat resembling the *Turbo clathra-*

tulus of Mont., but differing in having a small mucronation at the posterior part of each rib.

Turritella bicarinata.

Fig. 25.

Turrit. testâ elongato-turritâ, crassâ, anfractibus subrotundatis, spiraliter striatis, carinis duabus anticis, validis, posticâ majori.

The proportions and number of volutions cannot be given because the specimens are very incomplete.

Turritella (*Proto*, Def.) mutabilis.

Fig. 26.

Turr. testâ elongato-turritâ, spiraliter striatâ; anfractibus planulatis, posticè inflatis, superioribus carinis duabus vel tribus validis, anticâ majori.

Remarkable for the last whorls of full-grown shells being almost free from carinæ (J. D. C. S.).

Loc. Poço do Bispo, near Lisbon (Daniel Sharpe).

Pleurotoma lævigata.

Fig. 28.

Pl. testâ fusiformi-turritâ, crassiusculâ, lævi, anfractibus 9, planulatis, posticè subincrassatis, rotundatis, apicem versus minutissimè crenulatis; sinu labii externi lato, haud alto, canali mediocri.

A shell which bears but little resemblance to any described species; it is nearest in general form to *Pl. Borsoni* of Basterot, from which it may easily be known by the form of its volutions, which are thickened and rounded at the upper or posterior part.

Pleurotoma denudata.

Fig. 29.

Pleur. testâ fusiformi-turritâ, spiraliter striatâ; anfractibus convexis, posticè spinosis, anticè unicarinatis, carinâ subgranulatâ.

This differs from *Pl. tuberculosa* in having but one carina upon the lower or anterior portion of each whorl (J.D.C.S.).

Loc. Poço do Bispo, near Lisbon (Daniel Sharpe).

Cancellaria decussata.

Fig. 27.

Canc. testâ ovatâ, acuminatâ, anfractibus quinque, ultimo decussato; suturâ canaliculatâ, labii externi margine incrassato. Long. 0·7, lat. 0·5 poll.

Casts of the inside alone of this pretty little Cancellaria have been found; they resemble *C. elegans* in general form, but are much more coarsely decussated. It appears to be distinguishable from *C. buccinula*, Lam., by its much more delicate longitudinal ribs.

Nassa Pusio.

Fig. 30.

Nassa testâ parvâ, ovato-acuminatâ, anfractibus senis, rotundatis, versus apicem costato-rugosis, dorso lævigato; ultimi anfractûs lateribus anticèque concentricè costatis, spiraliter striatis; suturâ distinctâ; aperturâ subovali, labio externo incrassato, intùs sulcato, interno in laminam prominentem intùs anticè denticulatam producto; canali brevissimâ, recurvâ, extùs striatâ. Long. 0·4, lat. 0·25 poll.

Nearest to *Nassa semistriata,* but very different in its form and proportions.

Nassa proxima.

Fig. 31.

Nassa testâ ovato-acuminatâ, crassâ, anfractibus 7 posticè biseriatim graniferis, irregulariter costellatis, anticè spiraliter sulcatis; aperturâ intùs costellatâ, canali brevissimâ, recurvâ, extùs carinam efformante. Long. 1·0, lat. 0·5 poll.

Nearest to *Buccinum baccatum* of Basterot; like that species it has two spiral rows of grains at the posterior part of the volutions, one of which is smaller than the other and close to the suture. It differs from that species in its form and proportions, as well as in having its canal very short and recurved.

Nassa parvula.

Fig. 34 *a.* mag. nat.—*b, c.* auctæ.

Nassa testâ conico-pyramidali, crassiusculâ, longitudinaliter sulcatâ, transversimque striatâ, striis anterioribus fortioribus; anfractibus senis, subventricosis, suturâ validâ; aperturâ ovali, labio externo extùs varice instructo; interno subincrassato, paululùm expanso. Long. 0·4, lat. 0·2 poll.

This somewhat resembles *Nassa macula,* but may be distinguished by the form of the volutions, which are much less ventricose; the transverse striæ also are much less prominent.

Nassa inconspicua.

Fig. 35 *a.* mag. nat.—*b, c.* auctæ.

Nassa testâ conico-pyramidali, crassiusculâ, lævigatâ, anticè transversim striatâ; anfractibus quinque subventricosis, posticis longitudinaliter sulcatis, transversimque obsoletè striatis, ultimo multo majori, lævi; aperturâ subovali, labio externo varice haud prominente extùs instructo, intùs denticulato, interno subincrassato, paululùm, posticè præcipuè, expanso. Long. 0·4, lat. 0·2 poll.

By attention to the above characters, this species may easily be known from *N. Pusio* and *N. parvula.* This will not be confounded with *N. macula.*

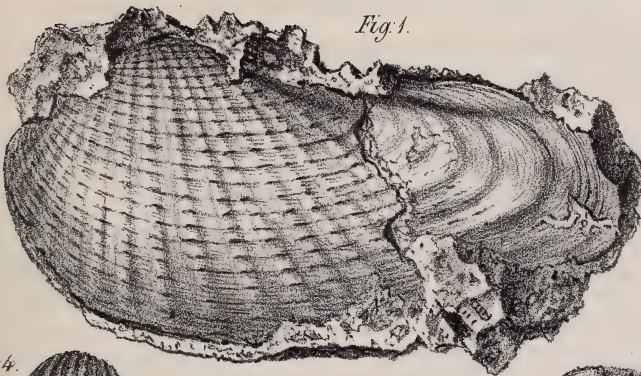
Voluta spoliata.

Fig. 32.

Vol. testâ ovato-coniformi, longitudinaliter costellatâ, spiraliter striatâ, granuliferâ, spirâ brevi, anfractibus quatuor, ultimo maximo, nonnunquam seriem tuberculorum coronato; aperturâ latiusculâ, posticè reflexâ, labio externo incrassato, reflexo, intus sulcato; plicis columellaribus quatuor.

As there are only casts of this shell, it is obviously impossible to give a full description of the species. The characters given above have been collected from several specimens: one of the most remarkable is the granulated outer surface, in which it resembles no other Volute that we are acquainted with; this granulated surface is similar to that of *Murex lingua-bovis* of Basterot.

Fig: 1.



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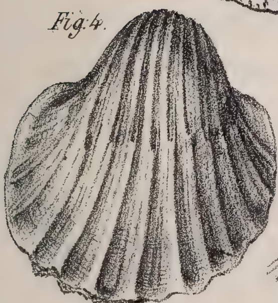

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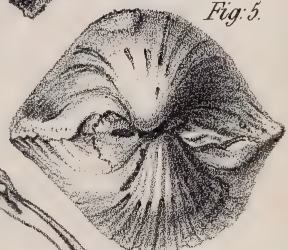


Fig: 3.

Fig: 2.

Fig: 6.

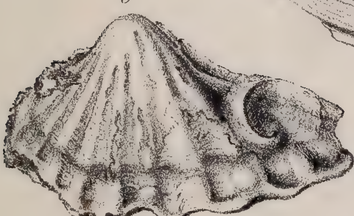


Fig: 8.

Fig: 7.

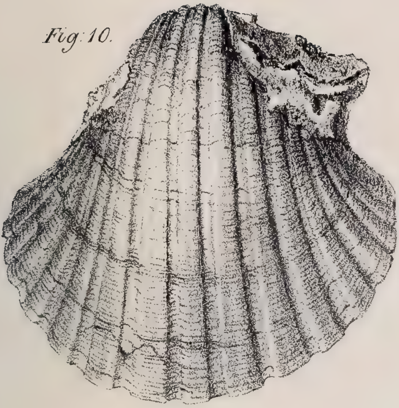
Fig: 9.

G.B. Sowerby Junr delt

J. De C. Sowerby lith.

Hullmandel & Walton Lithographers

Fig: 10.



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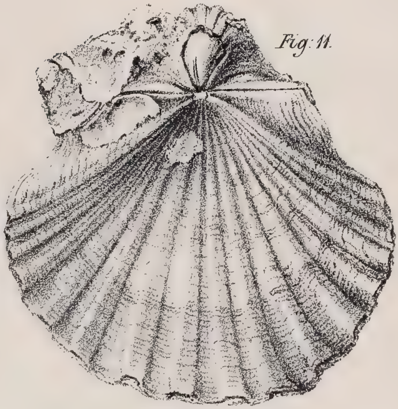


Fig: 12.

Fig: 13.

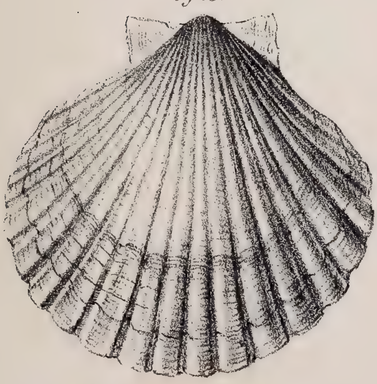
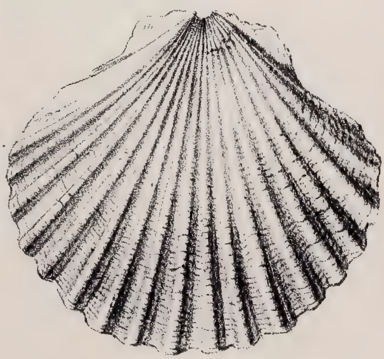


Fig: 14.



G. B. Sowerby Junr. delt.

J. De C. Sowerby lith.

Hullmandel & Walton Lithographers

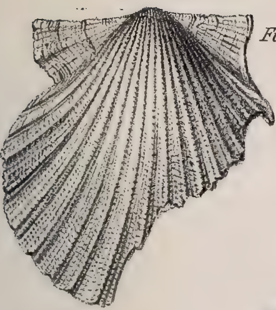


Fig: 15.

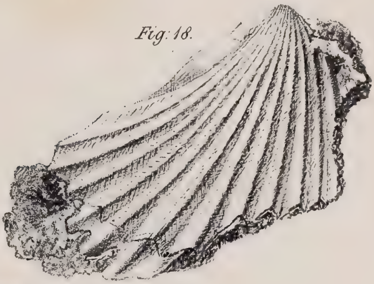


Fig: 18.

Fig: 16.

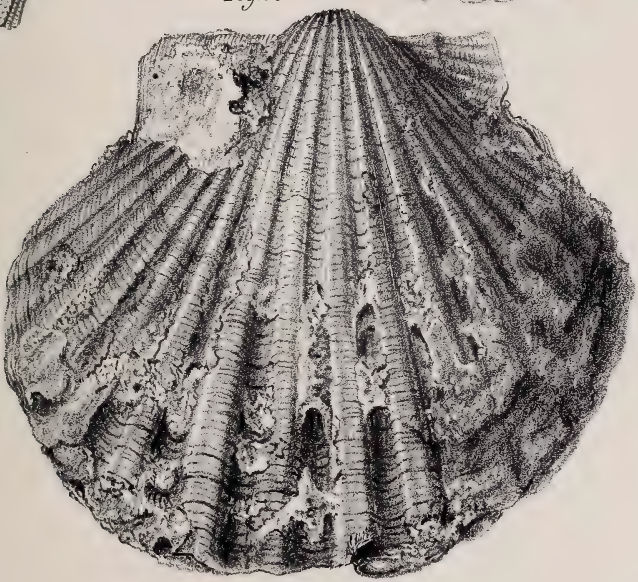
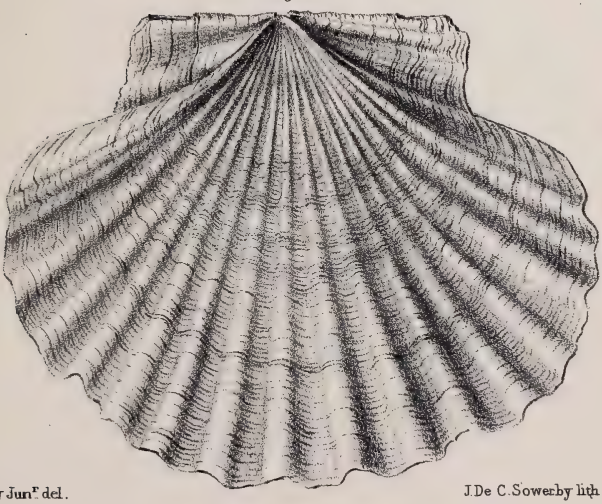


Fig: 17



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Hullmandel & Walton Lithographers.

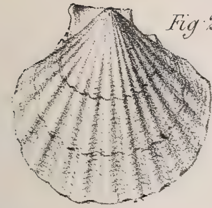


Fig: 20.

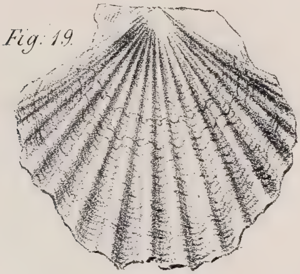


Fig: 19.

Fig: 20 a.

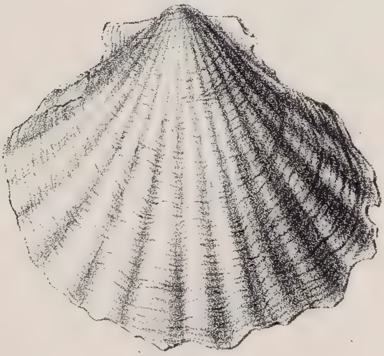
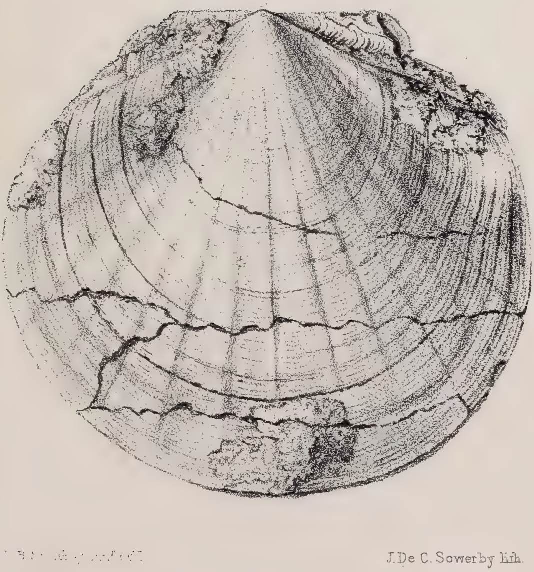


Fig: 21.



J. De C. Sowerby lith.

Fig: 22.

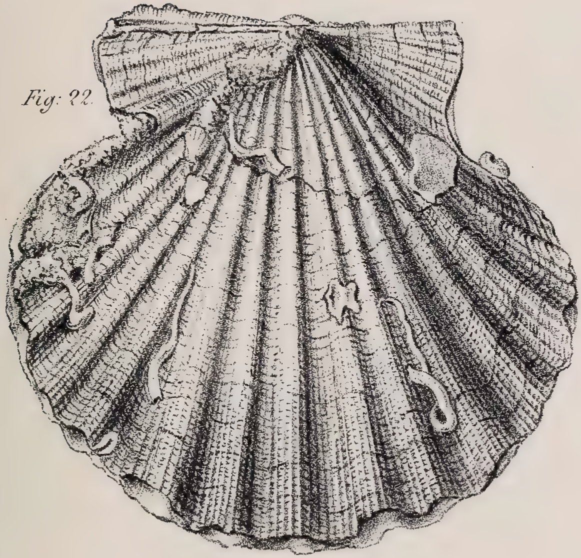
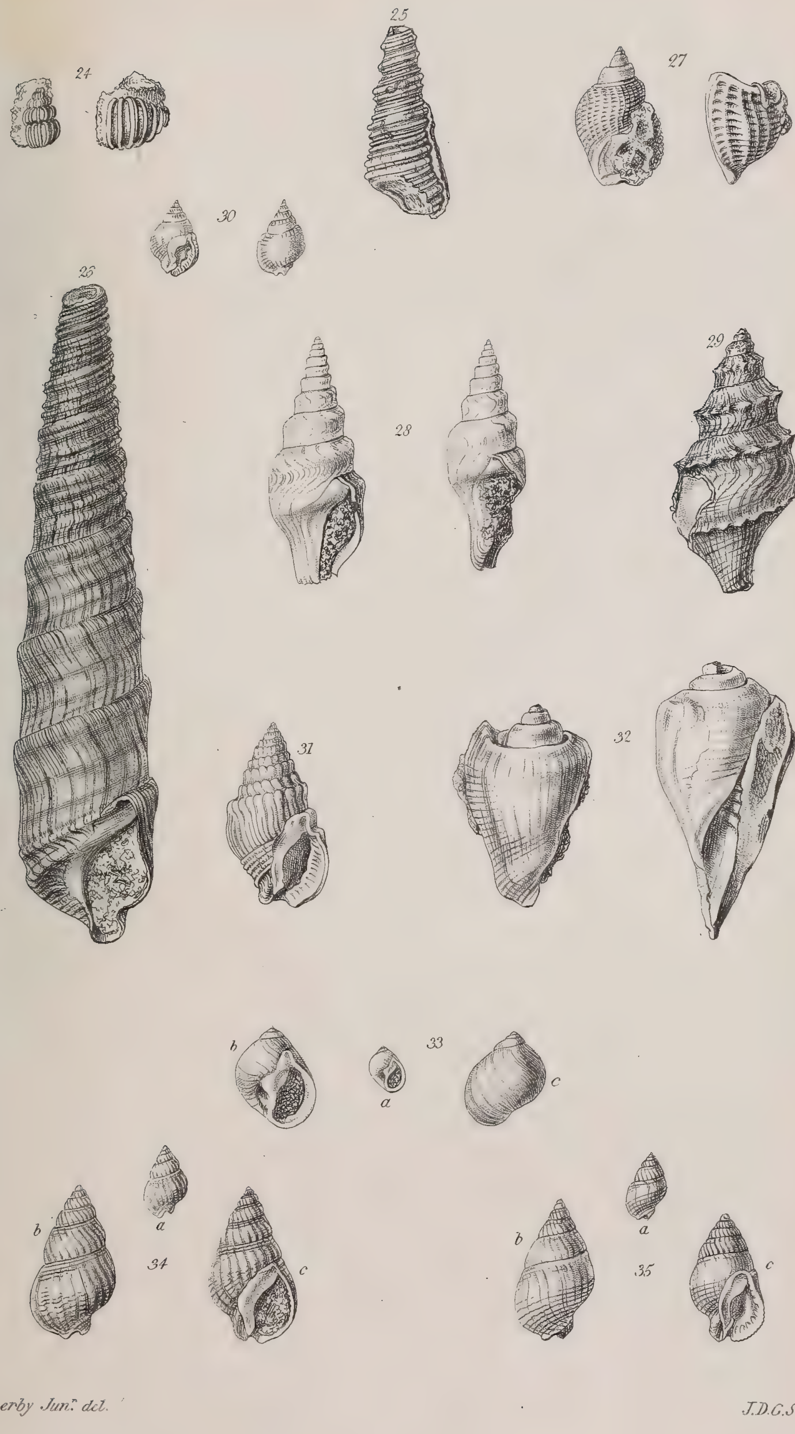


Fig: 23.

G. B. Sowerby Jun. r del. t

Hullmandel & Walton Lithographers



G.B. Sowerby Junr del.

J.D.C. Sowerby sc

The following letter from Mr. Sharpe has been received by Mr Smith since the above paper was read :—

"Adelphi Terrace, April 5, 1847.

"MY DEAR SIR,

"In my last visit to Lisbon I found that the tertiary beds on the two sides of the Tagus corresponded less exactly than I had before supposed; and I came to the conclusion, that although the whole of the fossiliferous beds belong clearly to one formation, having many species of shells common throughout, yet that the beds on the north side of the river lie below the whole of those near Almada on the south bank.

"At the village of Poço do Bispo, a few miles above Lisbon on the north side of the Tagus, a bed of enormous oysters (*Ostrea gigantea?*) makes its appearance on the beach, from whence it may be traced, gradually receding from the river, to the back of Lisbon. This bed is nowhere to be seen on the south of the Tagus, where it could not have been overlooked: about twenty feet above the oysters lies a bed full of univalve shells, which also has not been seen on the south bank, and these beds are almost the uppermost on the north side. Therefore as the base of this formation is seen on the north of the river and the top of it on the south, we must add the two together to obtain the whole thickness of the formation, which must be much greater than I represented it in the account of the geology of Lisbon, printed in our 'Transactions.'

"Believe me,
"Very truly yours,
"DANIEL SHARPE."

"*To J. Smith, Esq.*"

On Fossil Plants from the Coal Formation of CAPE BRETON. By C. J. F. BUNBURY, Esq., F.G.S.

SINCE Mr. Lyell gave, in his 'Travels in North America,' a catalogue of the fossil plants occurring in the coal formation of Nova Scotia, I have received, through the kindness of Richard Brown, Esq., a fine collection from the Sydney coal-field, Cape Breton, including many species which are not in Mr. Lyell's list, and some which appear to be altogether new. As this collection also enables me to illustrate more satisfactorily the structure of some species which have hitherto been incompletely described, I have thought it might be worth while to lay before the Society some account of it, together with a few remarks on the geographical distribution of these extinct plants.

1. NEUROPTERIS CORDATA, *Brongn.*

This appears to be the most common Fern in the Sydney coal-field: most of the slabs of shale which I have seen from that locality contain fragments of it. The leaflets almost always occur separately, very seldom attached to the stalk, and they vary to an extraordinary degree both in shape and size, so that this species might deserve the name of *heterophylla* quite as much as the plant to which it has been applied.

Dr. Lindley* and Prof. Goeppert have noticed the small, roundish leaflets which are commonly found scattered among those of the more normal form of this species; but neither of them appears to have actually seen the relative position and connexion of the two kinds of leaflets; and Goeppert seems uncertain whether they belong to the same plant. Some of Mr. Brown's Cape Breton specimens are the first in which I have seen the small, round or reniform leaflets attached to the base of the large and long ones, on each side, exactly in the same way as in the upper part of the frond of *Neuropteris heterophylla*. The large leaflets are not however constantly accompanied by the small round ones, for in another specimen we find one of them attached immediately to a stout stalk without any such appendage. Sometimes they are lobed near their base, a variation which may also be frequently observed in the upper pinnules of *N. heterophylla*. To that species indeed the *cordata* was probably very similar in the general form and composition of its frond, though so much superior to it in size.

In some of the Cape Breton specimens the surface of the leaflets is beset with small bodies, which have all the appearance of strong hairs, rather thinly scattered, originating apparently from the veins, and lying in various directions. These may be seen also on some of the specimens from Lebotwood, in the Society's museum, but they are not mentioned by any author that I know of. As the leaflets on which they occur do not differ in any other respect whatever from the rest, I do not suppose them to indicate a specific difference.

Appearances somewhat resembling fructification are visible on one of the specimens sent me by Mr. Brown, but I am inclined to think that they may have been produced by a disease of the parenchyma, or a parasitical fungus. They are small oval pits, with raised or thickened edges, and are placed mostly in groups, side by side, near the midrib; but they appear to me to be placed *between* the veins, not *on* them, and to be somewhat too irregular for spots of fructification.

2. Neuropteris cordata (var. *angustifolia*).

(N. angustifolia, *Brongn. Veg. Foss.* 231. t. 64. f. 3, 4.)

Agrees sufficiently well with Brongniart's figure and description, but I believe it to be merely a variety of *N. cordata*. The veins indeed are sometimes finer and closer than is usual in that species, but in other specimens, with very narrow leaflets, they are nearly as strong as in the ordinary state of the plant. The base of the leaflets varies very much in different specimens of the broad-leaved or normal form of *N. cordata*, and often is scarcely at all heart-shaped; not unfrequently also it is oblique. I have little doubt that *Neuropteris cordata, angustifolia, acutifolia,* and *Scheuchzeri* of Brongniart, are all of them forms of one species.

In the narrow-leaved variety, as well as in the other, the small round leaflets occur attached to the base of the larger, as is very well seen in one of the specimens from Cape Breton.

* Fossil Flora, vol. i. p. 120.

3. NEUROPTERIS INGENS? (*Foss. Fl.* t. 91. A.?)

Of this, I find in the collection only a part of a single leaflet, the extremity being broken off; the fragment is $2\frac{1}{2}$ inches long and 2 inches broad. It appears to have been of a much thinner and more flexible and membranous texture than *N. cordata,* for it is much and irregularly wrinkled and puckered, like the *Cyclopteris oblata* of the 'Fossil Flora.' It differs moreover from *N. cordata* in its more elliptical outline, the greatest breadth being not at the base, but nearer to the middle.

4. NEUROPTERIS FLEXUOSA.

The specimens agree well with those brought by Mr. Lyell from the anthracite mines of Pottsville, Pennsylvania, and with one from Somersetshire in the museum of the Geological Society. One of them is a small-leaved variety, (of which I have also seen specimens from Pottsville,) the leaflets not exceeding $\frac{3}{10}$ths of an inch in length; whereas in the ordinary state of the plant their length is from $\frac{6}{10}$ths to $\frac{8}{10}$ths of an inch. In another of the Cape Breton specimens, the leaflets, instead of overlapping, do not even touch one another at the edges, and so far it agrees with the distinctive character assigned to *N. gigantea*; but in everything else it corresponds entirely with *flexuosa*. The Pottsville specimens vary in the same way. Although M. Brongniart lays much stress on this character, I believe it is not to be relied on.

5. NEUROPTERIS GIGANTEA, *var.*

A single pinna of a frond, in a beautiful state of preservation, and exactly intermediate in character between *N. gigantea* and *flexuosa*. The shape of the leaflets is the same as in the latter species, but they equal in size the largest of those of *N. gigantea*; they are contiguous for the most part, but not imbricated, and the stalk is scarcely at all wavy. The whole pinna is about 7 inches long, with above 30 leaflets; the terminal one of the shape usual in *N. flexuosa*.

I have seen a specimen perfectly agreeing with this, from the Manchester coal-field, in the collection of Prof. Henslow.

I am much inclined to believe that *Neuropteris gigantea* and *flexuosa* are not specifically distinct; and probably *N. rotundifolia* might be added to them.

6. NEUROPTERIS RARINERVIS (n. sp.).

Spec. Char. N. fronde bipinnatâ, pinnulis contiguis obliquis oblongis apice rotundatis, basi obliquè subcordatis subauriculatis, margine subundulatis; terminali majore hastato-deltoideâ subtrilobatâ; venis remotis arcuatis bis furcatis.

I can find no description or figure agreeing with this plant, of which Mr. Brown has sent me very complete specimens, some of them above a foot long. In the general form of the frond and in the outline of the leaflets it so much resembles *N. flexuosa,* that on a hasty view it might easily be taken for that species, but it differs essentially in venation. The veins are farther apart than in any other *Neuropteris* that I know, and though arched in the manner characteristic of the genus, are scarcely ever more than twice forked; indeed, in many of the smaller leaflets, only once. Thus, in respect of its venation, this plant is really intermediate between the genera *Neuropteris* and *Pecopteris*; but its habit is altogether that of a *Neuropteris*, and its leaflets are attached to the stalk in the manner characteristic of that genus.

The frond is bipinnate; the main stalk striated, and rather slender in proportion; the pinnæ partly opposite and partly alternate, narrow and almost linear in their general outline. Leaflets closely set, but not usually overlapping, oblong, rounded at the end, slightly waved at the edges, oblique and somewhat dilated at the base, where they are more or less auricled; they are convex, and appear to have been of a firm consistence; their surface smooth and shining. In length they vary from $\frac{1}{5}$ to $\frac{1}{2}$ inch, those of the lower pinnæ being in general the largest and of the most elongated figure. The veins are strong and prominent. Towards the top of the frond the leaflets run into one another, so that the pinnæ become merely sinuated, and a few of the uppermost of all are completely undivided.

Of the species of *Neuropteris* hitherto described, the one that comes nearest to this is the *N. attenuata* of the 'Fossil Flora,' tab. 174. The veins in that Fern, though not noticed in the description, appear by the figure to resemble those of our plant; but there seems to be a sufficient difference in the terminal leaflet, which in ours is larger than the others, and somewhat halbert-shaped, whereas in the *N. attenuata* it is represented as smaller than those next to it. The present species is a larger plant altogether than the *attenuata* appears to be, and its leaflets do not diminish so remarkably in size towards the extremities of the pinnæ.

7. Neuropteris ——.

A small fragment, which appears different from any described species, but is insufficient for a satisfactory determination. It is a terminal leaflet, of an elongated lanceolate form, about $1\frac{3}{4}$ inch long, convex, and apparently of a thick and firm texture; the venation similar to that of *N. cordata*. It is not impossible that it may belong to one of the modifications of that most variable plant.

8. Cyclopteris obliqua? (*Ad. Brongn. Veg. Foss.* 221. t. 61. f. 3?)

A single specimen, very much resembling the British *C. obliqua*, but of a form more nearly circular; probably however only a variety.

9. Odontopteris Schlotheimii. (*Brongn. Veg. Foss.* p. 256. t. 78. f. 5.)

A single specimen, agreeing well with Brongniart's figure, except that the veins are disposed in a somewhat more radiating manner, and some of them appear to be more than once forked; they are less distinct in this specimen than in his figure.

The only locality, hitherto known, for *Od. Schlotheimii* was Mannebach in Germany, where it was discovered by M. Schlotheim.

10. Odontopteris subcuneata (n. sp.).

Spec. Char. O. pinnulis remotis suboppositis decurrentibus obliquè obovato-cuneatis subrecurvis apice rotundatis: terminali majore ovatâ; rachi latâ marginatâ; venis tenuissimis arcuatis dichotomis.

An imperfect specimen, but rather remarkable in its characters, and not agreeing with anything that I can find in books. It appears to be the extremity of a frond: the leaflets are rather distantly placed, opposite, nearly wedge-shaped, somewhat recurved, dilated and obliquely rounded off at the end, somewhat contracted towards the base, but not tapering into a petiole, decurrent along the stalk, which is flat, striated and bordered; the terminal leaflet is much broader, and seems to have been of a roundish-ovate form, but the end of it is broken off. The leaflets have no midrib; the veins are numerous and fine, repeatedly forked, and resemble those of a *Neuropteris*, except that they spring from the base of the leaflet or from the main stalk.

Different parts of the frond of the same Fern are often so unlike, that it may perhaps be rash to characterize a species from such a fragment as this; nevertheless, as it seems different from anything hitherto described, it is convenient to give it a name. *Odontopteris obtusa**, which comes nearest to it, has the leaflets much more crowded, not at all recurved, nor contracted towards the base.

11. Dictyopteris obliqua (n. sp.).

Spec. Char. D. pinnulis oblongis obtusissimis subfalcatis, basi obliquè subcordatis; costâ tenuissimâ evanidâ; venis prominulis.

This is the Fern with reticulated veins, mentioned in Mr. Lyell's 'Travels in North America†' as the type of a new genus, bearing the same relation to the *Lonchopteris* of Brongniart, as *Neuropteris* to *Pecopteris*. I have not access to Gutbier's work, in which, as it appears, the genus *Dictyopteris* was established, but from the brief character of that genus given in Unger's 'Synopsis' (p. 58), it would seem that our plant must belong to it. Possibly it may even be identical with the one species there noticed (*D. Brongniartii*, Gutb.), but as I have seen neither description nor figure of that plant, I am obliged to describe the one before us as new. This appears to be not very uncommon in the Sydney coal-field; but I have seen nothing like it from other parts of America, nor in the European collections to which I have had access.

The leaflets, in all the specimens I have seen, occur detached, so as to give no idea of the general form of the frond. They are oblong, from half an inch to nearly an inch in length, very obtuse, slightly convex, usually more or less curved, and sometimes in a remarkable degree; at the base they are oblique and slightly cordate, and evidently were attached to the stalk at one point only, as in *Neuropteris*. The midrib is very faint, often obsolete, and always vanishing far below the extremity of the leaflet; the lateral veins prominent and strongly

* Brongn. Veg. Foss. 255. t. 78. f. 4.

† Vol. ii. p. 202.

marked, forming a regular and beautiful network with small meshes which are longest and narrowest near the middle of the leaflet becoming shorter and rounder towards the margins.

The *Lonchopteris* of Brongniart, and *Woodwardites* of Goeppert, differ from this in having their leaflets confluent at the base, and in the presence of a strong midrib which reaches to the point of each leaflet or lobe.

12. PECOPTERIS LONGIFOLIA? (*Brongn. Veg. Foss.* 273. t. 83. f. 2?)

I think that the specimens from Cape Breton (which however are very imperfect) belong rather to this species than to its near ally the *P. emarginata* (*Diplazites emarginatus*, Goepp.), although in some instances the lower secondary veins appear to anastomose, as in the latter; more commonly they run directly to the margin, and both appearances are observable in the very same leaflet. This plant has narrower leaflets than the *P. emarginata* from Frostburg, (which I described in a paper read before the Society last December,) and they are also less convex, and apparently of a thinner substance. I do not feel at all sure however that it is a distinct species. There is no appearance of fructification.

13. PECOPTERIS TÆNIOPTEROIDES (n. sp.).

Spec. Char. P. pinnulis alternis confertis subcontiguis sessilibus oblongo-ligulatis planis integerrimis, apice rotundatis; costâ validâ sub apicem evanescente; venis crebris parallelis subperpendicularibus bis furcatis.

A small fragment, not sufficient to establish satisfactorily the affinities of the plant, but yet so evidently different from all the species described by Brongniart and by Goeppert, and exhibiting its venation so perfectly, that I have thought it worth describing. It occurs in company with *Asterophyllites equisetiformis*. There is nothing to show whether the frond was once or twice pinnated. The portion that remains of the stalk is slender, but of a very rigid appearance, nearly straight, somewhat angular, and quite smooth. Leaflets alternate, pretty closely set, broadly strap-shaped, flat, from $\frac{3}{5}$ths to $\frac{4}{5}$ths of an inch in length, and rather more than $\frac{1}{5}$th of an inch broad, rounded at the end, very entire at the edges, which appear to be slightly thickened; they are scarcely decurrent or dilated at the base. Midrib remarkably thick, but not reaching quite to the extremity. Veins strong, very numerous, close and parallel (resembling those of a *Tæniopteris*), nearly at right angles to the midrib, straight or very slightly curved; they are generally divided at the base or near it into two branches, and either one or both of these again forked above the middle.

This well-marked Fern appears to be referable to Brongniart's first section (*Pteroides*) of *Pecopteris*, which constitutes the genus *Alethopteris* of Sternberg; at least it has the venation, if not entirely the habit of that group. Among recent plants it bears a general resemblance to several species of *Blechnum* and *Lomaria* as well as of *Pteris*; and, as well as one can conjecture without a knowledge of the fructification, it may have belonged to any one of those genera.

14. Pecopteris nervosa, *Brongn.*

Agrees exactly with British specimens, and pretty well with the figure in Lindley and Hutton's 'Fossil Flora,' t. 94.

15. Pecopteris plumosa, *Brongn.*

Differs slightly from Brongniart's figures, the segments of the pinnatifid pinnæ being more obtuse, more strictly linear, and placed more perpendicularly with respect to the stalk.

The same plant, precisely, was obtained by Mr. Lyell from Pomeroy, Ohio.

16. Pecopteris abbreviata, *Brongn.*

Seemingly a very common plant in the Sydney coal-field; agrees entirely with Brongniart's description and figures.

There are also, among Mr. Brown's specimens, some which seem to belong to a variety of this with more distantly-set leaflets.

17. Pecopteris polymorpha? (*Brongn. Veg. Foss.*)

One of the specimens from Cape Breton I am inclined to refer to this species rather than to *P. abbreviata,* because, 1st, the leaflets are more convex than in the latter, and apparently of a thicker and more coriaceous texture; 2ndly, most of them are quite entire on the edges, a few of the lowermost only being slightly sinuated; 3rdly, the lateral veins, though not very distinct, appear to be twice forked, and not pinnated as in *P. abbreviata.*

18. Pecopteris Cyathea, *Brongn.*?

A few fragments, scarcely admitting of a satisfactory determination, but apparently belonging to this or to some closely-allied species.

19. Sphenopteris obtusiloba? (*Brongn. Veg. Foss.* t. 53. f. 2?)

Fragments, much resembling the figure above quoted, but with the lobes less deeply separated, the surface of the leaves apparently more convex, and the veins fainter. They have a considerable likeness also to the *Sphen. latifolia* of the 'Fossil Flora,' t. 156, which seems to be different from Brongniart's plant of the same name. I have a specimen almost precisely similar from Oldham in Lancashire.

20. Sphenopteris ——.

A small fragment of a very delicate and pretty little Fern, allied to *S. distans,* but too incomplete to be positively determined.

21. Sphenopteris artemisiæfolia? (*Brongn. Veg. Foss.* t. 46 & 47?)

Apparently referable to this species, or merely a variety of it. The secondary divisions of the frond are less wedge-shaped than in Brongniart's figures, more approaching to a linear form, and much more regularly cut or lobed, indeed almost pinnatifid.

22. Sphenophyllum Schlotheimii. (*Lindl. & Hutt. Foss. Fl.* vol. i. t. 27.)

Agrees exactly with the figure and description in the 'Fossil Flora,' and with the British specimens in the museum of this Society.

23. Sphenophyllum erosum. (*Lindl. & Hutt. Foss. Fl.* vol. i. t. 13?)

I am not quite certain that this is the *Sph. erosum* of Lindley and Hutton, but it perfectly agrees with British specimens so named (from Staffordshire and Pembrokeshire) in the Society's collection. It is observable, that in this species the veins constantly terminate in the teeth of the leaves, whereas in the preceding they uniformly end in the sinuses *between* the teeth. The leaves of our *Sph. erosum* are always sharply toothed, and more or less deeply, according to their situation on the stem: the upper leaves have very short teeth; those lower down are more deeply, and in a manner doubly, toothed, the alternate sinuses being deeper; lower still, the leaves are divided more than half-way down, and sometimes almost to their base, into two or more segments, each of which is deeply toothed. These latter leaves, when they occur separately, might easily be supposed to belong to a distinct species.

24. Lepidodendron elegans. (*Brongn. Veg. Foss.* vol. ii. t. 14. *Lindl. & Hutt. Foss. Fl.* vol. ii. t. 118.)

Seemingly a very common plant in the Sydney coal-field. The specimens sent from thence agree entirely with those collected by Mr. Lyell in Alabama. The areoles are in general rather narrower and more elongated than is usual in the Northumberland specimens, or than they are represented in the figures referred to; but this is evidently a variable character.

25. Lepidodendron gracile? (*Brongn. Veg. Foss.* vol. ii. t. 15? *Lindl. & Hutt. Foss. Fl.* vol. i. t. 9.)

There are some specimens among those sent by Mr. Brown from Cape Breton, and others procured by Mr. Lyell from the same country, which seem to agree with the figures of this supposed species, above-quoted; but I can find no characters whereby to distinguish it from *L. elegans*. It seems to be merely a small variety or a young state of that plant.

26. Lepidodendron ——.

An impression, in sandstone, of a large Lepidodendron with much-elongated contiguous areoles of a nearly lanceolate form, tapering to a long narrow point at each end, about 2 inches long, and scarcely more than $\frac{3}{10}$ths of an inch broad; their margins slightly raised and thickened; a very conspicuous ridge running the whole length of each areole. The leaf-scars are nearly obliterated.

27. Lepidodendron undulatum??

A very indistinct impression in a coarse sandstone.

28. LEPIDODENDRON ——.

In the most perfect specimen that I have seen of this plant, the areoles are of a remarkably narrow and elongated rhomboidal form, their greatest breadth being little more than $\frac{1}{10}$th of their length; the leaf-scars, which are situated a little above the middle of each areole, nearly resemble in shape those of *L. aculeatum*, but are very small. The most remarkable peculiarity consists in the spaces between the areoles being raised into broad, acute, interrupted, longitudinal ridges, which (as the specimen is an impression) must represent clefts or indentations in the original surface of the stem. These elevations are arranged like the areoles themselves, in spiral rows, but with rather less regularity. In another specimen, probably more advanced in age, the boundaries of the areolæ are nearly effaced, the leaf-scars are indistinct, and the ridges between them are more irregular both in form and situation. In a third the irregularity of the ridges is much greater yet, the areolæ are completely obliterated, but the leaf-scars are still distinguishable. I think that these differences are owing merely to age. The ridges, which give such a peculiar appearance to these impressions, are perhaps only casts of cracks in the bark, but their regularity in the first specimen is very remarkable.

29. LEPIDODENDRON? BINERVE (n. sp.).

This has so striking a resemblance at first sight to the *Lycopodites Williamsoni* of the 'Fossil Flora,' that if it occurred in a corresponding geological formation, one might readily take it for that plant. The two specimens sent me by Mr. Brown are small leafy branches, about 3 inches long, repeatedly and regularly dichotomous: the areoles are indistinct, (as is apt to be the case also on the young leafy branches of *L. elegans*,) and I cannot make out any scars of insertion. The leaves are rather thickly placed on all sides of the branch, and in some degree imbricated, much shorter and broader than in *L. elegans*, lanceolate, very acute, strongly curved inwards at the points; and, what particularly distinguishes them from the leaves of other *Lepidodendra* with which I am acquainted, they are marked with *two* longitudinal ribs, or rather striæ. One specimen has all its branches terminated by cones, which have very much the appearance (on a small scale) of the young cones of an *Araucaria*: the largest of these is about an inch long, of a broad oval figure, and appears to be composed of closely-imbricated triangular scales. The direction of the cones is nearly perpendicular to that of the branches on which they grow.

The general appearance of this plant very much resembles that of an *Araucaria*; and since the *Lycopodites Williamsoni*, which has likewise a dichotomous ramification, has been pronounced by Adolphe Brongniart to belong to the Coniferous tribe*, I do not know why this should not be referred to the same. It is however comprehended under the technical character of *Lepidodendron*.

* Hist. Veg. Foss. vol. ii. p. 68.

30. Lepidodendron? tumidum (n. sp.).

A large species, allied to *L. Ottonis* of Goeppert*, with remarkably large leaf-scars, which are of an unequally hexagonal form, transversely elongated, with the two lateral angles much extended, the two upper obtuse, and the lower rounded off. In the middle of each leaf-scar are two vascular points, placed close together, and often confluent, and two others above and outside of these. There are no distinctly limited areolæ as in the typical *Lepidodendra*, but the wide spaces between the leaf-scars are elevated, and as it were puffed up, and marked with numerous, rather irregular, wavy, longitudinal striæ. A well-marked furrow runs down some way, in a curved direction, from each of the lateral angles of every leaf-scar.

This is one of those ambiguous forms which would be referred by some to *Lepidodendron*, and by others to *Sigillaria*. It has some resemblance to *Sigillaria Brardii*, Brongn.†, but the leaf-scars in that plant seem to be much more closely placed, and seated on distinct and regular elevations (*mamelons*), which are separated by well-marked furrows crossing one another at acute angles, so as to give a tessellated appearance to the whole surface of the stem. To *Lepidodendron Ottonis*, Goepp., our plant approaches much more nearly, and seems to be distinguished from it chiefly by the much more distantly-placed leaf-scars, and by the intervals between them being more swollen and distinctly striated.

31. Lepidostrobus? trigonolepis (n. sp.).

I am in some doubt whether this is really a cone, or a young leafy shoot of some large and robust species of *Lepidodendron*; but at any rate it seems distinctly different from anything that I can find described. The most perfect specimen of it is about $2\frac{1}{4}$ inches long, rather thick in proportion to its length, nearly cylindrical, rounded at the end, and composed of closely-imbricated leaves or scales, which are of a broad triangular form, acute, slightly convex, apparently of a very rigid texture, and rather obscurely keeled. They seem to be attached to the axis by a very short claw.

32. Sigillaria elongata, *Brongn.*

A decorticated specimen, but apparently referable to this species.

33. Sigillaria reniformis, *Brongn.*

34. Sigillaria?

The genus of this is very doubtful. All the specimens are decorticated: they have at first sight much the appearance of the large broad-ribbed *Sigillariæ*, such as *reniformis*, but the vascular scars, instead of being arranged in single vertical rows between the furrows, are placed in a quincuncial order, or in spiral lines, like the scars of *Stigmaria*. The furrows, too, are not equidistant nor uniformly con-

* Syst. Fil. Foss. t. 42. f. 2, 3.
† Hist. Veg. Foss. vol. i. p. 430. t. 158. f. 4.

tinuous. The scars are simple, and of a linear form, like narrow slits. The decorticated surface of the stem is marked with very minute transverse undulations.

This fossil does not seem to be properly referable either to *Sigillaria*, *Stigmaria*, or *Lepidodendron*; but until perfect specimens, with the bark and its markings well-preserved, shall be discovered, it would be a vain attempt to determine its proper place in the system. I have a precisely similar specimen from Oldham in Lancashire.

35. STIGMARIA FICOIDES.

The specimens show no internal structure, but agree entirely in their external markings with some of the varieties found in English coal-mines. It may be remarked, that the variations observable in different specimens of this common *Stigmaria* are very numerous, yet slight, and scarcely admitting of precise definition; a circumstance rather favourable to the hypothesis that these fossils are merely the roots of *Sigillariæ*.

36. CALAMITES APPROXIMATUS. (*Brongn. Veg. Foss.* vol. i. p. 133. t. 24.)

Agrees most accurately with Brongniart's description and figures, especially figs. 1 & 3. The length of the internodes varies in the same specimen from $\frac{1}{5}$th to $\frac{6}{10}$ths of an inch.

37. CALAMITES RAMOSUS. (*Artis, Antedil. Phyt.* t. 2.)

Agrees with Artis's figure, which M. Brongniart has copied; but it is an ill-defined species, for the scars of branches at the joints are by no means peculiar to it, and it seems to have no other discriminating character.

38. CALAMITES SUCKOWII?

Probably a variety of *C. Suckowii*, although the bark is thicker than it is said to be in that species. The decorticated surface, like that of *C. undulatus*, presents the appearance of a cellular structure, with nearly square cells.

39. ASTEROPHYLLITES FOLIOSA. (*Lindl. & Hutt. Foss. Fl.* vol. i. t. 25.)

Agrees with British specimens. The branches are thicker than they are represented in the 'Fossil Flora;' the main stem is very thick, and appears to have been of a soft and succulent nature, being much crumpled and distorted, and in some places torn into long shreds. It is distinctly but not very regularly furrowed.

May not this species, at least, of *Asterophyllites* have been nearly allied to the *Calamites*,—perhaps a herbaceous form of the same tribe?

40. ASTEROPHYLLITES EQUISETIFORMIS. (*Lindl. & Hutt. Foss. Fl.* vol. ii. t. 124.)

Agrees well with Lindley and Hutton's plate, especially with fig. 3. The leaves are from $\frac{1}{2}$ inch to $1\frac{1}{2}$ inch long, and vary, in the same whorl, from a decidedly rounded termination to a very acute one. The plant appears to have been of a much more firm and rigid consistence than *A. foliosa.*

41. ASTEROPHYLLITES ——.

A small species, somewhat resembling *A. galioides* (Foss. Fl. t. 25. f. 2), but the leaves are much broader, very obtuse, and almost wedge-shaped.

42. BECHERA GRANDIS, *var.* (*B. tenuis,* C. B. in Silliman's Journal.)

So very similar to the *B. grandis* from Colebrook Dale (Foss. Fl. vol. iii. t. 173), that I can find no difference between them except in size, and I think they can hardly be considered as distinct species. The specimens from Cape Breton agree perfectly with those collected by Mr. Lyell in Alabama.

43. PINNULARIA CAPILLACEA. (*Lindl. & Hutt. Foss. Fl.* vol. ii. t. 111.)

Apparently identical with Lindley and Hutton's plant.

(Vegetable remains, which appear to have been the roots of aquatic plants, are frequent in the coal-shale in this collection; some of them resembling that which is figured in the 'Fossil Flora,' t. 110; others larger and thicker, but evidently of a soft and succulent nature.)

I find in Mr. Lyell's collection the following species from the same coal-field, in addition to those sent me by Mr. Brown:—

44. PECOPTERIS SERLII, *Brongn.*

Not distinguishable from small specimens of the Somersetshire plant.

45. CYCLOPTERIS.

Different from the *Cyclopteris* previously mentioned (No. 8 of this list); perhaps *C. dilatata,* but the specimen is not perfect enough to be determined with certainty.

46. SIGILLARIA ORGANUM. (*Lindl. & Hutt. Foss. Fl.* vol. i. t. 70.)

47. SIGILLARIA SAULLII. (*Brongn. Veg. Foss.* vol. i. 456. t. 151.)

Agrees sufficiently well with Brongniart's description and figure, but it seems to have been part of an aged stem, and the markings are rather obscure. The species was first found at Oldham, Lancashire.

48. ASTEROPHYLLITES TUBERCULATA?

According to Mr. Binney*, this is different from *A. tuberculata,* but identical with an undescribed species found near Manchester.

What at first appears most striking in the fossil vegetation of the Cape Breton coal-field is (as Mr. Lyell has already remarked) its very close agreement with that of the same period in Europe. Of about 37 species or varieties contained in the foregoing list, which

* See Lyell's Travels in North America, vol. ii. p. 198.

are sufficiently well preserved to be determined with tolerable certainty, 22 appear to be identical with British coal-plants; 4 or 5 may be considered as varieties of British types; 2 appear to be identical with European species, not yet discovered in Britain; 8 only are, as far as I yet know, peculiar to North America. It is also to be observed, that the most common plants, and those which more particularly give its character to this Flora,—*Neuropteris cordata, N. flexuosa, Pecopteris abbreviata, Lepidodendron elegans,*—are all of them English. Now, although it is certain that very many of the recent plants growing in North America, about the latitude of Nova Scotia, are identical with species of the north of Europe, yet I do not believe that, on comparing the whole recent Flora of Cape Breton with that of any part of Europe, we should find nearly so great an amount of agreement as this. But the case becomes much more remarkable, when we find very nearly the same assemblage of fossil plants extending through the coal-fields of the United States nearly to their southern extremity. In the anthracite region of Pennsylvania, Mr. Lyell collected the following species, undistinguishable from those well-known in Britain:—*Neuropteris cordata*; *N. cordata*, var. *angustifolia*; *N. flexuosa*; *Pecopteris Cyathea*; *Pecopteris abbreviata*; *P. pteroides*; *Sphenophyllum Schlotheimii*; *Lepidodendron obovatum*; *L. aculeatum*?; *Pinnularia capillacea*. In fact, *all* the species obtained, in a satisfactory condition, from the anthracitic coal-field of Pennsylvania, appear to be British.

The following British species were procured by Mr. Lyell from Frostburg in Maryland:—*Neuropteris cordata*; *N. gigantea* (an intermediate form between *gigantea* and *flexuosa*, nearly agreeing with a specimen from Manchester); *Pecopteris arborescens*; *P. abbreviata*; *Lepidodendron aculeatum*; *L. tetragonum**?; *Sigillaria reniformis*; *Calamites nodosus*; *Asterophyllites foliosa*; *A. tuberculata*; *Asterophyllites* (undescribed, but found in the Manchester coal-field according to Mr. Binney).

The following are from the Ohio coal-field:—*Neuropteris cordata*; *Pecopteris arborescens*; *P. plumosa*; *Lepidodendron obovatum*; *L. aculeatum*; *L. Sternbergii*; *Sigillaria tessellata*; *S. Murchisoni*; *Calamites approximatus*; *C. Suckowii*; *Asterophyllites foliosa*.

Thus it appears that, of all the fossil plants which have hitherto been procured from the carboniferous deposits of these regions, a great majority are undistinguishable from British species; whereas, it is well known that the recent vegetation of Pennsylvania, Maryland and Ohio is altogether of a different type from that of Europe.

From the coal-field of Indiana, Mr. Lyell brought in his last tour *Neuropteris cordata, Cyclopteris obliqua,* and *Lepidodendron obovatum.* Even in Alabama, in lat. 33° 10′ N., he found that the prevailing fossil plants were either identical with those of the European coal-formation, or but slightly different; and two at least are common to Alabama and Cape Breton, namely *Lepidodendron elegans* and *Bechera grandis*, var. *tenuis*.

* Whether this be the true *L. tetragonum* or not, it accords with British specimens.

In all these comparative statements I omit the *Stigmaria ficoides*, because it is very doubtful whether it can be considered as a *species*, in any proper sense of the word; and if it really be, as there seems great reason to believe, merely the *root* of one or more kinds of *Sigillaria*, it is evidently unavailable for such comparisons.

Among the fossil plants of the coal-formation, the Ferns alone can be referred with certainty to their proper place in the system of the vegetable world, and approach near enough to existing types to admit of satisfactory comparison. It may therefore be worth while to pay some attention to the geographical distribution of recent Ferns.

Looking, in the first place, to Europe, we find much less difference between the Ferns of the northern and those of the southern parts of this continent, than if we compare the flowering plants of those regions. Thus, of 42 Ferns found in Northern Italy*, 8 only are strangers to Britain. Iceland, according to Sir William Hooker, has 14 Ferns, all of which are found in England, and all but one in Italy. Of 26 Ferns enumerated as natives of Greece†, 21 are British, and 8 common to Greece and Iceland. Even beyond the limits of Europe we find many of the plants of this tribe, which are most familiar to us at home, reappearing in the islands of the Atlantic, almost on the verge of the tropics. One-third of the Ferns of Madeira‡ (12 species out of 36) are British. Two species (*Polypodium vulgare* and *Cystopteris fragilis*) are common to Madeira and Iceland,—a greater range in latitude than any fossil Fern has yet been ascertained to possess. In the Azores,—less removed from us indeed in latitude, but separated by a wide expanse of ocean,—the proportion of identical species is much greater; more than half the Ferns of the Azores§ (16 out of 28) being natives of Britain.

When we cross the Atlantic, indeed, a greater amount of difference is found in this tribe of plants. Out of 69 Ferns of North America, enumerated by Pursh, only 13 are considered by him as identical with European species, and in some of these cases the identity is very doubtful. Those which are really common to the two continents belong chiefly to the northern parts of America, and among them are most of those which, in Europe, have the widest range, and are most indifferent to temperature and exposure.

It is probable that the great difference in this part of the Floras of Europe and North America may be owing not merely to the breadth of sea between them, but perhaps more to the difference of their climates, that of Europe having comparatively an *insular*, and that of America an *extreme* character. If the United States had a climate resembling that of the west of Europe, it is probable that a much larger proportion of Ferns would be common to the two continents.

Within the tropics, many plants of this tribe have very extensive ranges both in latitude and longitude. I have not the means of drawing up full comparative statements of these, but it is certain that

* Pollini, Flora Veronensis.
† Smith and Sibthorp, Prodromus Fl. Græcæ.
‡ Höll and Lowe, in Hooker's Journal of Botany, vol. i.
§ Watson, in Hook. Lond. Journ. Bot., vol. iii.

a large number of the Ferns of the West Indies extend into Brazil, and as far south as Rio de Janeiro; and the details already published by Sir W. Hooker, in the first volume of his 'Species Filicum,' sufficiently prove that the number of Ferns common to the tropical regions of the old and new worlds is much greater than had been generally supposed.

We may, I think, conclude, that the wide diffusion of the same forms of vegetation through the ancient carboniferous deposits of Europe and America is less extraordinary than it would appear if we neglected to observe the large proportion of Ferns in this ancient vegetation, and their distribution at the present day. If the *Lepidodendra* really belonged to the *Lycopodium* tribe, and were analogous in their constitution to the recent forms of that order, the same conclusions may be extended to them; for a great number of the recent *Lycopodia* are plants very extensively spread over the globe. On this point I need only refer to the valuable observations of Dr. Hooker, in his 'Flora Antarctica.'

Still, it must be admitted, that the uniformity of this ancient vegetation over so large an area,—extending from Scotland to Alabama in latitude, and in longitude from Bohemia to the Ohio,—is greater than can be found at the present day; and I quite agree with Mr. Lyell in believing that this indicates a greater uniformity and equability of climate, depending probably on a different distribution of land and sea. I believe we are fully justified by analogy in saying, that if such continents as Europe and North America had not existed at that period, but in their stead groups of islands, large and small, and if the ocean which now intervenes between the two continents had been thickly studded with such groups, like the Southern Pacific at present, there would have been nothing unnatural or surprising in such a uniformity of vegetation throughout those regions, as we now meet with in the coal-formation. But I suggest this merely as a hypothesis, which, if admitted, would serve to explain a remarkable fact, and I do not wish to build much upon it; being aware, as I observed on a former occasion, of the danger of resting a large theory on such uncertain foundations as are supplied by fossil botany, at least in the present state of our knowledge.

November 1846. C. J. F. BUNBURY.

EXPLANATION OF THE PLATES.

PLATE XXI.

Fig. 1 A. *Neuropteris cordata*, natural size, exhibiting the position of the small basal leaflets relatively to the large one.

1 B. *Neuropteris cordata*, var. *angustifolia*, natural size, with the basal leaflets.

1 C. *N. cordata*, natural size, with apparent hairs on its surface.

1 D. Part of the same, magnified.

1 E. Another specimen of the same, with appearances somewhat resembling fructification.

1 F. Part of the above specimen, magnified.

Fig. 2 A. *Dictyopteris obliqua*, natural size.
2 B. A leaflet of the same, magnified.

Plate XXII.

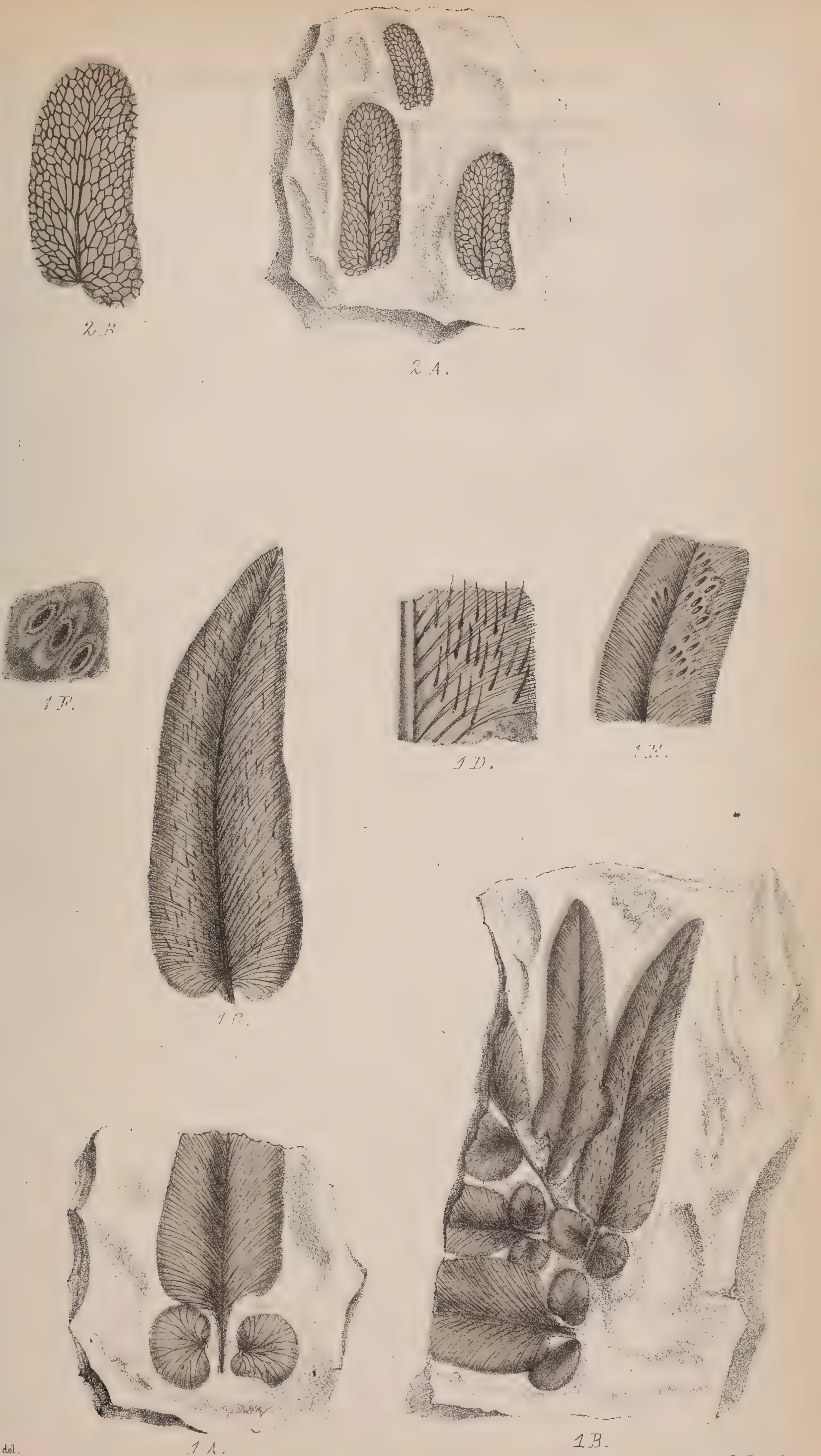
Fig. 1 A. *Neuropteris rarinervis*, natural size.
1 B. Leaflets of the same, magnified.

Plate XXIII.

Fig. 1 A. *Odontopteris subcuneata*, natural size,
1 B. A leaflet of the same, magnified.
2 A. *Pecopteris tæniopteroides*, natural size.
2 B. Part of the same, magnified.
3 A. *Sphenophyllum erosum*, natural size.
3 B. A leaf of the same, magnified.

Plate XXIV.

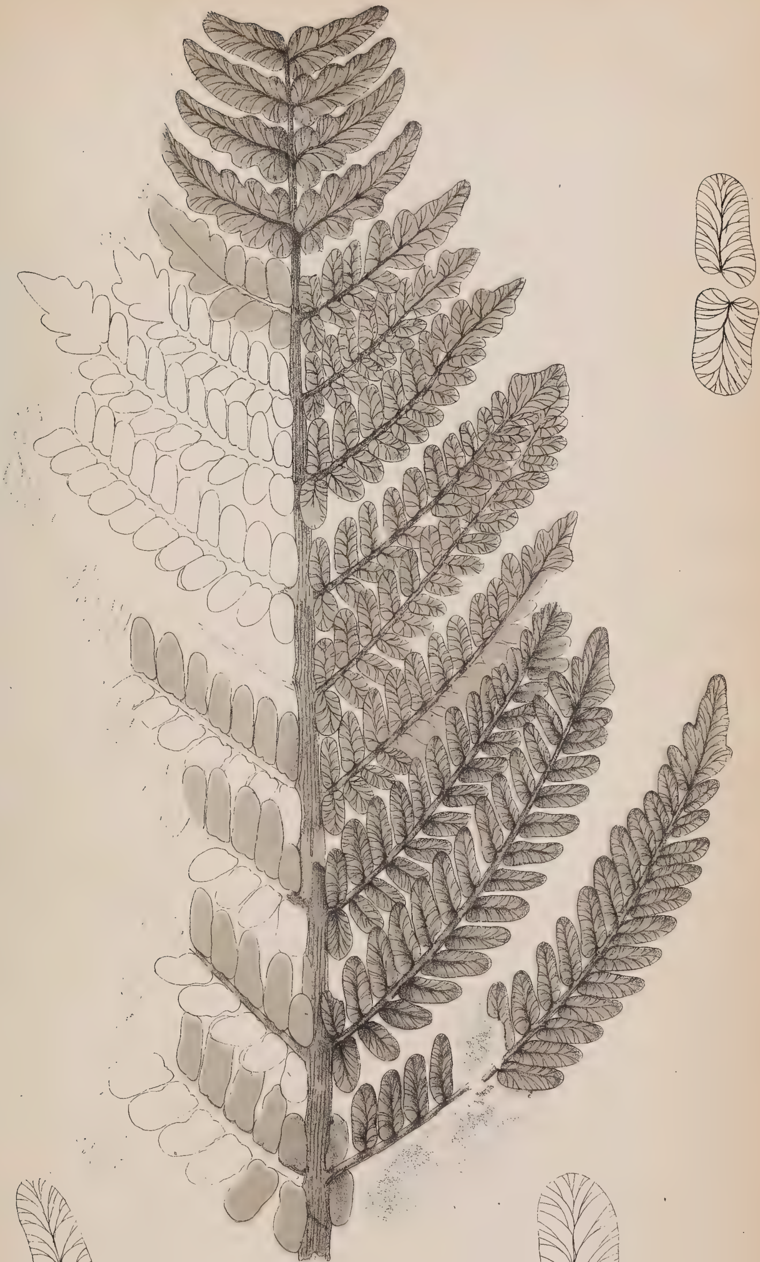
Fig. 1. *Lepidodendron ? tumidum*, natural size.
2 A. *Lepidodendron binerve*, natural size.
2 B. Another specimen of the same, with young cones, natural size.
2 C. Leaves of the same, magnified.



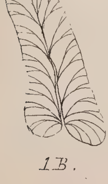
F. Bunbury, del.

on stone by Reeve, Brothers.

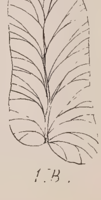
1. Neuropteris cordata. 2. Dictyopteris obliqua.



1.A.



1.B.

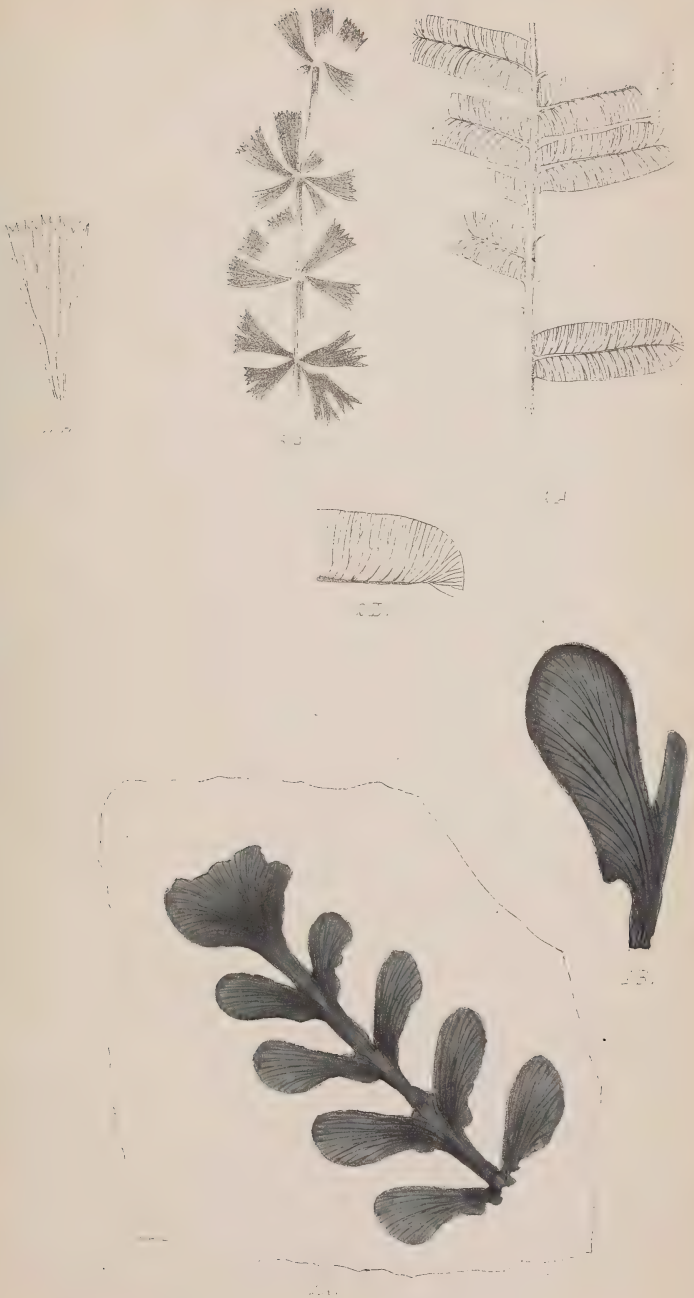


1.B.

Neuropteris rarinervis.

...Bunbury, del.

on stone by Reeve, Brothers.

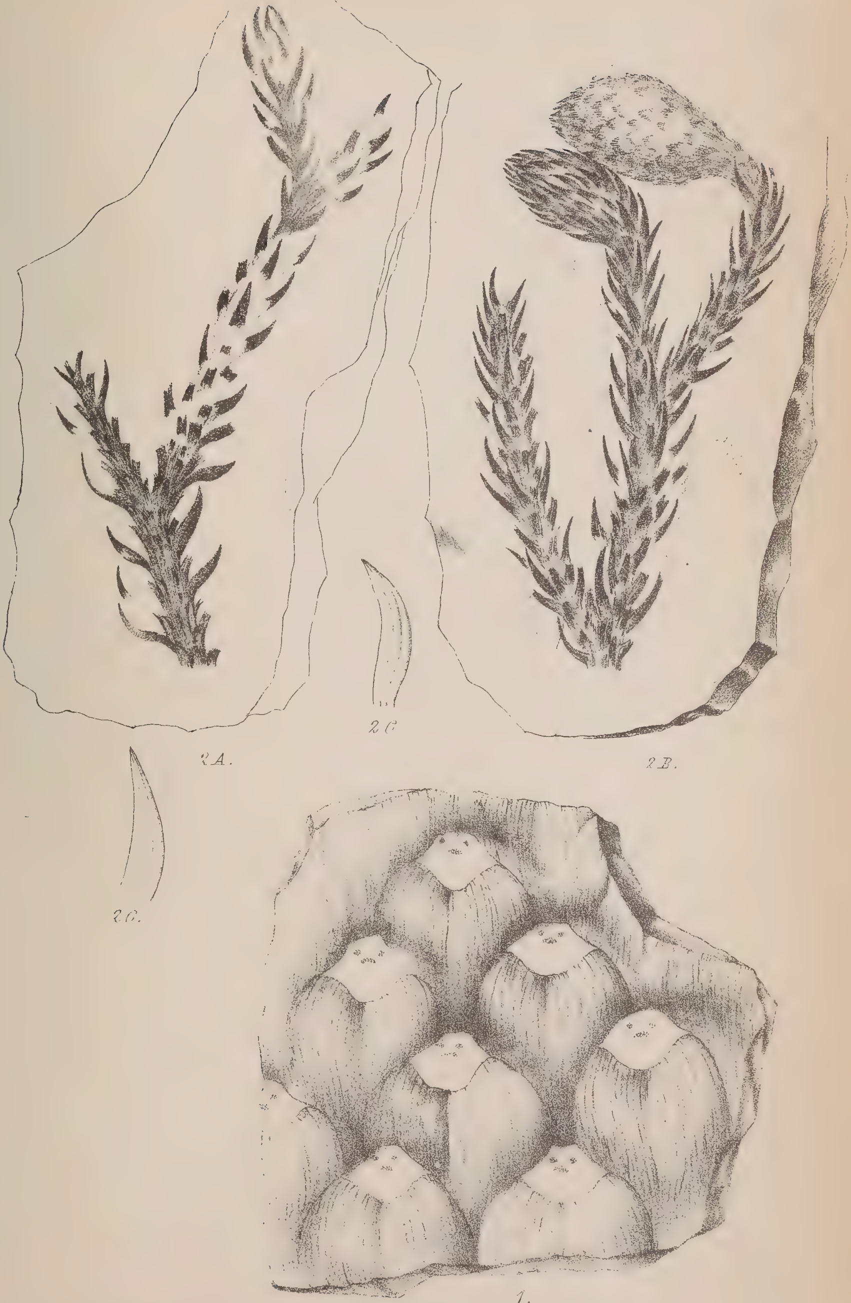


pteris subcuneata 2. Pecopteris tæniopteroides.

3. Sphenophyllum erosum.

Bunbury, del.

on stone by Reeve, Brothers.



1. Lepidodendron tumidum. 2. Lepidodendron binerve.

J. F. Bunbury, del.

on stone by Reeve, Brothers

DONATIONS

TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

April 1st to June 30th, 1847.

I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

Agricultural Magazine, April and May.

American Academy of Arts and Sciences, Proceedings, May to December 1846.

——— Journal of Science. 2nd Series, Vol. ii. No. 6; Vol. iii. Nos. 7, 8 and 9.

——— Philosophical Society, Transactions. New Series, Vol. ix. part 3.—Proceedings. Vol. iv. Nos. 34 and 35.

——— Quarterly Journal of Agriculture. Vol. iv. No. 2.

Asiatic Society (Royal), Journal. Vol. x. part 2.

Athenæum Journal, April to June.

British Association, Report of the Sixteenth Meeting, held at Southampton in September 1846.

British Museum, List of the Osteological Specimens, 1847.

Chemical Society, Memoirs and Proceedings. Part 20.

Cornwall Polytechnic Society (Royal), Annual Report, 1846.

Dublin Geological Society Proceedings. Vol. ii. parts 1–5; Vol. iii. part 1. Nos. 1–4; Vol. iii. part 2. Nos. 1–3; Vol. iii. part 3. Nos. 1 and 2.

France, Société Géologique de Mémoires. Deux. Série, Tome ii. partie 1.—Bulletin. Deux. Série, Tome iv. feuilles 1–7.

Geographical Society (Royal), Journal. Vol. xvii. part 1.

London Geological Journal. No. 2.

Munich Academy (Royal), Abhandlungen. Vol. iv. part 3.

——— Bulletin. Nos. 6–77. 1846.

——— Almanach. 1847.

New York, Annals of the Lyceum of Natural History. Vol. iv. Nos. 6 and 7.

Paris, L'École des Mines, Annales des Mines. Trois. Série, Tome v. liv. 1; Tome vi. liv. 6, 1834; and Tome vii. liv. 1, 1835.

Philosophical Magazine. April—June. *From R. Taylor, Esq., F.G.S.*

Scarborough Philosophical Society. Seventeenth Annual Report.

Torino, Memorie della Reale Academia delle Scienze di. Serie seconda, Tomo i. to vi.

Vaudoise Société des Sciences, Bulletin. Nos. 14 and 15.

II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names in italics presented by Authors.

Austin, Thomas, and *Thomas Austin, jun.* Monograph on Recent and Fossil Crinoidea. No. 6.

Binney, E. W. On the Origin of Coal.

Boué, Ami. Esquisse Géologique de la Turquie d'Europe. With corrected Geological Map.

Coxworthy, F. The Potato Disease and Bad Ventilation.

——— On the Constitution of the Atmosphere.

Dana, J. D. On the Volcanos of the Moon.

——— Geological Results of the Earth's Contraction in consequence of Cooling.

——— Origin of the grand Outline Features of the Earth.

——— On Zoophytes. No. 3.

——— On the Origin of Continents.

De la Beche, Sir H. T., Lyon Playfair, M.D., and Warington Smyth. Report on Colliery Explosions.

D'Hombres-Firmas, Baron. Mémoire sur les Hippurites et les Sphérulites du Département du Gard.

Gesner, Abraham. New Brunswick, with Notes for Emigrants.

Grateloup, Dr. Conchyliologie Fossile des Terrains Tertiaires du Bassin de l'Adour. Tome i. Univalves, and Atlas.

Johnston, J. F. W. Lectures on Agricultural Chemistry and Geology. Second Edition.

Leymerie, A. Statistique Géologique et Minéralogique du Département de l'Aube. With Atlas.

Leymerie, A. Mémoire sur le Terrain à Nummulites des Corbières et de la Montagne Noire.

Lyell, Charles. Elementos de Geologia, Traducidos por *Joaquin Ezquerra del Bayo.*

Murchison, Sir R. I. A brief Review of the Classification of the Sedimentary Rocks of Cornwall.

Pilla, Leopold. Istoria del Tremuoto che ha devastato i paesi della costa Toscana il di 14 Agosto 1846.

Pomel, A. Quelques nouvelles Considérations sur la Paléontologie de l'Auvergne.

——— Mémoire pour servir à la Géologie Paléontologique des Terrains Tertiaires du Département de l'Allier.

——— Note sur quelques Phénomènes Géologiques de la Vallée de la Brems, près Saarlouis.

——— Note sur Gergovia, ses Basaltes, ses Calcaires et ses Fossiles.

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PART II. MISCELLANEOUS.

CONTENTS OF PART II.

Alphabetically arranged—the names of the Authors in capital letters.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL BOOKS AND MEMOIRS.

Sulla Costituzione Geologica dei Monti Pisani. Memoria del Prof. Cav. Paolo Savi. Pisa, Presso rocco Vannucchi, 1846 *.

The author of this work, well-known for the interesting observations which he has published on the geology of Tuscany, having recently had an opportunity of completing his examination of the secondary formations in the neighbourhood of Pisa, has now published the principal results of his inquiries, in the hope that they may assist in clearing up some of the points which have hitherto been subjects of controversy amongst Italian geologists. It is proposed in the following pages to give an analysis of his observations, and of the results at which he has arrived.

After a brief account of the physical features of the district, the highest point of which, called Croce ai Termini, is 1569 braccie (2824 feet) above the level of the sea, the author describes the rocks of which it consists, commencing with the most recent, in descending order. The tertiary formations are entirely wanting in the Pisan mountains. The secondary rocks contain, as is well known, but few fossil remains or vegetable impressions; so that it is difficult to apply to them the same subdivisions which characterize those of the North of Europe; the various strata are, therefore, distinguished by our author by names bearing reference either to the nature of the predominant rocks, or to the fossils contained in them.

Thus the secondary formations of Tuscany are divided into the following principal groups, in descending order:—

1. Macigno; marly argillaceous schists with subordinate limestones.
2. Dark grey limestone with flint, and fucoid marly limestone.

* On the Geological Structure of the Monti Pisani. By Prof. Paolo Savi, Pisa, 1846.

3. Light grey limestone with flint, and red ammonite limestone.
4. Limestone with bivalve and turriculated (univalve) fossils.
5. Verrucano.

The author then describes the first of these groups, consisting of Alberese limestone and arenaceous macigno, with which the argillaceous schists alternate. The Alberese does not occur in the mountains of Pisa, nor is the macigno there extensively developed; the absence of the former, generally abounding in fucoids, and sometimes containing nodules of flint and beds of nummulites, is probably owing to the absence of the upper portion of the macigno, on which it always rests. The strata of the macigno have undergone great disturbance and dislocation; they are generally of an ashy colour and of a compact grain. Under the macigno are the beds of argillaceous schist, the lowest of which again alternate with bands of limestone and macigno. This lower portion of the macigno being as yet but little known, the author describes the varieties of limestone in it, and the alternations of strata connecting them with it and with the schists.

In the valley of Filettole occurs the following section in descending order:—

1. Macigno in thick strata, interstratified with thin argillaceous schists of an olive-grey colour.
2. A thick bed of friable olive-grey schist.
3. Whitish limestone, compact and homogeneous.
4. Olive-grey schist.
5. Thick beds of grey limestone with a rough fracture, to which the author applies the term *calcaria screziata*, variegated or mottled limestone (*bigarré* of the French).

The following section occurring near Monte di Quiesa is given as an instance of the passage of the macigno into the underlying limestone:—

1. Macigno in thick beds.
2. Marly argillaceous schists of an olive-grey colour, dark and slightly veined.
3. Macigno.
4. A mass of schistose beds passing into galestro.
5. Band of variegated limestone.
6. Schistose galestro.
7. Variegated limestone containing nodules of flint.
8. Thick stratified mass of galestro, dark or liver-red, joining the variegated limestone, and gradually passing into grey limestone with extensive beds of flint.

After adducing other instances, the author shows "that the schists underlying the macigno are perfectly conformable with it, being imperceptibly connected with those beds which alternate with the beds of the macigno itself, and connect this formation with the various kinds of limestone which underlie it." (p. 14.)

The author then describes the variegated limestone (*calcaria screziata*); this is almost universally without flint, and fossil remains are, if not absolutely, at least almost invariably wanting; but in the interstratified beds of schist, good impressions of *Fucoides targioni* occur.

The author thence deduces the following conclusions :—

First, That the marls and schistose clay, often altered into galestro, certainly belong to the macigno formation, because—

1. They are always found in the lower portion of the bed.

2. There is a geological passage between them and the beds interstratified with the macigno.

3. They are always conformable to that rock.

4. The *Fucoides targioni* occurs amongst the beds of the variegated limestone, which is in the midst of them.

Secondly, That the variegated limestone is a partial and not an universal deposit, being in some places replaced by compact limestone ; and

Thirdly, That by means of these calcareous beds, the macigno formation is in many places connected with the underlying formation of dark grey limestone with flints.

In the succeeding chapter (II.) we have a minute description of the calcareous rocks underlying the schistose marls ; the upper portion of these beds can only be satisfactorily studied in the mountains beyond the Serchio, and they consist of numerous thin beds, varying considerably in colour. No organic remains, whether animal or vegetable, have been found in this portion of the formation. It is succeeded in descending order by dark grey limestones, divided into two groups, and below these again are many conformable beds, consisting of marly limestone, compact schists, and a rock closely resembling sandstone, alternating with each other. The schistose beds contain many fine impressions of Fuci of cretaceous character, viz. *F. targioni*, *F. æqualis*, and *F. recursus*. In the dark grey limestone fossils are very rare, but near the gorge of Baraglia the author found an Ammonite resembling *A. Bucklandi*.

The red limestone is the lowest member of this formation ; it is identical with that of Gerfalco and Donoratico (known to lapidaries by the name of Broccatello della Gherardesca) and with that of Massa di Sasso rosso in Garfagnana ; this is proved by the fossils which the author found, viz. many Entrochi and Ammonites, and a fine specimen, probably the alveolus of a Belemnite ; below this is a considerable mass of limestone, divided by the author into upper and lower groups.

The following are the results arrived at respecting the formations beyond the Serchio :—

"In the first place, that the stratified formations underlying the macigno, and the argillaceous marly schists of which the lower portion of it is composed, consist of—

"1. A thick series of strata of dark grey limestone with flint, which in some places assumes a white colour.

"2. A group of beds, some calcareous, others marly siliceous (cherty ?), others of pure flint, variegated, generally thin and undulating. This bed does not occur everywhere.

"3. A second series of beds of dark grey limestone with flint.

"4. A succession of strata of yellowish marly limestone and olive-yellow schists, containing impressions of fucoids.

"5. A series of strata of light grey limestone with flint, containing a few Ammonites; this formation losing the flints in the lower part, and acquiring colour, passes into—

"6. Red ammonite limestone rich in Entrochi, &c.

"7. A whitish limestone, the stratification of which is seldom seen, but in some places appears unconformable to the former beds; it contains a few bivalve and turriculated fossils.

"8. A stratified deposit of a dark ash-coloured limestone without flints, in which hitherto no fossils have been found, and which in many places passes gradually into the former.

"*Secondly*, That the foregoing series of beds, from the dark grey limestone with flints down to the red ammonite limestone inclusive, pass into one another, both by mineralogical and geological transition; and

"*Thirdly*, That the red ammonite limestone is visible in some localities and not in others; that in some places it occurs without any modifications, and then it rests on the white limestone without passing into it; whilst in other places it is altered, and then almost imperceptibly passes into the underlying limestone, containing bivalve and univalve fossils."

In the next chapter (Chap. III.) the author compares the rocks of the *Monti oltre Serchio* with those of the Monti Pisani, from which it appears that the latter consist of the same series of formations as the former, with the addition of the Verrucano not visible beyond the Serchio. This verrucano underlies the lowest calcareous deposit; it is a siliceo-talcose rock, sometimes resembling anagenite, sometimes talcose schists, and forms the lowest portions of all the stratified deposits of Tuscany, and is often altered into nodular stea-schist, or a kind of gneiss. In the limestone which rests on the Verrucano is the deposit of limestone without flint, in which are the celebrated quarries of statuary marble of Carrara and Seravezza, containing Pentacrinites and fossil univalves.

In chapter IV. the author has attempted to classify the formations which compose the Monti Pisani, although in consequence of the scarcity of fossils, and the numerous disturbances to which these formations have been subjected, he considers it a most difficult and abstruse question. With this view he enters into a close examination of those characteristics by which formations are distinguished from one another, viz. 1. Direction or dip of the beds. 2. Unconformability of stratification. 3. Transition by alternating beds from one series to another. 4. Existence and nature of the fossils. The two former of these characteristics offer no results of importance in determining the age of the different beds.

The author then gives a list of localities where the geological transitions of the different formations may be observed, from the alberese and macigno down to the verrucano itself, and arrives at the conclusion, that all these formations are conformable in stratification, and, consequently, that they must be considered as having been successively deposited at the bottom of the same ocean, without any interruption; although it may be more difficult to determine this point with respect to the verrucano on account of the greater amount of disturbance which it has undergone.

In discussing the evidence derived from organic remains, both animal and vegetable, after having noticed the different genera (p. 48) which occur in the various formations from the alberese which contains small Nummulites, several species of foraminifera, and various echinoderms resembling Spatangus, down to the verrucano in which no organic remains have hitherto been found, the author comes to the following conclusions (p. 50):—

1. That the fucoids are the prevailing fossils in the secondary formations, overlying the dark grey limestone with flints.

2. That the Ammonites characterize this limestone as well as the red variety underlying and connected with it. They are more abundant in the latter bed, and are accompanied by numerous fragments of Apiocrinites.

3. That in the inferior limestones without flints, bivalves and turriculated fossils occur with the remains of zoophytes as in those of La Spezzia.

4. That below these limestones all organic remains disappear.

He then proceeds to establish a comparison between the formations of the Pisan hills and those of the N.W. of Europe, in order to determine with which of the latter the former correspond. For this purpose he considers the red ammonite limestone which extends into Lombardy as the best base-line. This appears, in the first instance, from the fossil evidence of the Ammonites, to belong to the lias; but Leop. v. Buch has referred it to the upper Jurassic formation, and with this opinion the author finally agrees, although the beds certainly contain lias fossils, and do not contain all those which are found in Lombardy. The light grey limestone with flint overlying the red is also referred to the same age.

The limestones below the red ammonite limestone, containing bivalves and univalves, Ammonites and Pentacrinites, are referred to the lias. The verrucano, although containing no fossils, is considered from its geological character as a continuation of the lias formation.

No animal remains are found in the deposits which overlie the red ammonite limestone; vegetable remains alone must therefore be referred to, particularly fucoids (amongst which *F. targioni* is most abundant); and after various arguments the author concludes by referring to the cretaceous series all the formations from the light grey limestone with flints, immediately overlying the red ammonite limestone, up to the alberese inclusively; they all contain fucoids; there is a total absence of fossils, either more ancient or more recent than the chalk; and they are all united by mineralogical transition as well as by conformability of stratification. But these same reasons tend to unite in the same series the last or overlying deposit, perfectly connected with the macigno in many parts of Tuscany, and containing several broken bands full of small subglobose Nummulites, numerous foraminifera, and a few echinoderms resembling Spatangi; viz. that variety of nummulitic lumachella long ago observed by the author at Mosciano near Florence, and at the Consuma. Above this last-described formation are other deposits, which, although they have all the appearance of miocene tertiaries, have nevertheless some characters which render it doubtful whether they are to be considered as secondary, or intermediate between the two formations; but the author considers these as beyond his province, and therefore terminates his investigations with the nummulitic lumachella as the most recent of the secondary formations of Tuscany.

The author then proceeds to discuss the opinions of other geologists, and admits that there are facts observed by them, and particularly by Prof. Pilla, which make it possible that some of the formations here described as cretaceous are not the equivalents of the cretaceous formations of the north, but must be considered as of a more recent date (p. 58):—

"In the learned memoir published by my colleague Prof. Pilla during the past year, he brings forward an opinion founded on many ingenious arguments, that the nummulitic hippurite limestone of the south, and of the north of Italy, is the equivalent of all the chalk of the N.W. of Europe, and that in it we may recognize the division of the white chalk and the greensand *. With these views respecting that formation which in Italy and the neighbouring countries contains Hippurites and large Nummulites, he naturally concludes that the macigno must be considered as posterior to the white chalk, since it is known from the observations of Paceto, Sismonda, Spada, Studer, &c., that the macigno overlies the nummulitic limestone; and further deducing from his own observations, that the nummulitic hippurite limestone underlies the macigno with a distinct line of separation, he declares the two formations to be decidedly separate and independent. All these conclusions of Prof. Pilla have been fully adopted by MM. Adolphe Brongniart, Beudant and Dufrénoy in their report to the Academy of Sciences of Paris † on his memoir, together with that of Mons. Leymerie respecting the nummulitic formation of the Pyrenees. Moreover, the same geologists considering our subglobose nummulites of Mosciano and those of Alberona as analogous to the nummulites of the Pyrenees, and finding in the calcareous schists of Bidache near Bayonne containing nummulites and other fossils peculiar to those formations, an identity with those of the macigno, both in respect of their external characters and of the fucoids contained in them, declare the correspondence of our macigno with the formation containing nummulites and tertiary fossils described by Leymerie to be perfectly established. Hence it is evident that these French geologists do not consider the Italian calcareous formation with large nummulites as the equivalent of that of the Pyrenees,

* Saggio comparativo dei terreni che compongono il suolo d' Italia, p. 54.

† Comptes Rendus, tom. xxi. n. 22. p. 1201.

but of the formation underlying it containing Diceras and Hippurites, which, according to Leymerie, represents the whole of the cretaceous formation, from the Neocomian up to the white chalk. If therefore the Italian nummulitic limestone underlying the macigno really does represent the upper portion of the cretaceous formations of the N.W. of Europe, as Prof. Pilla still considered, the macigno would clearly be shown to belong to a formation subsequent to that of the white chalk of the north of Europe, which has hitherto always been considered as the upper member of the secondary formations. And since the macigno, both on account of the nature of the rocks of which it is composed and of the fossils contained in it, and the close connexion which it offers with the underlying secondary rocks, must absolutely be retained as a secondary formation (and such is also the opinion of Prof. Pilla and the above-quoted French geologists), even if it should be proved to be posterior to the most recent secondary rocks of the north of Europe, this interesting fact could only be explained on one or the other of the following hypotheses:—1. Either by admitting that the macigno and its other overlying secondary rocks were formed during the period between the deposition of the white chalk and the eocene formations of the N.W. of Europe; or, 2. By admitting that these same formations were all, or at least partly, produced contemporaneously with the oldest tertiary formations of Europe, viz. the Eocene. The first of these hypotheses is admissible according to the usual geological laws, with regard both to the succession of the different deposits, and to the comparison of the different living animals. But if what I have already said concerning the connexion of our (Pisan) secondary beds with the tertiaries should be confirmed by future observations, this hypothesis will not suffice to explain the phænomena offered by Tuscan geology, and we must have recourse to the other. Speaking of our beds above the macigno, I have pointed out some facts, from which it may be argued, that with us a general elevation of the bottom of the sea did not follow the period of the deposit of the white chalk, as in the N.W. of Europe, but that instead thereof, the waters continued to cover a great portion of what is now Upper Italy, the deposits being continued without interruption from the cretaceous to the miocene tertiary formation. This being the case, we ought to find in the series of formations of the macigno, the alberese and the upper nummulitic limestone, the beds which were formed in our seas not only during the period between the deposition of the white chalk and the calcaire grossier of Paris, but also the equivalents of the other eocene formations of those countries.

"This supposition is certainly contrary to the prevailing ideas respecting the universality and contemporaneity of those catastrophes, which changed the state of things between the period of the secondary formations and that in which were deposited the tertiary strata. But, considering all things connected with the extension, the configuration, and the duration of the sea, which, during the cretaceous period, covered the space where are now the Alps and

Italy, and the phænomena which must have taken place when the period of the tertiary formations succeeded to that of the secondary, I think we may find the means of explaining, in a plausible manner, whatever appears inconsistent out of Tuscany, with the beddings of the macigno and of the alberese; and also that we may understand how formations containing secondary fossils, and others with tertiary fossils were deposited during the same period. As it results from many data, known to geologists, and as I shall more fully show hereafter, that the sea, by which the N.W. of Europe was covered during the cretaceous period, did not communicate directly with that which at the same period covered Italy and the Alps, these two seas may, I think, have existed under such different circumstances as to have felt, in a different manner, the effect of that catastrophe, or of those changes of circumstances by which the animals and plants of the tertiary period succeeded those of the secondary; in consequence of which the animals and the plants of the former period survived in the one sea for a longer period than in the other, and, at the same time, that state of things continued longer in operation which caused those marine deposits peculiar to the earlier period. In this manner we can understand the existence of contemporaneous formations with secondary and tertiary fossils, and we may also judge in what relation the mixed deposits may stand with reference to the old and new series of causes.

"It also appears to me, that under this supposition the newest secondary formations, formed contemporaneously with the oldest tertiary, cannot be considered otherwise than as cretaceous, being merely the result of the local continuation of the physical conditions of the existence of organic beings peculiar to the cretaceous period. If this had really been the course of events, it must have happened that where, as suggested, the conditions of the cretaceous period were prolonged, and those of the tertiary epoch had not yet commenced, the deposits peculiar to the latter epoch, and contemporaneously forming in other places, viz. the oldest tertiaries, or the eocene, must be wanting; and that is precisely what occurs in our country, where, whilst those problematical upper secondary beds of which we are speaking are so fully developed, the eocene, identical with those of the N.W. of Europe, are most rare, or perhaps are altogether absent."

The author then observes (p. 62) that further observations are absolutely necessary before this question can be satisfactorily determined respecting the position of the macigno and the nummulitic and hippurite limestones; there is still reason to doubt the exact correspondence as asserted of the nummulitic hippurite formation of Italy with all the chalk of the north; we have still to learn whether all the Nummulites above the macigno are different from those peculiar to the nummulitic limestone which underlies it, and we must ascertain whether the supracretaceous Nummulites of the Pyrenees belong to the same species as those which underlie the macigno in countries nearest to Italy, or whether the former resemble or differ from those in the upper part of the macigno. For the present therefore he determines to class the upper secondary formations of Tuscany, the macigno as well as the alberese, amongst the cretaceous formations, and consequently as belonging to the upper chalk.

From the absence of all interruption in the stratification, the author concludes that the secondary supra-jurassic beds of Tuscany must contain the equivalents of all the members of the chalk of the N.W. of Europe ; but owing to the scarcity, bad preservation, or even total absence of organic remains in many beds, it is extremely difficult, if not absolutely impossible, to ascertain the exact limits of the different portions corresponding with those of the chalk of the north. Nevertheless it may be considered that the beds comprised between the nummulitic lumachella, the variegated limestone, and the argillaceous marly schists inclusive, generally belong to the upper chalk, and then the underlying series would represent the lower chalk and the Neocomian.

Having thus completed the examination of these formations, a careful consideration of all the preceding phænomena leads our author to the following conclusions (p. 65):—

"1. That the secondary formations of Tuscany were all deposited at the bottom of one ocean, in regular and uninterrupted succession.

"2. That many of the living beings which inhabited the sea by which this country was submerged, during the deposition of the upper Jurassic beds, were not the same as those which at the same time inhabited the more northern seas; and that probably when some of these species had disappeared in the N. and N.W., they still continued to exist in the sea of the Italian regions.

"3. That the sea which covered a great portion of Italy and of the Alps during the period of the deposit of the chalk, existed under circumstances different from those under which the sea, which at the same time covered the west and north-west of Europe, and even the north of Italy, existed."

These conclusions are supported by various arguments, amongst which the author says respecting the second:—"The above considerations lead to a consequence which it is difficult to reconcile with the principles recently adopted, viz. to consider zoological characters as not always sufficient to determine the age of the Jurassic beds. But besides that this opinion is so powerfully confirmed by the above-mentioned facts, it is also supported by the considerations respecting the actual distribution of animals now living on the earth, and the fact of our knowing that some species have disappeared; and I am persuaded, that when we shall be better acquainted both with the numbers and the species of the fossils peculiar to the various formations of the southern regions, and when the synchronism of these formations with those of the north shall be perfectly known, not only will all uncertainties vanish, but perhaps we shall be able to lay down with accuracy the laws which have determined the succession of organic life at different periods and in different portions of the globe, and consequently be enabled to fix the rules by which fossil species are distributed in the various formations of different districts."

The author concludes the work we have been analysing with a tabular statement of the classification of these secondary rocks, and with a comparison of the Jura-liassic formations of Lombardy with those of the Monti Pisani.

[W. J. HAMILTON.]

Memoirs on Meteoric Dust and Volcanic Products from Hecla containing Organic Bodies. By Professor EHRENBERG.

[From the 'Bericht über die Verhandlungen der K. P. Akademie zu Berlin.']

1. *Investigations with regard to Meteoric Dust that fell in the Orkney Islands on the 2nd of September* 1845, *and on the Volcanic Products erupted on the same day from Iceland, and the admixture of Microscopic Organic Bodies with these substances.* (Berlin 'Bericht' for Dec. 1845, p. 398.)

IN October last Professor Forchhammer of Copenhagen forwarded a specimen of dust which fell on board the Danish ship Helena, on the 2nd of September, at nine o'clock in the evening, while in latitude 61° N. and longitude 7° 58′ W. of Greenwich*. This specimen was submitted by the author to microscopic investigation.

The dust was of a greenish black-brown colour, not unlike that of much-roasted coffee when ground; its particles were less adherent to one another than is the case with meal or coal-dust, rather resembling fine dry sand; it was easily blown away, felt somewhat harsh when rubbed by the finger on smooth paper, and was decidedly gritty between the teeth.

The microscope at once showed that the substance was not a vegetable ash; its particles were on the contrary irregular, often angular, indented and channelled little bodies resembling pounded or scraped pumice, and by transmitted light exhibiting the colour of brown bottle-glass or obsidian.

Amongst the fragments unquestionably inorganic and resembling pounded glass were soon recognized some distinct siliceous organic bodies, and especially the almost perfectly preserved shells or cases of an infusoria, *Navicula silicula.* By degrees also were recognized fragments of six other known organic forms.

Upon the discovery of these the investigations were extended, both with regard to the substance itself under examination and also its relations with corresponding phænomena, especially with reference to the meteoric dust of the Cape de Verd Islands and the volcanic deposits of the Eifel.

* A thick cloud with strong wind (not a storm) from N.W. by W. was seen to approach the vessel, and the ship and sails were covered with ashes. On the same day took place the eruption of Hecla, distant 115 German miles (533 English). According to Prof. Forchhammer, the cloud of ashes must have been driven at the rate of 10 German miles (46 English) per hour.

On this extension of the special examination of the material, it was soon found that there were in the dust several uncarbonized specimens of woody fibre and other filamentary bodies resembling the fine hair of animals, but these were presently recognized as derived from coloured absorbent paper, being those bodies which had been already falsely and rather oddly described by botanists as *Leptomitus polychrous,* although they are in fact nothing more than small fragments of absorbent paper. To remove such accidental substances the author burnt a small portion of the dust on a platinum dish, and afterwards obtained a series of forty experiments, twenty of them from the burnt and twenty from the unburnt substance.

The result of the new investigations was, that of forty little parcels of the dust, each about the size of a pin's head (about half a cubic line), seventeen were found to contain organic bodies sometimes more and sometimes less abundantly, and that in the rest of the mass, minute fragments of wood from 10‴ to 1‴ in length were recognized and separated. The following forms were found:—

a. Siliceous-shelled Infusoria.

1. Navicula silicula.
2. Cocconeis, sp. n.

b. Siliceous Phytolitharia.

3. Lithostylidium quadratum.
4. —— serpentinum.
5. Lithochæta borealis } Siliceous hairs of plants.
6. —— ? }
7. Spongolithis acicularis ?

c. Soft combustible bodies.

8. Variegated woolly fibres of absorbent paper.
9. Fibres of dicotyledonous word, unburnt.

The author therefore concludes—

1. That the conditions under which these organic bodies are contained in the meteoric dust, almost all of them being known terrestrial and freshwater forms, entirely preclude the idea that they can have become mixed with the dust by any accidental circumstance occurring during the time of its being collected. A sailing vessel from Iceland has been so long at sea before it reaches the Orkneys, that the surface of all the parts whence the dust was collected must have been frequently washed by the salt water.

2. That these organic particles have not at all the character of being foreign bodies included accidentally in the mass, but are distributed throughout, and so intimately mixed that it would be difficult to imitate artificially so perfect a dissemination.

3. That the fibres of dicotyledonous wood appearing as uncarbonized fragments in fresh volcanic dust, is no objection to this substance being produced by the same catastrophe in Iceland as that from which the glassy particles in the dust-cloud were derived, since the incalculable force of steam would easily tear into the smallest fragments all the vegetable substances of the turfy surface of the district where the eruption took place, and convert them so rapidly

into fine powder, that no time or opportunity would be allowed for them to be carbonized.

4. That the filaments of absorbent paper were the only things now remaining to throw any doubt on the author's mind as to whether the accurate investigations made with regard to them were of any value, in consequence of the chance of impurity of the material investigated.

The author therefore in October applied to M. Forchhammer, to know if there were other ships or localities from which similar dust could be obtained. He obtained in consequence three specimens of the most recent volcanic products from Iceland itself. The first was a specimen of volcanic ash " collected in the neighbourhood of the volcano, and probably thrown out at the first powerful irruption of ashes." The next was a piece of pumice, and the third a fragment broken from red-hot lava.

These specimens underwent careful investigation ; the second and third exhibited no organic body, and no remarkable appearance under the microscope, but the ashes were so singular that it appeared to render the publication of the present investigation and that of the Orkney dust a necessary duty on the part of the author.

The specimen of ash in question is black, finely porous and light, showing in a recent fracture a greenish grey colour and vitreous lustre. The broken surface exhibits many internal cells filled with a clear brown earth, many also only thinly covered with this earth on the walls of the cells. Some cells on the surface were similarly filled.

Microscopic investigation gave two remarkable results, which are of great interest as placing beyond doubt the true nature of the Orkney dust:—

1. Fine dust scraped from the ashes showed exactly similar fragments, both in colour and form, to those which make up the principal mass of the meteoric dust of the Orkneys.

2. The clear brown earth in the cells of the ashes abounds with siliceous-shelled infusoria and phytolitharia.

The following forms have been obtained from ten separate investigations, each consisting of about half a cubic line of this mass:—

a. Siliceous-shelled Polygastrica.

1. Eunotia zebra.
2. Gomphonema minutissimum.
3. Pinnularia borealis.
4. P. (? another species.)

b. Siliceous Phytolitharia.

5. Lithostylidium rude.

These are all known freshwater species, with the exception of a doubtful *Pinnularia* or *Fragilaria.*

General Result and Conclusion.

1. The fine brownish black vitreous dust which fell in the Orkneys on the 2nd of September, and appeared as an advancing cloud, does

not resemble the pumice or slag, but is singularly like, both in colour and material, the ashes that formed the first product of eruption at Hecla on that day. The dust derived from scraping the ashes also resembles in form the minute particles of the dust in question.

2. Numerous other ashes examined by the author, and amongst the rest that obtained from the new and afterwards sunk island of Ferdinand, exhibit a different appearance.

3. Amongst the particles of dust fallen occur siliceous organic bodies of freshwater origin, and precisely in the same way we find within the cells of ashes from Iceland, earthy matter filled with recognizable forms of freshwater siliceous infusoria.

4. In the recently erupted products examined there are on the whole twelve species determined, three of them doubtful, but nine identical with known organic bodies.

5. It is hardly probable that a sailing ship coming from Iceland should bring with it on its deck as far as the Orkney Islands dust or bog earth from the land in such a manner, that in sweeping up the meteoric dust a mixture with this earth should have taken place, and it is equally unlikely that the specimens of ashes should have been collected from a morass. The specimens also themselves were not at all dirty. A mere accidental resemblance between the ashes and the dust is a third improbability not more to be admitted than the others.

6. At the same time it is not to be denied, that the material for these investigations fails somewhat in absolutely authentic evidence with regard to the source whence it was obtained. Since similar investigations have not always conducted to the same result, the necessity of obtaining greater certainty with regard to this point will be manifest.

7. There is every reason to suppose, both from external and internal evidence, and also from the condition, altered by heat, of many forms, that the mixture of organic bodies takes place immediately in the volcano, and is not an accidental and subsequent intrusion of foreign particles.

8. If it is the case that organic bodies are certainly present in the substances thrown out by volcanoes in recent eruptions, all those objections must fall to the ground which assume a long period during which infiltration went on into old deposits, as necessary to account for the presence of minute foreign organic bodies in them. As, however, the skilful mineralogist does not allow himself to be deceived by the infiltration of particles, and distinguishes an incrustation from a nucleus, so the microscopic observer is able to separate the accidental from that which is original and real, and can distinguish the essential from the non-essential.

9. Although the well-known and loosely compacted chalk is completely penetrated by water, and has often been for ages exposed to all kinds of aqueous action, the siliceous-shelled animalcules are never found in it, while the infusorial cases in the chalk marl, although so long exposed, are often smooth and fresh as if they had just been left by the animal.

10. If there should not hereafter be discovered other organic bodies in the matter erupted from existing volcanoes, or should the phænomenon be rare, these isolated facts will have no general application. Should such contents however be common in particular kinds of erupted matter, and exist there in great abundance, we may hope to determine with some accuracy the probability or improbability of subsequent mixture of these bodies in certain geological formations.

11. It also seems that the present isolated case, since it offers an inducement to careful investigation, ought not to be suppressed, but rather made public, as marking the necessity of an earnest appeal for collecting with great care many materials for similar inquiry. The author wishes to take this opportunity of calling attention to the subject, in order that in future advantage may be taken of every instance in which it is possible to collect and forward different kinds of meteoric and volcanic dust, carefully packing it in clean white paper or in clean dry glass bottles.

12. Lastly, the author disclaims all indirect conclusions that may hence be drawn or attributed to him, especially with regard to the depth beneath the earth's surface at which organic life may exist, and reminds the reader that he is satisfied with the fact, of itself sufficiently interesting, and that to follow it out step by step, although it will be unquestionably an excellent and important work, must be one in which it cannot be expected that we should attain any certain result, except after a long series of investigations.

2. *Notes on additional specimens of Ashes from Hecla* (Bericht, 1846, p. 149), *4th May*, 1846.

M. Ehrenberg states that a packet received by M. von Humboldt, and containing ashes recently erupted from Hecla, has been put into his hands to examine. A still more interesting relation is perceived as the result of the investigation of the siliceous-shelled infusoria and phytolitharia contained in this new acquisition, since out of fifteen investigations, each upon about one-third cubic line of the mass of ashes, as many as thirty-two distinct species of similar beings have been recognized. Three of these are identical with species from the Orkney dust.

There have now been recognized thirty-seven or thirty-eight species of organic bodies in volcanic bodies, obtained from the substances thrown out during the recent eruption of Hecla. Fifteen of these had been before described as freshwater forms, occurring in the turf of Hussavic in Iceland, and in the brackish water of Reikiavik. Several others have been for some time known as occurring in Labrador and Kotzebue's Inlet. Not one of the whole number is decidedly new, and all of them are peculiar to fresh water. Hence it appears that the sea can have nothing to do with the formation of these ashes.

It follows that it would be highly advantageous in future volcanic eruptions, provided it is now too late for Hecla, if the following queries could be solved :—

1. How far are these ashes and ash deposits significant? Are they remarkable for extent or local thickness? How far do they extend? How thick are they?

2. How far from the crater are the thickest of these deposits, and what is their thickness, whether by calculation or actual measurement?

3. Do the finer ashes and the coarser ones, when erupted at the same time, repose in alternate layers on one another, or are they separated, falling at different distances from the crater? In what proportions do they appear? How are they affected by wind and rain occurring at the time?

4. Is it the case that much rain and storm occurs during the whole time of eruptions, or has it only regularly accompanied the more violent eruptions?

5. How thick and to what an extent of surface may we estimate the covering of vegetable mould immediately disturbed and affected by the eruption?

6. Does it appear from the recollection of persons living near, that there are or were, in the neighbourhood of active craters, any hollows, pools or marshes, formerly filled with water, or turf and vegetable mould (not with snow and ice only), which are now dried up or seem to have disappeared? If so, of what probable superficial extent are they?

The author then in conclusion offers the following suggestions with regard to collecting objects for investigation:—

a. Dry ashes of all kinds that have not been wetted since they were thrown out in a heated state, with an account of the probable thickness of the heap, the superficial relations, and especially very distinct information with regard to locality.

b. Dust conveyed by the air immediately upon sails, on clean linen spread expressly for the purpose, on plants, or on clean planks, especial care being taken to avoid any possible admixture with foreign bodies.

c. It would be useful to have specimens taken from some depth beneath the surface of thick recent deposits of ashes, together with an account of their estimated thickness and extent.

d. The fine ashes are quite as important for the inquiry as the coarser ashes and the lapillæ or slag.

e. Small fragments of pumice of all the various kinds carefully collected cannot fail to be interesting.

f. With regard to the perfectly solid masses, slags and true lava, the organic bodies have usually undergone so much change in them as to be scarcely recognizable; but when they are glassy or obsidian-like, there is always some hope that imperfect fusion may have left them in bubbles and cells, where are preserved some fragments that can be made out.

g. All specimens should be preserved in clean white writing-paper, and not in grey absorbent paper, since the filaments readily worn off from the surface of the latter material by the rough substances contained in them become mixed with the specimens and greatly impair their value. [D. T. Ansted.]

On the Arms of CYSTIDEA. By DR. ALEX. VON VOLBORTH.

[This article is the translation of an introductory chapter to a memoir on the Russian Sphæronites, published in the Transactions of the Mineralogical Society of St. Petersburg for the year 1845–6, and also printed in a separate form as a pamphlet: the memoir contains a systematic account of all the Russian Sphæronites hitherto known, a list of which is appended to the present translation.—ED.]

THE Sphæronites form a distinct subdivision of the so-called armless Crinoids which have been recently brought together under the name of *Cystidea**, and although I do not agree with the definition of this group as set forth by M. von Buch, I am willing to retain the name, provided it is not understood as involving the idea of the absence of arms. M. von Buch however absolutely denies the existence of arms in all the Cystidea, and speaks of the articulated organs of the Echino-encrinites, described and figured by me in 1844 † as tentacula ‡ (Armtentakeln oder Fühlertentakel). Now it is true that the soft tubular and contractile organs covered with skin and having the upper and under side alike, such as those which surround the mouth in many Echinoderms and Polyps, have been called indifferently tentacula and arms, because they not only serve as organs of touch, but by means of special contrivances, stinging, hooking and clasping, they really perform the part of arms. I am not however aware that the articulated hard crinoidal arms with distinct dorsal and ventral sides have ever been called tentacles, although they are certainly not without the sense of touch.

The reasons for assuming the absence of arms in the Cystidea seem to be the following:—

1st, Because they have only been found once. Even however supposing that the arms had only been met with in one instance, which by the way is not the case, since I have myself described and figured them in two species of Echino-encrinites, one cannot imagine why a fact is to be denied because there is only a single instance of it.

2ndly, Because the arms are not similarly placed to those in true Crinoidea. The arms are articulated, have a ventral groove covered with tentacles, and proceed from the dorsal portion of the cuticular skeleton—clear essential characters of crinoidal arms; their position nearer the mouth cannot deprive them of this designation, and only affords an additional reason for arranging these animals in a group distinct from the Crinoidea. The arms of the true Crinoidea are no doubt inserted in a very different manner.

Lastly, The Cystidea have a special ovarial orifice on the cup, and therefore do not require arms connected with the organs of reproduction, which in existing Crinoids are always to be recognized.

* See Quart. Geol. Journ. vol. ii. part 2. p. 20.

† Bullet. de la Classe Phys. Math. de l'Acad. Imp. des Sc. de St. Petersb. 1845, t. iii. p. 91.

‡ The arms of the Echino-encrinite are furnished with tentacula on the ventral side. What is meant by 'Fühlertentakel,' I do not understand; perhaps tentacles of a higher order intermediate between arms and tentacles? (See Transl. *l. c.* p. 37.)

M. von Buch's opinion, that the singular orifice alluded to on the cup of the Sphæronites is sexual, may be admitted the more readily, since in other Echinoderms the sexual orifice always has a position having reference to radiated structure, and that the arms on which, in the existing Crinoids, the sexual organs are carried, have not yet been perceived. But there is no proof of this: we find in none of the other Echinoderms any analogy with such singularly-formed organs, and there can be no absolute proof of such view in the case of animals which lived so many ages ago. Nor need we wonder at this, if we consider in how many points where the living animal is exposed to our investigation, there is still much obscurity. I need only refer, with regard to the Echinoderms, to the madrepore plates and the pedicellaria.

Since then the use of this orifice is not yet ascertained with certainty, is it reasonable, that on account of an hypothesis, were it ever so probable, a distinctly observed fact should be denied, even if it should turn out that there are no arms at the hypothetical ovarial orifice?

The conclusion, with regard to the armless condition of these animals, seems in the last place unreasonable, since an ovarial orifice on the cup is by no means inconsistent with the existence of arms. Is it the case, it may be asked, that the arms of the Comatula are only sexual organs? or rather, is not this function merely accessory, and are not the arms more especially organs of touch and prehension, obtaining food for the animal? Our knowledge, both physiological and anatomical, of existing Crinoids is almost entirely drawn from the Comatula, but who will assert that the numerous and varied forms of this family in the ancient world were all distinctly modeled after the same law? Even in the Asteria the ovaria are situated sometimes at the place where the arms are given off, sometimes in the arms themselves*; and in Comatula the sexual organs are developed in pennules which have not hitherto been shown to correspond with the arms of Cystidea. There is therefore no sufficient reason for assuming that in the case of the latter group there might not have been a special ovarial orifice not in the vicinity of the arms. The warmth with which M. von Buch has declared that arms do not exist, seems the more extraordinary when it is remembered that he it was who first asserted the possession of arms in the Cystidea. In his work on the formations of Russia †, he says, "the plates which on the summit of the upper part of the cup (in Hemicosmites) cover the mouth, appear to run out into three little probosces or arms, which are hollow, and which may probably be three orifices of the mouth." More recently however he recalls this view, and says ‡, "it appears as if the proboscis was separated into three parts which must have been surrounded with small plates, since they do not remind one in the least of arms." Many beautiful specimens in my

* Müller, Pentacrinus, p. 62.

† Beitr. zur Best. der Gebirgsform. in Russl. (1840, p. 35).

‡ Cystideen, p. 20, Transl. *l. c.* pp. 33, 34.

collection do, on the contrary, confirm the opinion originally expressed: the three orifices correspond with the insertion of the arms; the three probosces, proceeding from the buccal orifice, are tentacle-furrows conducting to the ventral sides of the arms; and when hereafter the true arms of Hemicosmites shall be found, it will be quoted to the honour of M. von Buch that it was he who first suggested their existence.

As a kind of compensation for the absence of arms, M. von Buch has described a clearly-marked effort of nature to produce them. He discovers them in the interior of the cup, and shows how powerfully they press against and endeavour to break through the enclosing surface, but he finds that their efforts are vain, and that they are merely *Molimina brachialia.*

When we consider that according to Müller's investigations the arms of Crinoidea proceed from the dorsal pole of the cuticular skeleton, and therefore do not proceed from within outwards, this explanation of the organic modification appears to me an incomplete attempt to explain the case, and therefore inadmissible. All change in organic nature consists of development advancing by metamorphosis; but each stage of development includes the whole, the ultimate result with the commencement:—the conclusion of the development is given with the original germ or bud, and on this account, not only the form of organization, but every change undergone is only intelligible within the original limits of the organization.

The manifestations of organic development in all geological epochs can only be considered complete,—in other words, the external conditions at each period, or the aim of creation, can only be understood, with reference to perfectly corresponding organic products. The Cystidea must however be considered as incomplete Crinoidea if they had not attained the condition of development permitted and marked out in the germ.

While however I do not admit these *Molimina brachialia,* I feel bound to assert distinctly the presence of true arms. All the Cystidea were, like the Crinoids, provided with articulated arms; and this statement is not a mere hypothesis, but is the result of philosophical induction from distinct well-grounded facts determined by observation—by the actual presence of the arms in some species, and the presence of tentacle-furrows in the others.

The Cystidea are also true Crinoids; either in the young state or throughout life they were attached by an articulated stalk or by a pedicle either to the bottom of the sea or to foreign bodies. They had articulated arms, which, as in Crinoidea, proceeded from the dorsal pole of the cuticular skeleton. Diametrically opposite to the orifice for the pedicle is placed the buccal orifice, and generally close to it is the subcentral anal orifice. The cup differs however from that of the Crinoids by such a predominance of the dorsal side over the ventral, that the latter is often reduced to a minimum, consisting only of the orifice of the mouth, so that the arms generally appear to be much nearer the mouth than is the case with

Crinoids. Some species, but not all, have, besides the three already mentioned, a fourth orifice in the cup, which M. von Buch has described as the ovarial orifice.

The Cystidea may be separated into two groups :—

1. Those in which the cup exhibits marks of radiated structure—*Hemiscosmites*, *Caryocystites*, *Echino-encrinites*, and *Cryptocrinites*.

2. Those in whose cup all trace of radiation is lost, *e.g.* the *Sphæronites*. These may be arranged into the genera *Echinosphærites*, *Sphæronites*, and *Protocrinites*.

The author then proceeds to describe the Russian species of the latter group. He states generally with regard to them, that their name is derived from the usually spherical form of the cup, and that they exhibit distinctly the characteristics of the Cystidea, in the projection of the dorsal part of the cup and the existence of an ovarial orifice. Gyllenhal was the first to recognise the organic origin of the cup, which had before been thought to belong to the mineral kingdom, and he spoke of them as Echinoderms. Hisinger and Von Buch afterwards recognized the proper systematic position of the Sphæronites among the Crinoids.

List of Russian species.

1. Echinosphærites aurantium, *Gyllenhal and Wahlenberg.*
2. E. aranea, *Schlotheim*
3. E. pomum, *Gyll. and Wahl.*
4. Sphæronites Leuchtenbergi, *Volborth.*
5. Protocrinites oviformis, *Eichwald.*

[D. T. Ansted.]

On the Origin of Monte Nuovo, *in a letter from an eye-witness of the eruption in* 1538.

The history of the formation of Monte Nuovo on the shore of the Bay of Naples near Pozzuoli, in 1538, has latterly been a subject of controversy. It was long held by geologists to have been produced by the accumulation of blocks, scoriæ, and ashes ejected from an opening that suddenly took place in the ground near the ancient Lucrine Lake, the loose materials being in part consolidated by condensed aqueous vapour that issued from the same orifice. This view is maintained by Mr. Lyell, after a personal examination of the spot in 1828, in the first edition of his 'Principles of Geology,' published in 1830, and in the subsequent editions. But in the fourth volume of the 'Mémoires pour servir à une Description Géologique de la France,' containing researches by MM. Elie de Beaumont and Dufrénoy, on the Volcanic Countries of the Two Sicilies, compared with those of Central France, published in 1838, M. Dufrénoy, in his memoir on the Volcanic country around Naples, maintains that the Monte Nuovo was formed by the sudden elevation of previously formed beds of tufa. He states as his opinion, "that the Monte Nuovo rose from the earth in the form of a vast swelling or dome (*ampoule*) which burst in the middle, and gave rise to the crater of elevation that exists at its summit," p. 275*.

In the sixth part, for 1846, of the 'Neues Jahrbuch für Geologie,' &c. of Leonhard and Bronn, recently published, there is a communication from M. Haagen von Mathiesen of Copenhagen, recently returned from Naples, relating to the formation of Monte Nuovo, which is accompanied by an original document of great interest, not previously known, an account of the event by an eye-witness, of which the following is a translation†:—

Letter from FRANCESCO DEL NERO *to* NICCOLO DEL BENINO *on the Earthquake at* POZZUOLI, *by which the* MONTE NUOVO *was formed in* 1538‡.

I am not aware whether you have ever been at Pozzolo. Six bow-shots from the town, there commences a plain about half a mile broad, directly before Monte Barbaro, which enclosed a part of this bay; but now the plain extends over the whole of it; a circumstance which, although a natural event, nevertheless is very remarkable and worthy of being accurately inquired into. Aristotle, in his 2° Meteor., mentions two similar events as worthy of record, the one in Pontus, the other in the island of Sagre.

On the 28th of September§, at mid-day, the sea-bottom near Pozzolo became dry over an extent of 600 braccie (1300 yards), so that the inhabitants of the town carried off waggon-loads of fish left on the dry land. About eight o'clock in the morning of the 29th, the earth sunk down about two canne ($13\frac{1}{2}$ feet) in that part where there is now the volcanic orifice, and there issued forth a small stream of very cold water, as we were told by some persons we interrogated; but others stated that it was tepid and somewhat sulphureous: as all the people whom we spoke to were persons worthy of credit, I am of opinion that they all spoke the truth, and that the water was at first cold and afterwards tepid. At noon on the same day, the earth began to swell up, so that the ground in the same place where it had sunk down $13\frac{1}{2}$ feet, by eight o'clock, or thereabouts, was as high as Monte Ruosi, that is, it was as high as that hill is where the little tower stands upon it; and about this time fire issued forth and formed

* For a full account of Monte Nuovo, see Lyell's Principles of Geology, 6th edition, vol. ii. p. 158, where various original documents and authorities are cited.

† This translation is from the German translation of the original Italian.

‡ This letter was found in a volume in the library of the Marquis Capponi, marked CLI, on which the following heading was written—Copy of a letter from Francesco del Nero to Niccolo del Benino of Naples, sent to Rome this year, 1538 (by mistake 1558). This manuscript formerly belonged to the family of Roffia di Samminiato. (FRANCESCO PALERMO.)

§ There were other phænomena besides this, the most remarkable of them all. They are thus stated by a cotemporary author: "At the beginning of spring, while the troops were attending divine service one Sunday morning, there was on a sudden so great a trembling of the earth, that the church and neighbouring buildings were nearly thrown down. Moreover this was not the only earthquake that happened this year, for early in the summer Naples and Pozzuoli were shaken by continued earthquakes, by day as well as by night, and very severely at the beginning of autumn."—Castaldo, Istor. lib. i. (FRANCESCO PALERMO.)

the great gulf with such a force, noise and shining light, that I, who was standing in my garden, was seized with great terror. Forty minutes afterwards, although unwell, I got upon a neighbouring height from which I saw all that took place. And, by my troth, it was a splendid fire, that threw up for a long time much earth and many stones. They fell back again all round the gulf, so that towards the sea they formed a heap in the form of a cross-bow, the bow being a mile and a half, the arrow two-thirds of a mile in dimension. Towards Pozzolo, it has formed a hill nearly of the height of Monte Morello, and for a distance of seventy miles round, the earth and the trees are covered with ashes. On my own estate I have neither a leaf on the trees nor a blade of grass; in the neighbourhood of Pozzolo, to a distance of six miles, there is not a tree standing which has not had its branches broken, and frequently it is not possible to say that there has been a tree on the spot. The ashes that fell here were also soft, sulphurous and heavy. They not only threw down the trees, but an immense number of birds, hares and smaller animals were killed. I was yesterday obliged to return by sea to Pozzolo; my companion being Messer Cacco de Loffredo, the agent of Messer Pavolo Antonio.

Many men were looking on, and with amazement. Nothing was to be seen there but the hill itself; when I say nothing, I mean in comparison with what took place the preceding night, when the earth swelled up, that is, at the time I came to the place. And as there was no one from Naples, and few capable of describing it who saw the fire on that night, there is no one but myself who can make a report upon it*. Since the night when the troops left the place, nothing remarkable has occurred, or that can in the least be compared with that which happened before; I will make the event clear to you by an example.

Imagine the fiery gulf to be the Castle of St. Angelo, filled with lighted rockets. There can be no doubt that these rockets, although they would shoot right up into the air, would, in coming down, change their direction, and in place of falling back into the castle from which they were sent up, would fall into the Tiber and on the neighbouring meadows. Imagine further, that the cases of the rockets fell in such numbers into the Tiber as to fill up its channel, that they lay $27\frac{1}{2}$ feet thick, and that they fell in such quantities in the meadows as to form a hill, extending from Messer Bindo's vineyard as far as Monte Mari, and with a height little less than that of Santo Silvestro near Tusculum: towards St. Peter's we shall suppose that few fell, because the wind blowing from the west carried them in another direction. Just so was it with the fiery gulf, from which there was shot up into the air, to a height which I estimate at a mile and a half, masses of earth, and stones as large as an ox. They fell down near the gulf in a semicircle of from one to three bow-shots in diameter, and in this way they filled up this part of the sea, and formed the above-mentioned hill. When the earth and stones fell,

* This sentence it is important to bear in mind, as it adds greatly to the weight of the testimony.—(Francesco Palermo.)

they were quite dry. The same fire however threw out, at the same time, a light earth and smaller stones, to a much greater height, and these fell down in a soft muddy state; an evident proof that they had reached the higher region, and that the vapours, like other vapours which rise to the same height, were converted into water. This was the cause that the ashes fell in a softened state, mixed with a small quantity of water, although the sky was clear.

I could now state the natural causes of the drying-up of the sea-bottom, and the mode by which that drying-up, by means of the little stream, first of cold and afterwards of tepid water, was brought about; I could also state the causes of the sinking of the ground and the elevation of it that followed, and finally the causes of the outburst of the fire, and of the earthquakes which were felt here ten days before, and so frequent as ten in an hour, which unceasingly shook the earth in Pozzolo, but entirely ceased both here and there as soon as the eruption took place. But as I know that Messer Simone Porzio, who possesses a thorough knowledge of the subject, has written to the Viceroy and to the highly distinguished Farnese, I will not seem to be decking myself with the merits of others. Pozzolo is quite deserted by the inhabitants, and you would not know the place of the sea here, for it would appear like a ploughed field, and it has a covering of what is here called *rapillo* about half a palm thick ($1\frac{1}{2}$ inch), which is so light as to swim on water. But what is to me inconceivable is the mass of stones and ashes that was poured forth from this gulf; and when we take into account the quantity that must have fallen into the sea, and upon the newly-formed hill, and think of the ashes which, as you know, were scattered in all directions, and are the remains of burnt materials, and if we imagine all these brought together in one place, what an immense mountain they would form! I spoke this morning with a man from Eboli, a town forty-five miles distant from the fire. He told me that the ashes had fallen in that place, that the fire had extended ten miles under ground, and that this was the cause of the extraordinary quantity of earth that had been thrown into the air. Had this eruption not happened, the fire must have extended much further under ground; and God grant that the vault may not spread out under Naples! Only yesterday, as we returned to Pozzolo by land, we saw two fire-gulfs, just opened in the ground three miles from Naples. Many opinions have been expressed by very able men, and some think that Naples is in great danger. There have been some processions, and innumerable very deep wells have been sunk between Naples and Pozzolo, "as it were *to bleed* the fire." Viewed as an omen, the event is thought to forebode, as the rockets were driven from west to east, that the emperor is going to attack the Turks.

Leonard Horner.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

Exploration du Volcan Rucu-Pichincha (Quito). Par MM. Seb. Wisse et Garcia Moreno, dans le mois d'Août, 1845. Abridged from the Comptes Rendus, 1846.

Pichincha is situated eleven miles in a straight line W.N.W. from Quito: its sides, which are covered with vegetation to the height of 12,116 feet, are furrowed by deep ravines. All the part above, called the 'Arenal,' is covered with sand and pumice, and is inclined at an angle of 25° to 35°.

The authors having ascended the Arenal to the height of 1542 feet, reached the edge of the crater, which is broken down on the south and on the west, and found the cavity of the volcano to consist of two funnel-shaped craters, apparently resulting from two sets of eruptions. They descended into the eastern crater, a depth of 1050 feet, and found it to consist simply of a vast ravine, at the bottom of which was the bed of a torrent, always dry except during rains.

The western crater is nearly circular, and regularly funnel-shaped: at the bottom is a small plain, through which flow two torrents, which unite near the western opening of the crater. On the western side of this plain rises a hill or cone of eruption, whose height is about 260 feet above the mean level of the bottom of the crater, and its diameter about 1476 feet. This hill is embraced by the two torrents, so as to form a kind of peninsula during heavy rains. It is far from perfectly conical at present, being covered with irregular heaps of stones, and fissured in all directions, proving the violence of the convulsions it has been subjected to in recent times. The volcanic vents, whether active or extinct, are all situated in this cone of eruption; not the slightest trace of one being found elsewhere. They are arranged in nearly circular groups of different dimensions, some of them attaining a diameter of 82 feet. There are in all nine of these groups, six in activity and three extinct, all situated in those parts of the cone which appear to have been most recently convulsed. The cavity at the eastern foot of the cone is 150 feet in diameter and 65 feet in depth, and contains three groups, two at the sides in activity, and one extinct in the centre. These are the first that are met by a person descending from the east, and are the only ones seen in fine weather from the summit of the eastern crater. At a short distance to the right of this cavity is a fissure about 4 inches in breadth, from which issue vapours; and on the left a single vent occurs in the midst of vegetation, which grows luxuriantly within a yard of the orifice.

In mounting the cone, two more groups of active vents are reached; and finally at the summit, the most considerable and imposing group of all. It contains nearly forty active vents within a cavity 260 feet in diameter and 65 feet in depth, and exhibits proof of tremendous exertions of force. Cubical masses of rock, upwards of 12 feet in the side, are thrown about in the utmost confusion; while between their interstices the most suffocating vapours arise.

Lastly, at the foot of the cone are found two more groups of extinct vents. The total number of active vents is about seventy.

Vapours also find their way through the loose soil, which consists of ashes, sand, and sulphur: their odour was that of burnt sulphur and of rotten eggs; from which it is to be presumed that they consist of a mixture of the sulphurous and hydrosulphuric acids. The authors next mounted with incredible labour to the summit of the volcano, whose crest is serrated with sharp pyramidal rocks, resembling the teeth of a saw. The inner walls near the top consist of detached blocks and rocks of all sizes; and lower down, of sand and soil with occasional patches of vegetation. The rocks blackened by time, the profound obscurity, and the vast columns of smoke issuing from an abyss 2460 feet in depth, are described as forming a majestic and terrible scene.

The authors give the following reasons for believing the eastern crater to be the more ancient. It contains no traces of volcanic fumerolles, and its cone of eruption has entirely disappeared; its interior walls are but slightly inclined; and the ridge which separates the two craters, though gently inclined towards the eastern crater, is cut off almost perpendicularly towards the western. The trachytic rocks of the eastern crater are covered over with sand and pumice, which have evidently been ejected from the western. The eastern crater burst forth near the summit of the ancient Pichincha, and the western on its side.

The later eruptions of Pichincha have produced nothing but pumice, that being the only rock visible at the surface. Below the Arenal, the sides of the mountain are covered with vegetation, the surface being composed of soil, sand, and pumice, without any débris which can be attributed to recent convulsions. The few masses of rock which pierce the vegetable crust are probably part of the interior stony structure. Yet the eruptions which caused the present craters must have been tremendous: solid rocks which once formed the summit of Pichincha and the matter thrown from the interior must have reached immense distances, while violent earthquakes must have desolated the neighbouring country. Had these been witnessed by man, tradition ought to have preserved the memory of them. But according to the historian of Quito, previous to the eruption of 1539, Pichincha was not known to be volcanic; the traditions of the Indians being absolutely silent on the point. The authors think it therefore probable that the eruptions which caused the present craters took place before man inhabited this part of the Cordilleras. The fumerolles of the present cone must also have been obstructed during a great lapse of time; otherwise the Indians must have noticed great columns of smoke, such as now rise from it. The only known eruptions in 1539, 1577, 1587 and 1660 have all issued from the existing cone; and to this epoch must be referred the blowing away of the matter which choked the old vent, and the formation of the present cavities.

But in spite of history and tradition, it is impossible to believe that the vast blocks, more than 12 ft. in diameter, which cover part of the plain of Iña Quito, distant $3\frac{1}{2}$ leagues, can have been thrown out by the eruption of 1539. There are no traces of such recent eruptions on the sides of Pichincha, and the present cone is far from being considerable enough to have furnished such a vast quantity of projectiles. Those which were thrown at angles less than 45° would strike against the inner walls of the crater, and roll back again into it; those only which were thrown at greater angles, and with force enough to rise 16,000 ft. above the plain of Quito, could reach their present positions; and though this is not physically impossible, yet it is contradicted by the appearances of the later eruptions, which have clearly been of a very tranquil description.

The authors consider as equally fabulous a tradition, that the eruption of 1660 was accompanied by showers of incandescent rocks, which are said to have fallen on all sides, but of which not a vestige is now to be seen.

J. C. M.

Ehrenberg *on the* Sirocco-dust *that fell at Genoa on the* 16*th May*, 1846.

[From the 'Berlin Monats-Bericht' for 1846, p. 202-207.]

The microscopic analysis of this dust produced 22 polygastrica, 21 phytolitharia, together with the pollen of plants and the spores of Puccinium. The varieties of dust which since 1830 have fallen in the Atlantic Ocean, as far as 800 sea miles west from Africa, on the Cape Verd islands, even in Malta and Genoa, which the author has had an opportunity of examining, all agreed in the following particulars:—1st, they are all ochre yellow, never grey, like the dust of the Khamseen in the north of Africa; 2nd, the colour is produced by iron oxide; 3rd, from one-sixth to one-third of their mass consists of recognizable organic parts; 4th, these are either siliceous polygastrica and phytolitharia, or carbonaceous but uncarbonized portions of plants, or calcareous polythalamia; 5th, the greater number of the ninety species already found equally occur in the most widely separated of the places just named; 6th, the most numerous forms are everywhere land and freshwater productions; yet some marine animalcules are constantly mixed with them; 7th, in no case were dried up, living species (except the pollen and spores), nowhere melted, calcined, or carbonized forms among them; 8th, even the dust of Genoa, although brought there by the Sirocco, exhibited as little as any of the former, characteristic African forms, which yet are found in every small portion of mud from Africa; on the contrary, one of them, *Synedra entomon*, is a decidedly characteristic South American form. It is remarkable that the few (2 ?) European observations hitherto made have always fallen on the 15th and 16th of May. The author concludes with the question, whether there is not a current of air uniting Africa and America in the region of the trade-winds, which is occasionally, and especially on these days, turned towards Europe, and brings that dust along with it?

J. N.

Observations on the general distribution of Copper and Arsenic. By M. Walchner (from the Comptes Rendus, Septembre 1846).

From his position as one of the directors of mines in the Grand-Duchy of Baden, M. Walchner had frequently occasion to examine ores of iron, in order to determine their purity, on which the quality of the iron in a great measure depends. "During these researches," he says, "I found that two metals, copper and arsenic, very prejudicial to the quality of the iron, were always mixed with and accompanied in every place the ores of iron dispersed over the whole globe. United in small amount with all the oxides of iron, they occur in every variety of the mines of this metal, and in some in such proportions that these mines are wholly unserviceable for the production of iron of a good quality, unless previously purified by a suitable process.

"Having observed that the natural hydrates of the peroxide of iron, the spathose iron ore, as well as the oolitic and pisiform ores of the Jura formation, which I consider as deposited from ancient chalybeate springs, contained copper and arsenic, I occupied myself in analysing the ferruginous clays which are the most recent deposits of hydrate of iron formed under our own eyes. The results of these experiments agree with my previous analyses; and even the ores found in peat-bogs and meadows, and formed during the present epoch, contain copper and arsenic.

"Nothing was now more natural than to look for these metals also in existing ferruginous springs, in the ochres deposited from acidulated waters. Considering that the deposits of iron formed by ancient springs at different far-distant geological epochs contained these two metals, it was necessary to infer, that they should also occur in the ochrey deposits of the present epoch. I therefore endeavoured to procure the ochres from mineral springs celebrated for their salutary effects, either by collecting them myself on the spot, or by employing trustworthy persons to do this for me. I took all necessary precautions in the analysis; and all the materials employed were carefully purified. In this manner I have examined the acidulated ferruginous waters of the Black Forest (of Griesbach, Rippoldsau, Teinach, Rothenfels, and Cannstadt), and also the ochres of the thermal springs of Wiesbaden, of the acidulated waters of Schwalbach, Ems, Pyrmont, Lamscheid, and the Brohl valley near to Andernach. All these ochres have yielded precipitates, the exact analysis of which has clearly proved that they contain copper and arsenic. Besides, I have found antimony in the deposits from the thermal springs of Wiesbaden.

"Hence all these mineral springs, whose salubrity is well known and celebrated for a long time, contain these two metals, but, observe, in proportions so minute, that they scarce rise to millionth parts. This destroys all fear of dangerous consequences. Should it happen that these metals in very small doses have a beneficial effect in certain diseases, we might attribute part of the salutary effects of these waters to their presence.

"Although this confirmation of my inferences might have been expected, nevertheless the results of my analyses have surprised me. I have repeated them myself several times, and have caused them to be also repeated by other able chemists, and in all cases with the same results.

"There is still one question remains: How does it happen that these metals have not previously been found in chalybeate mineral waters, which have been so often analysed? We answer, because they have not been looked for; or the experiments have been made on too small quantities of water, without analysing the deposits.

"Having once found that copper and arsenic always accompany iron, I could not fail in finding them in the earthy substances which contain the latter metal.

"I began my experiments with the arable soils of Wiesloch and Nussloch near to Heidelberg, which are sufficiently rich in iron, and I soon obtained indisputable proof of the presence of copper and arsenic in these soils, fertile in corn and wine. The deleterious action of the arsenic is wholly suspended by its intimate combination with the iron; it is in the state of arsenic acid, when it forms a subarseniate of peroxide of iron, which is wholly insoluble in water.

"Finally, the analysis of a great number of clays, muds and marls, and, among the last, of the marls of the Löss of the valley of the Rhine, of solid argillaceous rocks, more or less ferruginous, have furnished me with as many proofs that the two metals mentioned are everywhere mixed with iron. It is thus evident that they are no less common and no less generally dispersed over the surface of the globe than the latter metal.

"It now remained to demonstrate that these metals were equally contained in meteoric iron ores*. My first experiments were made

* M. Rummler of Vienna has found the arsenious acid in the peridot of the meteoric iron of Pallas. (Pogg. Annal. 1840, No. 4.)

on the meteoric iron of Pallas, well-known and repeatedly analysed by distinguished chemists, and in reality I have found in it both copper and arsenic; also in the Mexican meteoric iron of Yuanhuitlan, near to Oaxaca, brought home by my colleague M. Sommerschu, principal engineer of mines; in a meteoric iron from Tennessee, described by M. Troost in Silliman's Journal; and finally in a fragment of the great mass of meteoric iron deposited in the Museum of Natural History of Yale College in Connecticut. Consequently it is not only at the surface of the earth that iron is mixed with copper and arsenic, but also in the solid portions of other celestial bodies.

"The results of these researches are highly deserving of attention. In regard to the ores of iron, they particularly claim that of the worker in iron: in regard to mineral waters, they may explain certain peculiar effects of celebrated springs: finally, in discovering these two poisonous minerals in earthy substances, in clays and cultivated soils, they have a manifest interest for all those persons who occupy themselves with researches in medical jurisprudence; and for the interests of humanity and justice they are altogether indispensable."

J. N.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

Preliminary Notice on the Silurian System and the Trilobites of Bohemia. By JOACHIM BARRANDE*. Pamphlet in 8vo. pp. 98. Leipzic (Hirschfeld), 1846.

THE author states that he has often been asked during the long period that he has studied the palæozoic formations of Bohemia, "To what epoch do you refer the ancient formations of the centre of Bohemia?" Having at length collected the necessary material, he is busily engaged in preparing it for the public, under the title 'Système Silurien du centre de la Bohême.' This title sufficiently indicates the conclusion to which he has arrived with regard to the question alluded to.

The purely geological evidence and the order of superposition, together with a consideration of the lithological characters of the rocks, would however hardly be sufficient to produce conviction on this subject. These characters are necessarily uncertain, and we must have recourse to the palæontological characters to justify the classification adopted.

In the present pamphlet the author does not propose to pass in review all the members of the palæozoic fauna, since this would require greater space. He limits himself to those most characteristic.

The Trilobites are generally admitted to be the fossils which may most usefully be employed to determine the relative age of the ancient formations. Such fossils here require special attention, since they are very numerously represented in Bohemia. In the narrow limits of the present sketch no minute description is admissible, and the object is to establish a parallel between the ancient formations of Bohemia and those of other countries already known. It is therefore held sufficient merely to mention the genera and species, very slightly alluding to the principal characters which distinguish them.

The palæozoic rocks of the centre of Bohemia occupy a well-de-

* Notice préliminaire sur le systême Silurien et les Trilobites de Bohême, par Joachim Barrande. Leipzic, 1846.

fined basin whose shape is oval, the longer axis having a N.E. and S.W. direction, whose respective extremities are near Auval and not far from Klattau. The length of this axis is about eighty-two English miles: the breadth of the basin varies, but is nowhere greater than seventy English miles, and is generally much less, especially towards the N.E., where it is partly covered by the Quadersandstein, Pläner-kalk, &c. Elsewhere, for about four-fifths of the whole circumference, the palæozoic basin reposes on granites and gneiss, which often seem to alternate and be mixed up with metamorphic rocks.

In this extensive basin there are a number of deposits of different ages, also basin-shaped, and so arranged that their relations can be well-studied.

The palæozoic formations of the centre of Bohemia present a complete series of all the principal subdivisions indicated in the contemporaneous rocks of other countries. The series being here complete, the natural divisions seem manifest even before they have been made out by a consideration of the fossil evidence.

The author adopts three chief divisions corresponding to three very different kinds of deposits. Palæontological considerations have induced him to make yet further subdivisions or groups. They are thus classed in order of superposition.

3. Upper Division.—Including a mass of calcareous beds almost uninterrupted in appearance, but of which the great difference of dominant fossil types requires a subdivision into three distinct groups.

2. Middle Division.—Including the protozoic formations divided into two groups, of which the faunas are quite distinct.

1. Lower Division.—Including all the Azoic formations, and subdivided into two groups.

I. Lower Division.

These rocks appear wherever the exterior margin of the palæozoic basin is recognized.

Group A.—This lowest group includes all the crystalline or semicrystalline rocks generally designated as metamorphic; such rocks are very variable in distant spots. They repose on granite and gneiss, and the author states that he intends to give in detail at a future time, some facts which he has observed with regard to them, which appear to him to settle the question of metamorphism.

Group B.—This upper group consists of masses which are not crystalline, such as the grauwackes of Przibram, manifestly from their structure of marine origin; many rich metalliferous veins enrich this formation, especially near Przibram.

Of this age are probably the argillaceous schists, on the opposite or north-western side of the basin, as well as those which underlie the coal-basins of Pilsen and Radnitz. Several pyritous or alum schists are included also in the series, apparently in the upper portion. No organic contents have yet been found in these rocks, and the author believes that they belong to the group called Azoic, below the limits of organic existence.

II. Middle Division.

This division offers two groups of rocks as distinct from one another in mineral composition as they are in fossil contents. Their limits are well-marked and they may easily be recognized in several localities, especially along the abrupt cliffs which inclose the valley of the Litawa, in the direction of Przibram towards Zditz.

Group C.—1. *Geological characters.*—The beds of this group consist almost exclusively of argillaceous schists, containing but a small proportion of silex. They are fine-grained and readily distinguishable from those just described of the lower division, by the more or less rounded form of the particles of which they are made up. They have a decided colour varying from brown to blackish-blue, and exhibit a laminated texture. The bedding can often be only discovered by means of the fossils, as is the case with other schists.

These beds are widely traceable, but are for the most part concealed under those of the overlying deposit (D), which are greatly thicker. The average thickness of this group is however nearly 400 yards.

The spot where the edges of this formation are best exposed, is to the right of Duschnik near Przibram. Schists are seen there sufficiently resembling in appearance those we are now discussing, but not containing any fossils. Descending the valley these are covered up by quartzite, the order of superposition being very manifest. The schists of this group at Duschnik dip nearly N.E., and extend to the eastern extremity of the palæozoic basin.

Owing to disturbances and denudation, the fossiliferous schists appear in two localities, Ginetz and Skrey, associated with and forced up through the thick beds of the upper series (D). Both of these localities have supplied several trilobites, but especially the latter, which is situated about fourteen miles north of Ginetz.

2. *Palæontological characters.*—The fossils from these localities include twenty-four species of trilobites, and contain scarcely any other fossils. The general result of a comparison of these trilobites with those of the Silurian rocks of other countries, appears to be as follows:—

1. Of the whole number, none are yet known to occur either in France or Russia.

2. If the *Paradoxides Tessini*, doubtfully quoted by Sir R. Murchison* as a fossil of the Llandeilo flags of Wales, really occurs in these beds, this highly characteristic species will be common to Bohemia and Great Britain. The halves of *Agnostus pisiformis*, figured in the 'Silurian System' (pl. 25. fig. 6), have also the greatest resemblance to the author's *Battus Orion*, and may be considered its equivalent. The mere fact that the genus Battus is represented in the lower beds of Wales and also in Bohemia, is considered by the author as sufficient to bring the two formations into relation, for this genus is not known to extend vertically to a great height. Its position in

* Memoir on the Palæozoic deposits of Scandinavia, Quart. Geol. Journ., vol. i. table p. 402.

the British Isles is stated by Sir R. Murchison to be in Lower Silurian rocks.

From these resemblances, which are unfortunately founded on a very small number of species, the author thinks himself justified in concluding, that the lower group (C) of the middle Bohemian division corresponds to the lowest fossiliferous beds of Great Britain—to those namely which contain *Agnostus.*

The author states that he shall afterwards have occasion to explain why he excludes at present the other beds above the Llandeilo flags.

3. In Sweden and Norway, the *Paradoxides Tessini* and *Agnostus pisiformis* offer the same elements of comparison with Bohemia, since these two species are also the only ones that can be identified among the fossils of this kind in the two countries. They both belong to the alum schists which form the base of the Silurian system of Scandinavia, considered by Sir R. Murchison as the beds corresponding to his Llandeilo flags. The author concludes that this group (C) is on the same geological horizon as the most ancient fossiliferous series of Sweden, Norway, and the British Isles. It forms, therefore, the base of the protozoic rocks, as recently defined by Prof. Sedgwick.

Group D.—1. *Geological characters.*—Most of the rocks of this group contain a large proportion of silex. The abrupt passage from the dark schists to these siliceous conglomerates and white quartzites is distinctly seen in the valley near Ginetz. The beds are conformable, or very nearly so, although at first sight this appears not to be the case.

The lower member of this group chiefly consists of siliceous schists varying in colour, above which appear thick beds of coarse conglomerate. Still higher very fine quartzites are found, and at the top appear black and very fissile schists, including, but much less commonly, bands of quartzite.

It is worthy of remark, that from the base of the azoic rocks to the upper part of the present group of formations, there are no remarkable limestone bands. The author possesses only a single fragment of rock of this kind, found in the middle of the quartzites, and containing the head of a *Trinucleus ornatus.* He could never discover the bed from which this came. Other indications of limestone in very thin beds are met with near Prague, with impressions of trilobites among the quartzites of this formation. M. Zippe has mentioned the fact, but the author states that he has searched in vain to discover the bed, which is probably only a lenticular mass.

The calcareous element was therefore absent during the formations hitherto described.

2. *Palæontological characters.*—The author describes twenty-five species of trilobites, which occur only in the upper beds of the quartzite and in the schists superimposed. The lower beds of quartzose sandstone, and the conglomerate and siliceous schists which form the base of this group (D), have not yet afforded any trace of organic beings. Of all the fossils described, one only, *Trilobites Lindaueri,* belongs to the lower beds.

The family of crustaceans, which exclusively composes the fauna of the next lower group (C), is not completely absent in (D). The other families are here also represented, but the number both of species and individuals is small.

Of other fossils are found—

1. Among Heteropoda, two species of *Bellerophon*, one of which is *B. acutus*, Murch., and the other resembles *B. bilobatus* of the same author.

2. The Cephalopods only furnish us with some fragments of *Orthoceras*, without either shell or siphuncle, and therefore not very easy to determine.

3. The Pteropods are represented by four species of *Conularia*.

4. Among the Brachiopods are four species of *Orthis*, one of which is *O. semicircularis*, Murch., and two appear to be new. There is also a species of *Orbicula*.

5. The Monomyaria and Dimyaria are represented by two species of *Avicula*, of which the shells are absent, together with some casts very indistinct.

6. There is a species of Encrinite resembling the genus *Agelacrinites* of Vanuxem.

7. There are several corals, badly preserved, among which the author recognises *Porites pyriformis*, Lonsd.

From this general sketch of the other fossils, it will be seen that these beds exhibit great poverty, except in trilobites. This no doubt is partly owing to the absence of calcareous deposit; and it appears that the trilobites could live in the Silurian seas, in water charged with siliceous matter, unfavourable for the development of mollusca.

Before comparing this group with other Silurian deposits, it is worth while to remark the total difference presented between its fossils and those of the lower group (C) of the same division. Between the two there is not one species, and hardly a genus in common. Notwithstanding this, if we only judged of the succession of deposits by their local relations, the quartzites near Ginetz would appear to repose directly on the fossiliferous schists, owing to the absence of the intermediate beds.

In spite of this discordance of the fossils, the author brings the two groups into the same division, in consequence of the predominance of trilobites in both.

The author then compares this group, as occurring in Bohemia, with the corresponding Silurian rocks of other countries, and commences with Great Britain. He considers that his group (D) corresponds to the whole of the Lower Silurian group of Great Britain with the exception of the Llandeilo flags, which he concluded were the analogues of his group (C) before described. He even believes that the mineral and lithological character of the beds in the two countries might almost be sufficient to determine contemporaneity in this case. The subdivisions of the Caradoc sandstone he recognises in sections exhibited near Beraun. The five subdivisions mentioned by Sir R. Murchison he forms into two groups, the upper one characterized by a less predominance of silex. These two groups he compares with corresponding lithological groups in Bohemia; but mentions the presence of two others in that country whose absence in England does not, he thinks, invalidate his argument. These absent groups do in fact appear in other districts besides Bohemia, and especially in France.

But, without dwelling on this evidence, the fossils exhibit analogies sufficiently striking in the palæontological characters of the formations of the two countries. The identical species are not numerous, being limited to *Illænus perovalis*; but the presence of the genus *Trinucleus* peculiar to this part of the series, in Bohemia, as in England, would be sufficient, the author thinks, to prove the contemporaneity of the beds containing it. He thinks it possible that, on comparing good specimens, *T. Caractaci* might be identified with *T. ornatus* of Bohemia. The *Asaphus tyrannus* and *A. Powisii* of England are also analogues in dimensions of *A. ingens* and *A. nobilis*, found in the quartzites of Bohemia.

The *Bellerophon*, the *Orthis*, and the *Conularia*, already mentioned, give additional evidence in favour of the author's view; and he therefore concludes that his group (D) corresponds to the Caradoc sandstone and the upper part of the Llandeilo flags.

In France, as already observed by the author, there is no representative of the group (C); but the present group (D) is abundantly developed in Brittany and Normandy. The beds, as described by MM. Dufrenoy and E. de Beaumont, agree exactly with the lower members of this group. The author has received fragments from these parts of the country, and identifies some few of the fossils; and he considers that the Lower Silurian beds of the north of France, in which the *Agnostus* seems entirely absent, are of the same age as the Bohemian group now under consideration.

The Silurian rocks of Sweden having been already identified with those of England by Sir R. Murchison, the author has no difficulty in concluding that there also representative rocks exist.

In concluding this sketch of the middle division, the author observes that two fossils, especially abundant and characteristic of the English Caradoc Sandstone, absolutely fail in Bohemia. These are *Asaphus Buchii* and *Tentaculites*, of neither of which there has yet been found the smallest trace.

III. Upper Division.

This is composed almost exclusively of calcareous beds forming the exposed portion of the basin and surrounded by the dark-coloured schists of the former group (C), which has been assimilated to the Caradoc sandstone. The portion of the basin thus occupied is of an elliptical form; its longer axis (directed N.E. and S.W.) being about 22½ English miles, and its shorter axis about 3½ miles. It extends from a little south of Prague to near the small town of Zditz. There are also some small outlying patches.

It would not be easy to account for this accumulation of all the palæozoic limestones expanded to a great thickness in a nearly compact mass, and almost without offering a trace of the rocks which had before prevailed, and had till then excluded the limestone. There must have been in Bohemia a long and unbroken continuance of the action of causes which had elsewhere produced their effects at intervals, schistose and siliceous deposits alternating with calcareous ones, as in England, France, and elsewhere.

From the apparent continuity of the beds in this basin, one would be inclined at first to suppose that the subdivisions complicating the geological scale might here be dispensed with. Palæontological facts, however, of which only the most striking are mentioned, render it necessary to form three distinct groups.

Group E. (*Lower Calcareous Group.*)—1. *Geological characters.* —The author states that he has not been able to discover hitherto any want of conformability between the limestones of the group and the beds on which they repose; the passage being unbroken, so that it is almost impossible to discover the line of separation. The calcareous matter seems to have been gradually introduced, and commences by the introduction of nodules of moderate size (from half an inch to 16 inches diameter) and sparingly distributed; these gradually increase in abundance but not in size; they afterwards become united and form irregular bands; these then assume greater regularity, alternating with the schists, and at length completely replace and exclude them.

The colour of the lower calcareous bands is generally blackish, or of a very decided grey. The beds are compact, and occasionally contain veins of calc-spar and geodes of hyaline quartz. The siliceous element is rare. The thickness of the whole group varies greatly, but may be stated at from 30 to 120 yards. The thickness of the separate beds varies from an inch or two up to about six feet.

2. *Palæontological characters.*—The introduction of the calcareous nodules corresponds with an important change in the fauna of this period; not a single species found in this newer group being identical with those of the lower beds.

The trilobites, far from disappearing, offer a much greater field of variety. The genera represented differ from those found in (D), except in the case of *Chirurus*, *Phacops*, and *Odontopleura*. The dimensions, however, attained by these animals are much less considerable in the limestones than in the lower beds. Notwithstanding also the increased number of species, the trilobites cease to be the predominant fossils in these newer deposits.

On the other hand, the Cephalopoda, before scarcely represented, here exhibit a prodigious development; and the following genera are met with, their relative abundance being in the order in which their names are quoted. We have—1. *Cryptoceras*, a genus formed by the author to include certain hitherto unknown and very strange forms; 2. *Gyroceras*; 3. *Nautilus*; 4. *Gomphoceras*; 5. *Phragmoceras*; 6. *Lituites*; 7. *Cyrtoceras*; 8. *Orthoceras*.

Of these eight genera the six first-mentioned have most of them only from two to four species, and specimens are rare; but the Cyrtoceras exhibits about fifty distinct forms, and the Orthoceras seventy, this number including only those which have well-marked and constant specific characters.

Notwithstanding this great abundance of Cephalopodous remains, there are very few species which can be identified with those of other countries. In the absence of sufficiently good specimens, the author, judging from the figures in the 'Silurian System,' makes the following identifications :—

Orthoceras Ibex	Upper and Lower Ludlow.
O. distans ?	Lower Ludlow.
O. dimidiatum ?	Lower Ludlow.
O. ludense ?	Lower Ludlow.
O. annulatum, M.C.	Lower Ludlow.
Gomphoceras pyriforme	Lower Ludlow.
Phragmoceras ventricosum	Lower Ludlow.
P. (Cyrtoceras) arcuatum	Lower Ludlow.
P. (Cyrtoceras) compressum	Lower Ludlow.
Orthoceras nummularius	Wenlock shale.

It will be seen that species belonging to different stages of the Upper Silurian rocks of England are brought together in the Bohemian limestones. These do not admit of subdivision, for the distribution of Cephalopoda varies much less in vertical range than according to local peculiarities.

The Orthoceratites are present in such a multitude of species, and the number of individuals is so great, that the calcareous beds are filled with their remains. This genus was evidently preponderant during the deposit of the group of beds now under discussion.

The genus *Phragmoceras* was considered by Sir R. Murchison as very characteristic of the Lower Ludlow rocks, but in Bohemia it appears lower down, and at the base of the calcareous deposit.

The family of Brachiopoda was little developed in the beds of this group, in comparison at least with its extent in the overlying beds. The following species found in Bohemia are common to that country and England.

Terebratula prisca	Upper Ludlow.
T. imbricata	Lower Ludlow.
Leptæna euglypha	Lower Ludlow.
L. depressa	Lower Ludlow.
Terebratula (Atrypa) compressa	Wenlock shale.
Orthis canalis	Wenlock shale.

To which we may add a Terebratula resembling *T. navicula*, and called by the author *T. altidorsata*; it belongs to a very low portion of the group.

With the exception of *T. prisca*, which traverses two of the author's groups, the brachiopods are peculiar to the lower limestones of Bohemia, whilst they are variously distributed in England.

Many bivalves observed by the author are not alluded to for want of materials of comparison in other countries. He mentions however the *Cardiola*, of which there are five or six species, two of which, *C. interrupta* and *C. fibrosa*, characterise the Lower Ludlow. The genus is confined in Bohemia to the lower limestone.

The author here mentions the presence in Bohemia of a number of bivalves of the genus Cardium resembling those described by Count Münster from Elbersreuth.

Of Zoophytes the number of species in Bohemia is 44 ?, and therefore less considerable than those of England, which amount to 65; but the same genera are represented (*Favosites*, *Cyathophyllum*, *Catenipora*, &c.). Most of these are found in the middle of group (E).

Graptolites ludensis, *G. convolutus*, and some other species are found chiefly in the nodules. In England they characterise the Lower Ludlow rocks.

On the whole it appears, that of the English fossils represented in Bohemia, including the corals, the greatest proportion belong to the Wenlock formation, and the smallest proportion to the Lower Ludlow. If however the corals are excluded, the proportions are reversed.

The group (E) of Bohemia might be considered as representing an epoch corresponding to that during which were formed the English beds extending from the Wenlock shale to the base of the Aymestry limestone, provided the identical species were sufficiently characteristic. Since however they can hardly be considered so, it is necessary to obtain some more definite knowledge before absolutely determining the question. To the evidence afforded by the mollusks the author then adds some new indications furnished by the Trilobites. These do not indeed give any forms that are identical in the two countries of Bohemia and Great Britain; but there are certain analogies, which however seem hardly sufficiently important to deserve being quoted here, and are admitted by the author to be too vague to enable him to establish the comparison of the groups; the materials not including specific identity, and merely a similarity of generic form.

The author concludes that his group (E) belongs to a palæozoic period, different, so far as Bohemia is concerned, both from that which preceded and from those which followed. It does not appear, however, that it can be identified with any subdivision of the Silurian series in other countries; while, on the other hand, it seems to represent several groups of Upper Silurian rocks as developed in the British Islands.

Group F. (*Middle Calcareous Group.*)—*Geological characters.*—There is no unconformability between the beds of this and the preceding group, nor can they be accurately distinguished by lithological character, although there are unequivocal marks of their belonging to a different period, even without the evidence of fossils. These are derived from the presence of silex, which, as has been stated, is not found in the beds of group E. The silex appears in two conditions; sometimes distributed through the rock, and altering its colour and cohesion, but sometimes detached and in cherty nodules.

The thickness of the different beds is inconsiderable, varying from 4 inches to about 16. The thickness of the formation varies, but sometimes amounts to 300 or 350 feet.

The colour is, on the whole, different from that of the lower beds, being more grey or whitish, and instead of giving out a fetid odour when struck, as is the case with the Orthoceratite limestone, the odour rather resembles that obtained by rubbing two pieces of quartz together.

2. *Palæontological characters.*—In these beds the trilobites appear to be gradually dying out. No new genera are introduced, although all the species are new. These crustaceans are here, as elsewhere, more developed in beds which contain silex than in those entirely made up of carbonate of lime.

The Cephalopoda are in this group also reduced to a smaller number of species and but few individuals. They also differ from those of the former period. There have not been found amongst them any typical forms named and described in the Silurian rocks of other countries.

The Brachiopoda, which had been very rare in the earlier deposits, are here predominant, although the number identical with known forms is very small. Amongst these are *Terebratula* (*Atrypa*) *compressa*, *T. prisca*, *Orthis orbicularis*? M. v. Buch has given the name *Pentamerus Sieberi* to a species closely resembling *P. galeatus*, and characteristic of this group (F). This Pentamerus is associated generally with a Terebratula which the author calls *T. princeps*, the geological equivalent of *T. Wilsoni*, from which however it differs by specific peculiarities.

There are 40 species of Terebratula in this middle calcareous group of Bohemia, about 10 Spirifers, 5 or 6 species of Leptæna, several of Orthis, and one single Lingula. Most of the Brachiopods occur in a white limestone which forms hills between the villages of Konieprus and Mnienian, and of whose richness in these fossils the author has been aware for some years. It has been erroneously stated that these fossils are from Litten, which is not within the calcareous basin, and is situated at some distance from the true locality.

In the same calcareous rock are several new genera of Gasteropoda and also *Euomphalus sculptus*, a species found in England in the three middle groups of the Upper Silurian series.

In the vertical extension of this group there have been found beds formed almost entirely of encrinital stems; but the author thinks he can recognise species distinct from *Scyphocrinites elegans*, Zenk., which characterises the lower limestone.

Corals are not rare in the beds now under discussion. Most of the species of *Favosites* are the same as those in the lower beds; but they are associated with several species of *Retepora*, *Hemitrypa*, &c., very analogous to those of England.

The author then describes 27 species of Trilobites from the beds of this group, amongst which he distinguishes 21 exclusively confined to them. He considers this fact, combined with the generally distinct character of the species in other countries, as sufficient to justify the separation of the group from the beds below and above it.

The comparison with the fossils of other countries offers too little that is definite to justify any conclusions being drawn.

Group G. (*Upper Limestone Group.*)—1. *Geological characters.*

—The passage from the lower beds to these is conformable, and the transition perfect. The beds of this group are more argillaceous than those of the former; and they may even be regarded as nodules of limestone in a fine argillaceous base. The limestone is fine and compact; its colour grey, reddish, and blackish. The bands of limestone are sometimes separated by schists finely laminated.

The central palæozoic basin of Bohemia terminates with these calcareous beds, which are here and there covered up by the Quader-sandstein. The thickness of the beds on the whole amounts to about 200 feet.

2. *Palæontological characters.*—It would appear that the conditions of the palæozoic seas were gradually becoming less and less favourable for the existence of organic beings. All the mollusca have disappeared almost at once in these beds, or are reduced to a small number of species and individuals, and in many cases the calcareous portion of the shells has been removed. The fossils are thus very difficult to determine.

The Trilobites form the only exception to this condition: owing to the nature of their covering, they have been usually sufficiently well preserved to furnish the means of determination.

Both in variety of species and number of individuals, the Trilobites in these deposits had become predominant; and the author describes sixteen species, four of which also occur in the next lower group. There is little means of comparison between these beds and those of other countries.

The author then concludes with the following *résumé* of the most remarkable facts suggested in his memoir.

1. The palæozoic basin of the centre of Bohemia considered as a whole is extremely rich in Trilobites, most of them unknown. These are abundant in the lowest fossiliferous beds, less prominent in the middle, but again dominant in the newest deposits of the basin.

Since Trilobites specially characterise Silurian formations, all the formations in this Bohemian basin are exclusively of that period. This is recognized at once by an examination of the fossils in spite of the Devonian look of some of them at first sight.

2. Excluding the two groups A, B, which form the base of the system, and which have been called Azoic, the other groups (C, D, E, F, G,) offer well-marked palæontological characters corresponding to as many local creations each different and successive. These characters are based partly on the almost total difference between the Trilobites of each group, and partly on the predominance of certain mollusca in some groups and the almost total absence of identical species of these animals as well as Trilobites in adjacent groups.

3. The two lower fossiliferous groups C, D, form a division entirely distinct, geologically, and above all palæontologically, from the three upper groups E, F, G.

4. There are thus three great natural divisions in the succession of formations in this Bohemian basin, the lower division being azoic, and the middle and upper divisions fossiliferous.

These correspond exactly with those recognized in Great Britain under the names of

Cambrian system (as modified in 1845)...	Azoic.
Lower Silurian system	Fossiliferous.
Upper Silurian system	

5. The azoic divisions in the two countries may be considered to correspond in point of age, both from the nature of the rocks and from their position.

6. The middle divisions which are fossiliferous are comprised in both districts between two geological horizons, characterized by including the genera *Battus* and *Trinucleus*. These two horizons are especially distinct in Bohemia, in consequence of the great thickness of the group D, of quartzites or Caradoc sandstones. In both countries there is an abrupt and total change in the palæozoic fauna, immediately above the horizon of the *Trinucleus*.

This coincidence is considered by the author to establish the identity of the middle divisions of Bohemia and England.

7. The author considers, that the analogies that exist between the palæozoic faunas of England and Bohemia demonstrate, in spite of irregularities in the development of certain families, that the Upper Silurian series of England, and the three calcareous groups of Bohemia, were formed during the same portion of the palæozoic epoch.

8. He believes, therefore, that taking for the terms of comparison the three grand divisions sketched out, the central basin of Bohemia represents in the same order as that traced in England, the succession of the three great Silurian periods.

9. Having established this resemblance and identity, the author proceeds to the subject of the diversity recognizable in countries remote from one another, and offers in a series of tables, a comparison of the fossils of the two countries for the three periods. He then concludes, that there is a complete correspondence between the three great divisions of the Silurian system in Bohemia and Britain;—that from a detailed comparison of the local faunas, it appears that the different groups in the two countries do not correspond;—that the Silurian system has therefore unity as a whole, but a diversity in detail; and lastly, that this unity and diversity are everywhere to be remarked in nature, and equally characterize the works of the Creator.

General View of the Silurian Fauna of Bohemia.

Fishes.	(Ichthyodorulite fragments)	1
Crustacea.	Trilobites..............................	129
	Cytherinida..........................	10
Mollusca.	Heteropoda..........................	5
	Cephalopoda	150
	Gasteropoda.........................	50
	Brachiopoda	100
	Monomyaria	9
	Dimyaria	100
Encrinites	....	2
Corals, &c.	....	44
	Total.........	600

Note. This table is made out from the specimens in the author's collection.

[D. T. A.]

Geological Sketches from the Provinces beyond the CAUCASUS. By Professor ABICH.—*Geologische Skizzen aus Transcaucasien.* Vom Herrn Professor ABICH*.

[Read before the Imp. Academy, April 17, 1846.]

[Bull. de la Classe Phys. Mathém. de l'Acad. Imp. des Sciences de St. Pétersbourg.]

On the Volcanic Plateaux of the Lower Caucasus.

IN attempting to describe the physical geography of the mountain districts which extend south of the Caucasus, between the Black Sea and the Caspian, we find great difficulty in applying one or more general appellations to the many ramifications of this mountainous region; principally because well-combined geological investigations have not yet been extended to Asia Minor. The great natural causes which have given a peculiar physical character to the simple features of the surface of these districts, modifying even their historical importance, are the results of geological developments, chiefly owing to forces acting from the centre towards the surface of the earth. By the agency of these processes, which succeeded one another at definite periods, similar natural forms were produced from similar elements, and were spread in connexion with one another according to the same law over vast spaces. These propositions, which a geological description of the uplands of Armenia will establish, prove the subterranean connexion of all parts of the above-mentioned mountain groups, and justify the scientific propriety of a common name for them. The choice of this name is optional; yet as there are important practical reasons for maintaining the geological union of this mountain group with the Caucasus, it appears most natural to assume on the isthmus between the two seas, an *upper* and a *lower* Caucasus, and in the first place to limit the latter term to the mountain district which is comprised in the almost elliptical space enclosed by the Araxes on the one side and by the Kur on the other. It will not be possible to give a more exact definition of the extent and the boundaries of the Lower Caucasus until more accurate geological investigations shall have been extended over the whole of Grusia.

The Lower Caucasus.—It is remarkable that this lofty mountain chain, so richly provided with every variety of physical productions, with its lofty summits 12,000 feet above the sea, should be below the limits of perpetual snow, while the summits of the Elburuz and the Kasbek, at a height of 10,380 and 9950 French feet, are above it. The principal ranges of this mountain chain are parallel with those of the upper and real Caucasus. Along a line which may be said to represent the principal portion of this mountain chain, it is traversed by a succession of table-lands connected with one another, having a considerable, though not always the same mean elevation above the sea. The rocks of which they consist have been brought to the surface of the earth in an igneous or molten state. These volcanic masses burst forth in the centre of those mountains, the heights of which they now cover, as with a mantle, with undulating nearly hori-

* See Journal of the Geol. Soc. vol. ii. part ii. p. 93.

zontal beds of extraordinary extent and thickness. They were elevated by the same forces which have caused the many regularly-formed conical hills, crowning the tops of those remarkable table-lands for an extent of fifty-four geographical (German) miles, at longer or shorter intervals, and which contribute so much to the landscape charms of the Armenian highlands. With this peculiar natural condition of closely connected volcanic table-lands, apparently universally repeated in the more western mountain districts of Asia Minor, are connected certain conditions of climate and of a physical character, which have exercised a considerable influence on the habits and development of the people of these regions.

The liability to decomposition of these volcanic crystalline rocks, which, like dolerite and trachyte, produce such a favourable soil for the vegetation of grasses and cerealia, acting on these table-lands, which for the most part are above the limits of the growth of trees in these regions (which in the Lower Caucasus may be reckoned at from 7000 to 7800 French feet), has principally called into existence those boundless alpine meadows, on which the existence of the Nomadic tribes of Asia Minor mainly depends. Whilst the horizontality of the connected uplands favours the equal distribution and collection of the snows of winter, the porous nature of the rock itself is the principal cause, that on this substratum a much smaller proportion of the melted waters returns by evaporation into the atmosphere, than is the case on steeper mountain heights, consisting of a more compact rock, and having either none or only a very thin covering of soil. Hence the production and origin of those numerous and peculiar sources to which the name of Karasu waters has been applied* ; and this term has so far the merit of physical distinction, as by it all springs rising in lofty uplands, elevated by volcanic action, can be distinguished from such as rise out of other formations. Everywhere do these Karasu springs rise with an astonishing abundance of water, partly at the edges of the volcanic table-lands, even at the greatest heights, and partly immediately amidst and below the beds of lava which stretch down from the mountains into the open valleys.

The great reservoir of the Goktschai lake, 5500 feet above the sea, and covering a surface of 1126 square wersts, which at different periods of the year exerts such a favourable influence on the climate of the neighbourhood, and particularly on the meteorological state of the plain of the Araxes, is almost solely maintained by the powerful streams which flow into it from the volcanic heights which in an unbroken line shut it in on the south and on the west. The Sanga would be an inconsiderable stream, were it not for the numerous Karasu rivers which it receives in its long course of 100 wersts, issuing from the lavas which have extended to the N.W. in enormous *coulées* from

* The word Karasu signifies *black water*, and is a term universally given throughout Asia Minor to a deep-flowing river in a mountainous district. I cannot quite adopt Prof. Abich's theory, as I have met with rivers called by that name in many parts of Asia Minor, where the nature of the country and the rocks preclude the idea of the term being derived from any cause like that alluded to in the text. Several rivers of this name are mentioned in my work on Asia Minor.—W. J. H.

the Agmangan table-lands. The most important streams taken up by the Araxes in its course through the elevated plain, viz. the Akurean, Abarran, Garni, Wedi, Arpatschai and Makutschai, rise at once as Karasu waters from the volcanic deposits of the hills and plains.

Those rivers are in fact the real arterial feeders of luxuriant vegetation, and by means of the venous system of the canals at the mouths of the valleys, are the sole causes of the cultivation and fertility of the darker soil of the plain of the Araxes. Its abundance of water is the gift of the volcanic energy of times antecedent to history. We may partly understand what the plain of the Araxes would be without those volcanic uplands with their mighty springs in the bosom of the mountains, by considering the desert and steppe-like character of those districts which are spread out before the entrances of other valleys, the upper ends of which do not, like the former, extend into the volcanic table-lands, as *e. g.* the valley of Wazargach, between the valleys of the Arpatschai and of the Sardarack. These valleys, arid and deserted, are not watered by perpetual streams; stones and gravel have artificially raised their bottom, and the sudden freshets of the spring annually carry down additional quantities into the plain. The elevated portions of the district thus raised, and which are often of considerable extent, can either not at all, or only with great difficulty, be reached by means of canals from the low river-beds of the neighbouring valleys. They have assumed the character of steppes, and now only produce heather and saline plants. By means of Artesian wells, these and similar districts, now neglected only for want of water, might easily be brought into a state of cultivation.

Within the central region of the great volcanic range, respecting which only a few considerations bearing on the general question have been above alluded to, are to be found the greatest heights of the Lower Caucasus. There we have, as an isolated and independent system, the imposing and extensive mountain of Alaghéz, the base of which is 170 wersts in circumference; it is a phænomenon as peculiar as it is remarkable, in which the laws of craters of elevation are most fully borne out, and affords an amount of facts of the greatest importance for the doctrine of mountain chains. The uplands which exist on the summit of the flat dome of Alaghéz have, from a number of measurements from the best points, a mean elevation of 9970 French feet above the sea. Four pyramidal rocky points are placed with great regularity round the highest base of the excentrical *Caldera**. The highest of them has, according to Fedorow's trigonometrical measurements, an absolute height of 12,886 French feet; and the lowest, towards the S.W., is by my barometrical measurements 866 French feet lower. The conditions of climate round the mountain are very different. Wheat scarcely ripens on the upland of Goeseldara†, at the north foot of Alaghéz, 6343 French feet above the sea; whilst at

* The point where the maximum of elevating power was exerted, causing the separation of the edges of the Caldera, is stated by the author in a long explanatory note, not to correspond with the central axis in the real summit of the whole dome, but to lie seven wersts to the north-east from the summit.

† Ghieuzel-dereh, Fair Valley.

its southern base, near Astarab, on the rocky banks of the Abarran, excellent wine is obtained at a height of 2462 French feet. On the south-western declivities of the mountain, owing to the favourable influence of the neighbouring plains covered by volcanic beds, the vine was formerly cultivated to a much greater height. Independently of historical report, this is proved in the environs of the remarkable fortress near the ruins of the old Armenian towns of Talyn and Eschnak, where the many deserted vineyards regularly arranged in terraces one above the other, with the vine-dressers' huts still in existence, are, according to my measurements, at an absolute height of 4254 French feet.

By means of uninterrupted volcanic deposits and a series of hills of various physical characters, the Alaghéz is in geological connexion with the lofty dome of the table-land of Agmangan, which is partly formed of eruptive matter of a doloritic nature. It stretches down in a S.W. direction opposite Mount Ararat, along the Goktschai (lake), and has a circumference of about 140 wersts. The level of the great crater-lake Kanly goell (Blood lake) gives the nearest average statement of the elevation of this flat dome, viz. 9278 French feet. The state of cultivation along the S.W. and S.E. sides of the Goktschai lake resembles that of the north of Europe; but on the S.W. of the Agmangan plateau, the lavas of the Naltapa and Agmangan extend into the district of the celebrated orchards of Erivan. The culminating points of the above-mentioned flat dome are fixed—1st, by the magnificent erupted cone, of a vesicular character, of Agmangan, 11,160 French feet in height, where at the bottom of a moderately deep crater, is the most elevated lake in Armenia; 2nd, further to the S.E. by the majestic crater of elevation of Agdag (Akdagh or White mountain), 11,480 French feet, and Bosdag (Grey mountain) or Altundag, 10,728 French feet above the sea.

These magnificent systems of trachytic porphyry are, in consequence of the predominance of certain vitreous modifications, mineralogically connected with the great obsidian mountains of Mexico. The high plain of Agridja, which forms the south-eastern prolongation of the Agmangan table-land, and is celebrated for its fertile meadows, leads by a gradual ascent to the flat ridge of the three volcanic systems which, closely connected together, complete the southern mountain barrier of the Goktschai. These are, 1st, the great cráter of elevation, the Karanlysch dagh (Dark mountain), with its summit reaching to an elevation of 10,431 French feet; 2nd, the Tik Pilakan (Steep Step), or Tasch Pilakan (Stone Step); and, 3rd, the Goeseldara Baschi (head of the beautiful valley). The southern slopes of these fine mountains, the *Barancos* of which stretch down in parallel lines to the lake, keep up a direct communication by means of a gentle inclination with the lowest southern member of the vast chain of table-lands above-mentioned. This well-watered and extensive upland, the luxuriant grassy plains of which swarm during the summer with countless hordes of Nomadic Tartars and Kurds, is washed on the S.E. by the Akaran, and on the S.W. by the Bazartschai, which at a distance of 12 wersts from the Araxes, form by their junction the acute angle of the Berguschet. It assumes the form of a long ellipse, the short diameter of which is 32, and the circumference 180 or 190 wersts. The loftiest plains of this elevated district are near Tik Pilakan; their mean elevation is best decided by the level of the Alagoell, the surface of which is 8492 French feet above the sea. From hence the mean inclination of the whole plateau to the S.E., having a fall of 47 feet to the werst, is scarcely 1°, whilst on the N.W., from Alagoell down to the Goktschai, there is a mean inclination of 157 French feet to the werst.

The meteorological condition of the central table-land district exercises an important influence on the climate of Karabag. The moisture perpetually brought up by the E. and S.E. winds from the Caspian Sea, is condensed under the cooling influences of the wooded mountains of Karabag, and particularly over the extensive grassy volcanic uplands, and there falls in the form of fog and rain more frequently than higher up in the districts of Erivan. Frequently during summer, when the finest weather prevails for days in the plain of the Araxes, and even on the Goktschai lake and on Agmangan, heavy clouds from the neighbourhood of the lake are drawn up the valleys of Karabag to the south, which settling on the table-lands, refresh the vegetation and check its too rapid development. Thus the botanist finds on these central highland districts, as well as in the wooded valleys which descend from them, a rich harvest, when the Flora of the plain of the Araxes and the surrounding hills has been long dried up.

On these same table-lands, and in the exact direction of their longer axis, four great systems of volcanic eruption rise at almost equal intervals from one another. At a distance of 32 wersts from the south shore of the Goktschai, and 18 wersts from Tik Pilakan, the Carial or Kissil-tappa* begins the remarkable series. This extensive system consists of a group of rounded hills, from the centre of which rises a flat crater, and contains within its circumference the sources of the three great rivers, the Arpatschai, the Bazartschai, and the Terter, which flow from the Carial in opposite directions to the N.E. and S.W. It is still more remarkable in a geological point of view, that the two most important hot-springs of this great volcanic chain occur in the bottoms of the valleys of the Arpatschai and the Terter. The hot-spring in the Terter valley of 39° R. is 12 wersts distant from the Carial, at an absolute height of 6794 French feet; and the hot-spring of 29°·5R., which gives the name of Istissudara† (Warm-water valley) to the upper valley of the Arpatschai, rises at an absolute height of 6712 French feet, and at nearly the same distance from the Carial.

The system of the Baloglu or Dawagoesu‡ is 14 wersts to the S.E. of the Carial; it is a similar group with a flat erupted dome in the middle, still furrowed by the lava-streams which poured down its sides. Sixteen wersts beyond the Dawagoesu is the extensive system of the Kizilboghasdag, with its broad crater called Maphrasch-tappa. The broadest lava-streams which, with their rough and stony surfaces, still cover a large portion of the table-land, have flowed from this

* Kizil tepéh, or Red Hill.
† Properly Issi su dereh.
‡ Deve ghieuz, or Camel's Eyes.

crater. Finally, 16 wersts further rises the remarkable crater of elevation of the Klissalidagh, the last and greatest system of the whole series, with its remarkable mountain forms, the highest point of which, according to my measurements, is 9738 French feet above the sea. At the Klissalidagh commences the deposit of a tuff and trachytic conglomerate of vast thickness, by which the slope of the table-land is continued to the Araxes 73 wersts further. At the southern foot of the Klissalidagh, a broad valley, 962 feet deep, has been excavated in this tuff formation, where, at a distance of 15 wersts from the summit of the mountain, is Gürüs, the chief town of the district of Sangysur, on the river of the same name, at an elevation of 3900 feet, surrounded by the fantastic forms of pointed conical pillars of tuff, partly attached to the steep sides of the valley, and partly forming singular and isolated groups*.

Now if we draw a straight line from the summit of the Klissalidagh at an angle of 58° W. of the meridian, and extend it to the Caspian and Black Seas, it will strike, at a distance of 176 wersts to the S.E., the summit of the Alaghéz. In this direction the line passes close to the extinct central volcano of the Daralaghéz called Dalychtappa †, the crater of which has a circumference of 1960 paces, and an absolute height of 8042 French feet; it then strikes at a distance of 75 wersts from its commencement the already-mentioned Karantychdagh, and subsequently in succession the volcanic cones Abul Hassar, 8596 feet high, on the upland of Agridja, with a crater-lake—the already-mentioned Akdagh—the Scham Iram or Hadis, and the volcanic hill Kiotan-dagh, 7111 French feet above the sea, both the latter abounding in obsidian and pumice-stone, on the N.W. declivity of the Agmangan hills 20 wersts from Erivan. Lastly, the above-mentioned line before reaching the Alaghéz also cuts through the Karnijerach (Cracked-Belly). The construction of this flat mountain, which the Tartar language so expressively and figuratively describes, renders it an interesting modification of the craters of elevation in Armenia. The Karnijarach rises to an absolute height of 7913 French feet, commanding a stony and sterile tract of dolerite, 20 wersts above Erivan, 16 wersts in breadth and about 20 in length, between the rivers Sanga and Abarran. The further extension of the line to the N.W. brings us to the great crater-lake of the Tschyldir group with a surface of 116 square wersts, and resembling in a geological point of view the lakes of Bracciano and Montefiascone in the Papal States, and then over the summits of the great volcanic frontier mountains of the modern province of Achalzik in the old country of the Lazes and the Chalybes. These mountains, which enclose the great source of cold of the Armenian highlands, and have been celebrated from the earliest time for their ungenial climate, are best observed from the heights of the Meski mountain chain, behind Abastuman. Amongst them, beginning from the S.E., the Dochuspungar, the Ardagandagh, the

* Compare this with the remarkable hills described in Hamilton's Asia Minor, vol. ii. p. 250, in the valleys of Utch Hissar and Urgub.

† Delik-tepéh (Hole-hill).

Arzian and Pozchowdagh with their flat conical forms, are the most remarkable.

A straight line connecting the summits of the two Ararats runs parallel with the above-mentioned line, deviating 58° W. from the meridian. Prolonged in the opposite direction (viz. S.E.), it strikes the isolated rock pyramids of the Takjaltu near Kulpi, and of the Yelanlidagh (Snake Mountain) near Nachitschewan. These two formations are mineralogically the same, and with a remarkable similarity of appearance, stand in an equally important geological relation to the great masses of rock-salt which are found in the mottled clays at both extremities of the valley of the Araxes. At a distance of 150 wersts N.W. from Mount Ararat, the above-mentioned line touches the summit of the Saganlu-dagh, the wooded volcanic mountain mass overlooking the plain of Kars *.

If in the same way we draw a line from the summit of the Kasbek at an angle of 66° 30′ W. of the meridian, it will at a distance of 176 wersts N.W. cut the summit of Elburuz, and to the S.E. at a distance of 196 wersts, the Djultidag rising on the ridge of the Dagestan mountains above the limit of perpetual snow. This line however must be looked upon as representing the entire length of the whole Lower Caucasus.

The above-mentioned relations and connexions in the relative position of the principal summits of the mountain district of the Caucasus are not merely accidental; they are important facts, which must be considered as the result of those internal laws which were alluded to at the commencement of this notice.

It was well known that volcanic forces had contributed to the elevation of the Caucasus in the same way as had been the case with regard to the Andes of South America; but the extraordinary share which volcanic action had exerted in modifying the surface of the mountain districts in the Southern Caucasus was neither known, nor even suspected. The geological period when these remarkable effects took place is, relatively speaking, very modern; its last appearances are clearly visible in the early dawn of the history of the human race. Throughout the whole extension of the Araxes plain up to the high plains of Schuragel and Kars, the upper sedimentary bed is a loose calcareous tuff, which is filled with the well-preserved shells of the same species of Mytilus which still inhabits the Caspian Sea †. This calcareous tuff is immediately covered by the lavas and other volcanic products which extend from the volcanic uplands to the plains, which are now respectively at the heights of 2400 and 4500 French feet above the level of the ocean.

Most remarkable is the difference of the results which elevating volcanic forces, and particularly eruptive volcanic action, which is still continuing, although with diminished intensity, on our planet, have produced in the development of the forms of the Upper and Lower Caucasus. In the former district they raised, by a great effort of

* See Hamilton's Asia Minor, vol. i. p. 189.
† Ibid. vol. i. pp. 186 and 203.

power in a vertical direction, a lofty and continuous mountain wall 145 geographical miles in length, separating different quarters of the globe, and only passable in a few places ; in the latter heaving and eruptive forces were most effective, and the masses driven directly from the volcanic focus to the surface were principally elevated and spread out in horizontal extent. From this difference is derived the greater variety and more favourable development of the natural features of the Lower Caucasus, and with this its ethnographical importance is most inseparably connected.

[W. J. H.]

Bear Island, *geognostically described from the Observations of* B. M. Keilhau, *with Remarks on the* Spirifer Keilhavii *and its relation to similar forms.* By Leopold von Buch.—*Die* Bären-Insel *nach* B. M. Keilhau *geognostisch beschrieben von* Leopold von Buch ; *und, Ueber* Spirifer Keilhavii, *über dessen Fundort und Verhältniss zu ähnlichen Formen.*

[Memoir read to the Berlin Academy of Sciences, 14th May 1846.]

Far in the north of Europe, half-way between Norway and Spitzbergen, in 74° 30′ of latitude, lies a small island, scarcely ten miles in circumference *, and almost constantly concealed in clouds or hid by the waves of the Arctic Sea. The well-known navigator Barentz discovered it during his third journey to the North on the 9th June 1596, and named it Bear Island, from a great bear killed upon it. The number of walruses that then surrounded the island like a wall, induced a rich merchant in London, Sir Francis Cherrie, to send Mr. Stephen Bennet, to kill them and extract the oil from their bodies. Bennet reached the island, with which he was already acquainted, on the 8th July 1604, and now gave it the name Cherrie Island after his patron, which it still retains in English charts and books, though Bear Island is used by other nations, and seems to be more familiar even to the English. The profits from the walruses caused the voyage to be repeated for five or six years. In 1608 nearly a thousand walruses were killed in seven hours, and yielded twenty-seven tons of oil. Yet these undertakings were accompanied with much danger. The island has few attractions for the seaman. The shore all round rises precipitously to about 120 feet of elevation : the waves break with much violence on this shore, and in no part of the whole circuit is the smallest bay to be found, where a ship can obtain protection from wind and waves. They cannot therefore come close to the island, and the boats must either be immediately drawn up on land or return to the ship. The men put on shore hasten to complete their task in a few hours, yet it often happens that the ships cannot keep their place on account of the violence of the wind, and the men must be left to their fate for months, and even for the whole

* According to Scoresby, it is in 20° E. longitude, 130 miles S.S.E. of the most southern point of Spitzbergen, and is about ten miles long.—Trans.

winter, before they can be again brought off. It would not seem very probable that naturalists should visit such an inhospitable island, or remain long enough to observe its internal structure, and there is not much probability of such visits being often repeated. Yet it has occurred, and this investigation, which as yet is almost unknown, has produced some facts of very great importance for geology.

The Burgomaster of Burtscheidt near Aachen, M. Barto von Lövenigh, resolved in July 1827 to undertake a pleasure-trip to Spitzbergen. On reaching Hammerfest he hired from a Russian merchant a sloop adapted to the voyage, with the proper crew; and took the Norwegian naturalist Keilhau, who happened to be then in Hammerfest, along with him to Spitzbergen. Both travellers have published their observations; but M. von Lövenigh has less attempted to describe what he saw, than to express, chiefly in verse, the feelings excited in him by the surrounding icy scenery. Keilhau's observations are of more value, and in all respects worthy of an experienced naturalist. They form a considerable part of his comprehensive work on the physical relations of the northern part of Lapland. But an unfortunate accident has caused the almost total destruction of this work, printed at Christiana in 1831, so that it has been seen by very few persons, and hence Keilhau's discoveries in Bear Island and Spitzbergen have excited almost no attention. Convinced, that since the no less admirable than important researches of Murchison and the Russian geologists in the Russian empire, every geological observation in the regions that encompass the North Pole must have an essential influence in developing the laws according to which the surface of the earth has been formed, I attempted during my visit to Christiana in July 1844 to procure Keilhau's book, and succeeded, through the kindness of the author, in obtaining one of the very few copies which alone remain of the whole edition.

M. Keilhau has likewise placed in the Museum of the University at Christiana a very instructive and beautiful collection from Bear Island, and accompanied each specimen with many very acute remarks. I am thus enabled to add something, not found in the book, to Keilhau's observations; especially the determination of the many beautiful petrifactions collected on Bear Island, among which one of the largest and most beautiful Spirifers is certainly not unworthy to bear the name of its discoverer.

"On the 16th August 1827," says Keilhau, "about two in the morning, we left Hammerfest, and on the 19th at mid-day came in sight of Bear Island. We ran along the coast on the east side to the so-called Nordhafen. The land rose steep from the shore to 50 or 150 feet high, and then spread out flat like a table, far into the interior. We went on shore with the boat and provisions for three or four days, at Nordhafen, whilst the ship cruised about in the open sea. Not far from the shore is a well-built house, containing a good room for living in, and a store for provisions. It was erected in 1822 by some merchants from Hammerfest, and ever since, each ship that visits the island leaves some provisions in the house for those who may be compelled by necessity to remain behind. We found, in truth, an axe, a saw, a barrel of quass or small-beer, along with a store of salt, dried fish, meal, and salted sea-fowl (*Alca arctica*). I immediately proceeded to examine the more elevated south side of the island, and followed the eastern shore. Even in the vicinity of Nordhafen, I saw in a precipice certainly more than 200 feet high, four beds of coal, running between the strata of fine-grained grey sandstone, but none of these beds was above an ell (two feet) thick. Hence in a situation so unfavourable for working, they can never become of any economical importance." Even Bennet in his time knew of this coal and brought some of it with him to England. At the same time he collected on Gull Island, near Nordhafen, a quantity of galena, and thus procured for Bear Island the reputation of great mineral wealth. Yet the Norwegian sailors from Hammerfest, who are well-acquainted with the whole island, look in vain for Gull Island. They either altogether deny its existence, or assert that it must have been destroyed by the waves. Farther to the east a small stream falls into the sea, named Engelsk Elv, from the graves of some Englishmen at its mouth. In

Fig. 1.

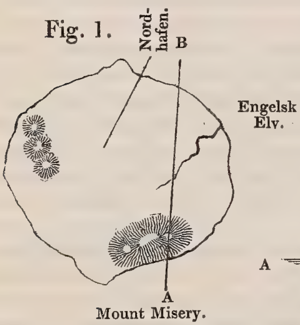
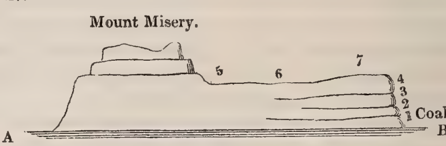


Fig. 2.



that place two beds of coal again appear, running as before perfectly horizontal along the cliff. The harder beds of sandstone project from the precipice, and extend like steps one above the other for a great distance. They form the abode of whole hosts of sea-fowl, which here lay their eggs and bring out their young. This perfect horizontality of the beds over the whole island is a very remarkable and striking phænomenon. Even the common sailors remark, that they are constantly sailing over the horizontal foundation of Bear Island, when proceeding from this place to Hope Island, or even further to the Archipelago of the Thousand Isles near Spitzbergen, a portion of the Arctic Ocean, which has everywhere only a very moderate depth. Even on the mountains of East Spitzbergen the same horizontality is maintained, as Keilhau has himself observed and represented in his work ; a proof of the great distance of these beds from the destroying and elevating action of the granite and gneiss mountains. And as Keilhau has found that on Stans Foreland, hyperite or hypersthene rock (basalt of Keilhau) forms the foundation of all the other beds, we may well inquire, whether here also, as in Westgothland, the extended foundation of hyperite has not preserved the strata from the metamorphosing action of the granite.

On the eastern side the almost perfectly horizontal surface of Bear Island rises between two and three hundred feet above the sea. From this point a good general view of the whole form of the island can be obtained. It was clearly seen, that only two mountain-groups on the south side rose higher. One, the more westerly, about $4\frac{1}{2}$ miles distant, remained concealed by mist. It is the one that in Scoresby's view from the westward is so remarkably divided into three cones. The eastern elevation, named Mount Misery in English charts, because from its summit Bennet for many hours continued expecting the instant destruction of the boat sent to bring him off the island, consists of three declivities or steps, clearly distinguished from each other. The lowest, covered with blocks fallen down from the beds above, is about 300 feet high; the second follows, only thirty feet high, but running like a perpendicular wall along the mountain side. A plain divides this acclivity from the highest step, which is intersected by small flat irregular valleys. The whole scarcely rises to a thousand feet. No snow lay on the hill, except in the valleys, where it had been collected into great heaps by the wind. As the table-land of the island was also free from snow, it is certain that the lower limit of perpetual snow passes above the summit of Mount Misery, and consequently at more than 1000 feet of elevation. M. Du Rocher, in his valuable Considerations on the Snow-line (Expéd. au Nord, Géographie Physique, p. 51), places the lower limit in 550 feet; certainly too low, for Mount Misery is extensive enough to form glaciers if its summit rose above the snow-line.

I think I may now well venture on this conclusion, deduced from nature and experience, without needing to fear uncalled for, verbose and therefore unmeaning opposition, since the singular doctrines of Venetz and Carpentier regarding the origin and progress of glaciers are only heard in the far distance, and since the general conviction, that Agassiz's unsuccessful attempt to live three summers on a glacier, and all the care and labour expended there, have led to no other result, than to confirm still more the wise considerations and deductions of Saussure, and to prove that the faculty of extended generalization, which depends on few but sure observations, leads sooner and more directly to the truth, than all the instruments we may heap together, without using them with proper precautions. Even the echo, still faintly repeated from the other side of the Atlantic, will in a short time cease. When we question the maps of the Swiss Alps, the mountains in Tyrol, the Norwegian glaciers, the few seen in the Pyrenees, the magnificent vicinity of the sources of the Ganges and Jumna,—everywhere the same law appears, namely, "That glaciers only form on mountains that rise above the limits of perpetual snow, and spread out in this region; the origin of such glaciers must be sought in depressions,—wide basins of snow. They never originate on the open rocks far from large masses of snow. From these wide pots of snow the icy mass proceeds down in deep valleys, perhaps even to inhabited places, where the temperature of the air sets limits to its further progress, and where the portion destroyed by melting must be continually and rapidly renewed from above." From these essential conditions in the formation of glaciers it evidently results, *that the cause of their progress and sliding down into the valleys must be sought, either altogether, or at least chiefly, towards their origin, and above the snow-line,* never in the ice-masses themselves, which in this respect are altogether passive. In this upper region the pressure of the connected ice-masses operates, exactly as the pressure on the Rossberg has pushed down a whole stratum of the mountain, destroyed it, and covered half a canton with the giant-fragments; and this pressure is not destroyed in its progress, but increased, until the temperature and smaller declination of the valley are able to counterbalance the pressure of the mass. No glacier continues to move, when the bottom of the valley on which it rests has a less inclination than 3° (Elie de Beaumont). No doubt large extended masses of snow often appear in confined valleys below the snow-line; they may even be changed into vaults of ice, as is so beautifully seen in the ice-chapel not far from the Bartholomæus lake at Berchtesgad; only these masses never move; they fill no valley like a long ribbon, like a frozen cataract,—for they want *the pressure from above,* the only thing that can move them downwards into the valley.

M. Du Rocher has visited one of the three conical hills mentioned by Scoresby; he estimates it, from barometrical measurements on the declivity, at 1185 feet high (385 mètres); it is consequently higher than Mount Misery; and yet its steep acclivities were scarcely covered with snow; just because the sides of this cone are so steep. The violent winds do not allow the snow to rest on such abrupt slopes, says M. Du Rocher; and the almost horizontal rays of the sun fall nearly at right angles on the snow, though they touch the surface of the island at a very low inclination. Besides, this volcanic-looking cone consists, like all the other elevations on the island, of immense blocks of carboniferous sandstone heaped one above the other. Yet M. Du Rocher seems to have visited only the western side, and that only for seven hours, from mid-day to eight in the evening. This time may have been too short to draw the attention of the French naturalist to the profusion of instructive organic forms which fills this sandstone, and which Keilhau has collected with so much industry and care on the declivity of Mount Misery—at least the figures of petrifactions in the work of Gaimard contain only those observed in Spitzbergen, and even in Nova Zembla, but none from Bear Island.

The temperature of the air varied during Keilhau's stay on the island, in the middle of August, from $2\frac{1}{2}°$ to $4\frac{1}{2}°$ R. ($=37\frac{1}{2}°$ to 42° Fahr.); and on the west side of Nordhafen, at the base of a cliff ten feet high, two running springs gave, the one 0·6° ($33\frac{1}{3}°$ Fahr.), the other 3·8° R. ($40\frac{1}{2}°$ Fahr.); so that 2°—3° R. ($36\frac{1}{2}°$—$38\frac{3}{4}°$ Fahr.) may be considered as the mean temperature of the surface in this month,—a warmth sufficient to permit the lively growth of some flowers and herbs. Among these the *Cochlearia* is the most distinguished, flourishing more luxuriantly than even on the Kongsöar in East Finmark, then the deep blue *Cardamine bellidifolia, Saxifraga cernua* at least ten inches high, and abundance of *Polygonum viviparum* with white ears. Altogether the island produced twenty-eight distinct species of Phanerogamous and twenty-three of Cryptogamous plants.

M. Keilhau adds to these some other information regarding the temperature and the meteorological phænomena of Bear Island during winter, which he obtained from some seamen in Hammerfest who had passed the winter of 1823 and 1824 upon it. The notices are important, for the knowledge of the circulation of the atmosphere in the northern half of the earth, and form a striking contrast to the picture of winter at the mouth of the Kolyma, which is presented to us by Admiral Wrangel in his valuable 'Travels in Siberia,' a region which yet is far from being so far north as Bear Island. Southerly and westerly winds in November brought rain indeed, but no snow. East winds, on the other hand, in the beginning of December, and a snow-storm from the north-west, covered the coast with ice. The wind changed again towards the end of the month, and with a south wind rain even fell during the Christmas days. Walruses were caught at all times, by the light of the moon and the aurora borealis; and during Christmas week seventy were killed in one day. In January a great quantity of snow fell, which the violent wind again carried away; cold weather only occurred in February, and even then not so intense as to prevent them working in the open air.

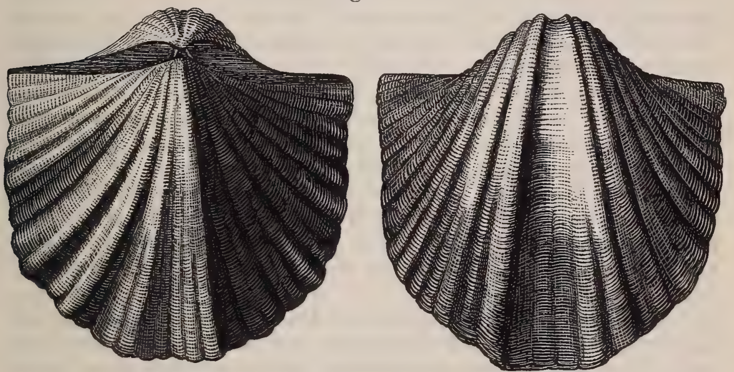
From the 18th February they again saw the sun, and with it the Stormy Petrel, *Procellaria glacialis* and *Laryx hyperboreus*. In March the cold increased exceedingly, especially with north-east winds, just as happens on all the eastern shores of the Atlantic as far down as Spain, where, in the beginning or middle of March, a considerable retrogression of the rising temperature is perceived during north-east winds; the Eider duck also again appeared. April was the coldest month, but only accidentally, and not in regular course. In May strong west winds broke up the ice on the sea; the earth thawed, and by the end of the month they could collect the Cochlearia in great abundance. The north-east winds in June and July anew enclosed the island with ice from the polar regions, so that the end of July first admitted of a free navigation. Other winters have been more severe, yet never so much so as to confine people to the house or prevent labour in the open air. The island thus still enjoys the beneficial warming influence of the Atlantic Ocean, and in this respect is very different from the neighbouring ice-bound Spitzbergen.

M. Keilhau has added to the collection in Christiana a sketch of Bear Island, and a section, on which is distinctly marked the various points where the different specimens were collected. These observations prove the remarkable and important fact that the coal strata of this island belong to the lower formation,—to that which is covered by the greater part of the Productus or carboniferous limestone, and which has been so thoroughly made known to us by the researches of MM. Murchison, Helmersen and Keyserling in Russia. In reality the coal forms the lowest bed in the island, and all the strata with petrifactions, to the very summit of Mount Misery, lie above it. This is very different from those deposits of coal which are wrought in Germany, Belgium, France, in by far the larger portion of England, and in vastly extended deposits in the Western States of North America, for these are never covered anew with beds containing marine shells belonging to this formation. The lower coal-seams on the Donetz and in the government of Kaluga are scarcely, in the Waldai district not at all, worthy of being wrought. They are mere thin discontinuous layers, yet they have the same composition with the thick beds of coal that lie above them. *Stigmaria ficoides* fills the sandstone below; fronds of *Pecopteris* and *Neuropteris* the upper part of the coal. Even in the beds of Bear Island M. Keilhau found a beautiful, perhaps a new, species of *Pecopteris,* which is preserved in the Christiana collection. In the highest beds above it, at 7 in the section (fig. 2), the *Productus giganteus* is common, sometimes two inches in diameter; besides the *P. punctatus* of equal size; and lastly the *P. striatus,* characteristic of the Productus limestone of the coal formation. These were even seen in the blocks which have fallen down from the summit of Mount Misery, along with the *Productus plicatilis* and with the new beautiful *Spirifer Keilhavii. Calamopora polymorpha* and *Fenestella antiqua* also occurred among these blocks, together with a striated Pecten with an angle of 60° at the hinge, and many finely striated fragments of Crinoidea with a round opening, but whose true nature could not be well determined without the head (Krone). All these petrifactions, and even the coal, are again found in Spitzbergen, and, it is probable, in exactly the same position. Keilhau himself found *Productus giganteus* on the south cape of Spitzbergen; and in 1839 the French naturalists observed the same species of Productus and Spirifer in Bell Sound, in latitude 78°. They are figured in the large Atlas (Livrais. xxvi.) to 'Gaimard's Polar Expedition.' And from still deeper-situated beds, whale-fishers brought sixty tons of coal from Isfiord to Hammerfest. Calamites, Sigillariæ, even Lepidodendron, are not uncommon in the same beds (Robert, Bull. de la Soc. Géol. xiii.).

According to these observations Bear Island forms the most southern point where this remarkable formation of carboniferous Productus beds occurs; for in the whole Scandinavian peninsula, which lies opposite to it on the south, not a trace of it has yet been discovered. But on the other hand it has been found by M. von Baer in Nova Zembla, and by Count Keyserling even on the shores of the icy ocean near Mezen and eastwards from the mouth of the Petschora. But when we follow, on the most complete of all the geognostic maps of Russia—on that which accompanies Murchison's great work on that country, and for which we are in great part indebted to his distinguished acuteness of talent for combination—the distribution of the Productus limestone, it immediately strikes the eye how it surrounds, in a great semicircle, the granite and gneiss mountains of Finland. This semicircle is now evidently continued on the northern side through Nova Zembla, Spitzbergen, and Bear

Island, although in these islands the characteristic petrifactions are enveloped in sandstone and not in limestone; and in this manner the Scandinavian peninsula as a centre is enclosed on the northern, the eastern, and the southern sides;—a nucleus round which a whole system of formations are grouped, and which has been the seat of mighty revolutions on the surface of the earth. That the southern limit of the Productus formation has been advanced so far to the south by the knowledge of the stratification of Bear Island is an important gain to geology, for which we are indebted to Keilhau's researches.

Fig. 3.



Ventral valve. Dorsal valve.

SPIRIFER KEILHAVII (fig. 3) belongs to that division of Spirifers (the winged, Alati) in which the hinge-border is not curved, and is as wide, or even wider, than the greatest breadth of the shell; the sides descend perpendicularly from the ends of the hinge-border, and unite with the front by a gentle curve. Thick broad ribs (Falten) cover the shell, and only six or eight on each side. These ribs are again divided, not only once, but each rib has usually at most two smaller ones on the sides. They are only simple towards the beak. These broad divided ribs particularly distinguish this Spirifer from others similar to it. In the sinus only the finer ribs are observed, and no larger ones. The beak is strongly curved over, and the area is consequently low and itself somewhat arched. The ventral valve is only moderately arched, indeed far less so than is usual in similar forms; the dorsal valve rises much higher. This dorsal valve is thickly covered with those siliceous groups and rings (Kieselsystemen und Kieselringen) which are always observed where shells become silicified. Here also the silicification takes place below the calcareous shell, which is pushed off and destroyed by the siliceous rings.

This Spirifer is nearly two inches broad, and almost as long. Length, 100; breadth, 111; thickness, 48; breadth to length of sinus = 40 : 100.

The division or dichotomy of the ribs and striæ is by no means so characteristic and decisive among Spirifers as among Terebratulæ;

for in simple-ribbed Spirifers an incipient dichotomy very often appears in the sinus. Yet a division so strongly marked as that of the ribs of *Spirifer Keilhavii* must be sufficient to establish a peculiar species. It does not appear so distinct and with so few ribs on the Spirifers of other regions, although related forms are easily found. Singularly enough, those with the greatest degree of similarity occur at the distance of the whole diameter of the globe from Bear Island, in Van Diemen's Land and the interior valleys of New South Wales.

Spirifer Tasmanni was brought to London along with many others by Count Strzelecki, and is described in his instructive work (Physical Description of New South Wales and Van Diemen's Land, 250) by the cautious and experienced palæontologist Mr. Morris, in London, and figured (pl. 15. fig. 2). It had, however, been deposited in the Royal Mineral Collection (Berlin) many years previously by M. von Dechen, and, singularly, under the same name that Mr. Morris has given it. It has many more, and hence smaller ribs, than the *Spirifer Keilhavii*, at least ten on each side, and the ribs are likewise bifurcated from the middle, or more commonly divided into three, two smaller on each side of the larger rib in the middle. The sinus and lobe (Wulst) are in it also covered with the finer ribs only, and a great part of the area is concealed under the curved-over beak.

Spirifer Stokesi (Strzelecki, pl. 15. fig. 1) would come nearer to the *Sp. Keilhavii*, were not the external form too distinct. For the sides of the shell converge towards the front, instead of being vertical, and the ventral valve rises considerably higher than the dorsal, and with more decided convexity. Otherwise there are in like manner six broader ribs on each side of the sinus, which divide into three distinct ribs. It is also found in Van Diemen's Land, and belongs to the carboniferous formation.

As Van Diemen's Land, the most southern promontory of the great continent of New Holland, terminates in formations full of Spirifers, this phænomenon is in like manner repeated on the promontories, so similarly formed, of Africa and South America. There also the beds, with which these quarters of the globe end, are especially characterized by species of Spirifers, thus proving that in them also the oldest strata known to us crop out, whilst on the other hand newer formations are rare in the southern hemisphere, and almost limited to the northern continents. The Spirifers, however, both of Cape Horn and the Falkland Islands, as well as those of the Cape of Good Hope, belong to the older Silurian strata, far removed from the coal formation, and not to the carboniferous limestone, like those found in the vicinity of Hobart Town in Van Diemen's Land. Hence these species of Spirifers are no longer covered with divided, but only with simple ribs. On Hokmans Kloof in Zwellendam, at the Cape, M. Kraus of Stuttgart, the no less bold than enterprising naturalist to whom we owe so many new and important discoveries in Port Natal, has discovered a whole stratum almost composed of such Spirifers. It is one of the largest species.

Spirifer Capensis. It is more than two inches broad, and belongs to the division of the *Ostiolati*, with perfectly smooth sinus; and among these to the subdivision of the *Spirifer speciosus*. The lateral ribs are much rounded and broad; hence only eight or nine ribs cover each side. The sinus is remarkably narrow and confined, as is common in the Spirifers whose hinge-border is broader than the valve. Its proportion to the whole breadth is as 17 : 100. The striæ of growth do not appear very distinct.

The most similar of all the species of Spirifers hitherto known is found in the Spiti valley in Thibet, on the northern declivity of the Himalaya. It was brought thence by the well-known Dr. Gerard to Calcutta, and has been well-figured, though without a name, by Hamilton Royle in his large botanical work. In this species, however, the striæ of growth project like scales.

On the Rhine also, not far from Ems, there are found lying between the casts, so remarkably numerous, of *Spirifer speciosus* var. *microptera*, other casts with divided ribs, and also only six on each side of the sinus. They are greatly broader than long; but for closer determination more perfect specimens are still desirable.

On the whole, however, it is very remarkable how species of Spirifers with divided ribs are far more peculiar to the Productus, or carboniferous formation, than to the older Devonian, or still more, the Silurian strata. From the latter not even a single species is known which has the smallest similarity with the Spirifers of Bear Island or of Van Diemen's Land. If dichotomy appears anywhere on the valves, it is only on the border of the sinus, and not on the sides. *Spirifer dorsatus* (His. Lethæa Suec. t. 21. f. 14) from the Silurian beds of the island of Gothland, which might perhaps be regarded as an exception, belongs to the Terebratula, and is not distinct from *Terebratula borealis*, Schl.

This law of the distribution of the species of Spirifers in the various older and newer formations appears very distinctly when we subject the species with divided ribs to a more accurate review. The more important, and those best known, are the following:—

1. *Spirifer Keilhavii*, in the Productus sandstone of Bear Island.
2. *Sp. pectinoïdes*, De Koninck, pl. 16. fig. 4 (*dichotomus*, Goldfuss), in the carboniferous limestone of Visé and of Ratingen, with finer ribs in the sinus.
3. *Sp. recurvatus*, De Koninck, from Visé, many fine ribs, divided on the border, in the sinus also, pl. 16. fig. 5.
4. *Sp. laxus*, Portlock, Geol. of Londonderry, pl. 37. fig. 6. With smooth sinus, four or five broad ribs on each side, which towards the border divide very wide and open. From the carboniferous sandstone of Fermanagh.
5. *Sp. furcatus*, McCoy in Griffith Ireland, pl. 22. fig. 12. Finer ribs in the sinus; five divided ribs on each side. It ought scarcely to be distinguished from the *Sp. pectinoïdes*. In the Irish carboniferous limestone.
6. *Sp. Strangwaysi*, De Verneuil, Murch. Russia, vol. ii. pl. 6. fig. 1. Very like the *Sp. trigonalis*, the ribs of which, however, do not dichotomize. Even in this species only a few of the lateral

ribs divide. In the carboniferous limestone of Russia near Moscow, and on the Dwina.

7. *Spirifer crassus,* De Verneuil, Russia, pl. 6. fig. 2. Seven or eight ribs in the sinus, which towards the beak unite in two. The dichotomy of the lateral ribs appears only on very few. De Koninck's *Sp. crassus,* on the contrary, has no dichotomy of the ribs. In the carboniferous limestone of Cosatschi-Datschi in the Ural.
8. *Sp. Blasii,* De Verneuil, pl. 6. fig. 9. The hinge-border is shorter than the breadth of the valves; in this respect the only instance of the kind. The dichotomy of the ribs is very distinct. From Kirilow in the Zechstein.
9. *Sp. fasciger,* Keyserling, Petschora, pl. 8. fig. 3. The ribs are divided into diverging bundles (büschelförmig), the hinge broader than the valve. Upper carboniferous limestone on the Soiwa.
10. *Sp. striatus,* with very distinct dichotomy of the numerous ribs. It has never yet been wanting where the carboniferous limestone occurs in considerable extent, and *Sp. mosquensis,* probably a mere variety of *Sp. striatus,* even distinguishes the upper beds of the carboniferous limestone in Russia, in opposition to the *Productus giganteus* characteristic of the lower strata.
11. *Sp. duplicostatus,* Phil., Yorkshire, vol. ii. pl. 10. fig. 1.
12. *Sp. semicircularis,* Phil., Yorkshire, vol. ii. pl. 9. figs. 15, 16. Both from the carboniferous limestone of Yorkshire.
13. *Sp. Stockesi,* Strzelecki, Phys. Descr. of New South Wales, pl. 15. fig. 1.
14. *Sp. Tasmanni,* Strzelecki, pl. 15. fig. 2. Both from the carboniferous limestone of Van Diemen's Land.
15. *Sp. undulatus,* a characteristic shell of the Zechstein in Northern Germany and England.

Besides the division of the ribs, all these Spirifers have this in common, that their area never stands upright in an even surface, as is so remarkably the case with *Sp. cuspidatus* and similar species, but that this area is always curved, and in great part even concealed by the beak, which is sometimes far curved over. But in this position the remarkable triangular opening from the beak to the hinge-border is *never grown up,* but always open. Only openings on even vertical areas permit this angular growing up to be observed. In them alone do lamellæ proceed from the point towards the hinge, which being concave towards the hinge, leave only a small opening towards the hinge-border, for the passage out of the filaments of the tendon by which the animal fastened itself to foreign bodies. M. de Verneuil (in his description of the Russian species of Orthis and Spirifer in Murchison's Russia, vol. ii.) has not sufficiently attended to this; he has forgotten the beautiful law of the correlation of organs, which led Cuvier to such surprising and splendid discoveries, and which has been developed in such an intelligent, lively and clear manner by Flourens in his work on Cuvier (Cuvier de Flourens, p. 151). He maintains that the deltidium of the Terebratulæ which pushes the tendon ever higher up and farther from the hinge-border, is not different from the lamellæ which close the opening of the Spirifer and Orthis, and hence names these, in a way that leads to confusion, the deltidium of the Spirifers. He even goes the length of believing that the perforation of the Terebratulæ is to be found also on the Spirifers, under the beak, only on these it is usually grown up. Assuredly this is not the case. When such openings appear on species of Spirifer or Orthis, their position is sometimes higher, sometimes lower, often on the side, then again on the point itself; there is thus no precise law for their situation, clearly proving that they owe their origin only to accidental circumstances. They are also wanting on the greater number of specimens, with no trace of having been grown up. M. de Verneuil tries to prove, that even in the Terebratula the deltidium is not always convex towards the hinge-border, concave towards the point, from a single species of Terebratula, the *T. pectiniformis* of the chalk. But in these Terebratulæ the two teeth of the ventral valve, as in the Calceola, are united into one elevated double tooth. The deltidium must rise over this tooth; and this produced an elevated medial ridge, by which the striæ of growth on the deltidium itself are elevated, and hence appear convex upwards. It is only an appearance; for each side of the striæ of growth is evidently concave upwards. And even were it otherwise, still the mode of growing in Terebratulæ from *below upwards,* in Spirifer and Orthis from *above downwards,* would not admit of any parallel between the two modes of growth. Even the long ridge, observable in the middle of the area of Calceola, is named by M. de Verneuil, and by many German palæontologists too, a deltidium, and they believe in reality that it is an opening in the middle of the hinge-border, again grown up at a subsequent period. How easily may one convince himself of the contrary! The striæ of growth on the area of Calceola proceed without interruption over the medial ridge, but here, in consequence of the slight elevation, are somewhat drawn upwards towards the point. Here also it is again the double tooth of the ventral valve which elevates the middle of the area into a ridge. Generally the ridge is interrupted; then the striæ of growth proceed forwards horizontally in the interval, which is not possible either in Terebratulæ or in Spirifer and Orthis. The middle ridge of Calceola has hence never been open, and has nothing in common with a deltidium.

All these may appear minutiæ of no moment; but they are not so, when we reflect that all the phænomena of organic forms stand in a necessary causal connexion, and that it is the duty of the naturalist to search out how one character draws all the others along with it as necessary consequences. The knowledge of the true nature of the deltidium of the Terebratulæ, with its absence in Spirifer and Orthis, enables us to comprehend the diverse development of all the other organs of these forms, and along with this, why the one lives in the greatest depths of the ocean, the other near the surface of the sea. And in this manner the inconsiderable small deltidium tells us whether in a certain formation we find ourselves on the sea-shore or in the depths of an almost unfathomable ocean.

[J. N.]

On the Fossil Insects of the Tertiary Formations of OENINGEN *and* RADOBOJ. By Professor OSWALD HEER of Zürich.—*Ueber die Fossile Insekten-Fauna der Tertiär-Gebilde von* OENINGEN *und* RADOBOJ, von Hrn. Prof. O. HEER.

[From Leonhard und Bronn's Jahrbuch für Mineralogie, Jahrgang 1847, p. 161.]

BESIDES the insects of Oeningen, I have also taken those of Radoboj in Croatia into consideration; to these are added a few species I discovered on the Upper Rhone, and some from Panchlug in Steyermark. My researches on the Coleoptera being now concluded, I am proceeding with the other orders, and hope to finish the whole within a year. This work will appear in the Memoirs of the Swiss Society of Naturalists in two parts. The first, containing the Coleoptera, will be published in a few months, as the seven plates (the figures all drawn by myself) are already engraved, and the text, of fifteen to sixteen sheets, at the press. On these seven plates 115 species of Coleoptera are figured, and in the work 119 described; 101 species from Oeningen, 14 from Radoboj, 3 from Panchlug, and 2 from the Upper Rhone. Only one species (*Telephorus tertiarius,* m.) occurs both at Oeningen and Radoboj. The hundred Oeningen species are divided into 68 genera and 34 families. Of these genera 51 still exist in the Swiss Fauna; 4 cannot be correctly determined; 5 genera, wanting in our present Fauna, belong to that of Southern Europe; one is found only in North America, and 7 are extinct. Only the last consequently are new genera, which introduce new and truly remarkable forms into the system, whilst the other genera exhibit only known types, but in peculiar species, foreign to the present world. The seven extinct genera, which chiefly distinguish the tertiary coleopterous Fauna from that now existing, belong to six different natural families; only one genus is so singular as to form a new family. Next to these peculiar Oeningen genera, a marked characteristic of this Fauna is the number of Buprestides and Hydrophilides. Most of the aqueous coleoptera of Oeningen belong to these latter families, whereas at present in our waters, and indeed throughout all Europe, the Dytiscides prevail. A comparison of the Oeningen coleoptera with those now living shows, that in general the most closely allied forms do not belong to our Fauna, but to that of Southern Europe. I will only mention the genera Capnodis, Perotis, Sphenoptera, Mycterus and Brachycerus, genera which characterise the countries on the Mediterranean, but are altogether wanting with us. To this must be added, that among the fifty-one genera still living in Switzerland, some (Mesosa, Sphenophorus, Gymnapleurus) only occur in the warmer districts; further, that almost all these genera are found also in Southern Europe, and that only a few among them belong to Switzerland and Germany, and not to the Mediterranean countries; I therefore think myself justified in affirming, that the coleopterous Fauna of Oeningen has the character of that of Southern Europe, or rather of the Mediterranean zone, but mingled with a few American forms.

[J. N.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

New Considerations on the Palæontology of Auvergne. By A. Pomel.

[Abridged from the ' Bulletin de la Société Géologique de France,' 2e série, t. iii. p. 198.]

The author commences with a summary of the labours of geologists who have described the fossil remains so abundantly scattered over Auvergne, from M. Bravard their first discoverer, to M. Croizet and M. Bertrand de Doue, whose works appeared previous to 1841. Up to that period, the fossiliferous beds of Limagne had been considered to belong to two epochs: 1st, the older lacustrine sedimentary beds; and, 2ndly, the more recent alluvial beds, consisting in some places of volcanic debris, wherein fossils were first discovered in this country. He then shows that this classification is incomplete with regard to the second epoch; and proposes his own, which he has arrived at after devoting several years to the study of the different localities which have furnished remains of vertebrated animals, often accompanied by M. Bravard and aided by his suggestions.

I. The more ancient division, comprising in one fauna all the species of the lacustrine beds of Velay and Auvergne, has all the characters of a Miocene deposit; a view of the subject according with the observations of M. Elie de Beaumont on the lines of dislocation, which had induced that geologist to refer these beds to the same epoch as those of the Loire and Beauce.

II. The second, which comprises the species buried in volcanic alluvium beneath the pumiceous conglomerates of Mont Perrier, is unquestionably a Pliocene fauna, as proved by the analogy, and even the perfect resemblance of the greater number of species to those of the subapennine beds of Tuscany. M. Rozet has independently arrived at the conclusion, that the basaltic phænomena of Auvergne were immediately connected and synchronous with the upheaval of the Alps in the chain of the Valois in Austria; which dislocation, as demonstrated by M. Elie de Beaumont, put an end to the subapennine formations. The species which lived during the Pliocene period, and were contemporary with this grand phænomenon, are therefore those whose remains we should expect to find beneath the oldest basaltic eruptions.

III. The third and most recent fauna, called by M. Pomel the Diluvian, comprises the species of all the localities now known, excepting those previously named: the beds are numerous, and scattered over Auvergne in the valley of Limagne. They are unquestionably synchronous with the great diluvial or erratic phænomena; for they contain the same species as the beds of that epoch, though quite different from them in geological characters, being usually the result of the slow and partial degradation of calcareous and basaltic hills.

This division differing from that of the naturalists of Auvergne, has been opposed by them, and especially by M. Bravard, who recognises four distinct faunas: the lacustrine Miocene; the Pliocene, or, as he terms it, the Mastozoic, characterized by the presence of the mastodon, and the absence of the elephant, horse, hippopotamus, &c.; the Elephantine, characterized by the presence of these last genera; and lastly the Diluvian, in which they as well as the rhinoceros are wanting. But as the species common to the two latter faunas are, as M. Pomel asserts, the most important, and the absence of the genera named depends upon the geological conditions under which they were entombed, these two faunas differ no more than the Mollusca of two beds reposing upon one another, which though of different mineralogical composition, yet belong to one subdivision of one and the same group which no geologist would propose to separate.

Two fossil faunas may be called distinct, when (many species of each being known) they admit of comparison by their types being generically analogous, though specifically distinct: in such case there are two parallel series of species more or less resembling, composing two zoological groups: those species which appear to be common must either be such as are doubtful from our imperfect acquaintance with them, or from their osteological character not being strongly marked, as is the case with the hare, the horse, &c. of the existing fauna. Now the two faunas proposed by M. Bravard under the names of Elephantine and Diluvian do not answer this description, since the species which pass from the one to the other are numerous, well-characterized, and important in many points of view. M. Pomel proceeds to establish the existence of two distinct faunas, the Pliocene and Diluvian. First considering the Carnivora, he shows that the *Ursus Arverniensis* of Étouaires is distinct from that of Champeix and Neschers. The *Canis spelæus* of Juvillac, *C. Neschersensis* of Anciat, and the *Vulpes fossilis* found in many other caverns, are very distinct from the *Canis megamastoïdes* of Mont Perrier. The Martins of the Diluvium are very different from *M. lutroides* of Pomel, and from the Zorilla lately discovered in Ardé by M. Bravard. The Otter from the same locality (*Lutra Bravardi*) cannot be confounded with the cavern species which does not occur in Auvergne. The Hyenas of Perrier, one of which also occurs in Tuscany, are quite distinct from those of St. Privat and Tormeil, which last are identical with the cavern species. The remarkable subgenus of *Felis* named *Stenodon* is peculiar to the Pliocene deposits; and the other *Feles* cannot be confounded with the more recent species of La Tour de Boulade and of Coudes.

The Pachyderms and Ruminants present even more striking distinctions: the Mastodon of Auvergne is replaced in the diluvial beds by the Elephant; and the remains of the two are never found mixed together. The Rhinoceros of the Pliocene beds of Perrier is quite distinct from the clumsy-proportioned *R. tichorhinus* of the Diluvium. A negative character of these two deposits may be noticed: the Pliocene beds do not contain the Horse or Hippopotamus; while the Diluvial beds are marked by the absence of the Tapir.

The numerous species of *Cervus* of the Pliocene age have no real resemblance to any existing; while those of the later fauna approach modern types, and one is even identical with a recent species.

The *Boves* of the Pliocene period are characterized by slender forms approaching the Antilopes; whilst, as in the case of the Rhinoceros, the Diluvial species are heavy and clumsy in their proportions.

The Rodents cannot supply such strong proofs, owing to our ignorance of their specific forms; at the same time the Arctomys of Perrier differs from that of the Diluvium of Paris, which appears to be identical with that of the synchronous beds of Auvergne. But even if no appreciable difference could be detected, it is evident no weight could be laid on this circumstance in considering genera so prolific in species, whose very extremes are so nearly related.

M. Pomel proceeds to show that the same character of non-identity of species does not obtain for the two faunas of M. Bravard, the Elephantine and the Diluvian. That naturalist considers the following localities as belonging to the former:—Champeix, Peyrolles, Tormeil, Malbatu, Paix, La Tour de Boulade, to which M. Pomel adds Anciat; and to the latter, Neschers and Coudes.

The Elephant is only well-known from the remains found at Malbatu, and in the alluvium extending from the foot of the Dômes: they present the two forms which have been named *E. primigenius* and *E. meridionalis,* which, according to M. de Blainville, are one species. The Hippopotamus has only been found in the newest tufaceous alluvia of Tormeil, and near Montaigu; and all the remains seem referable to the diluvial species. The Boar is also rare, and the remains are found at La Tour de Boulade and Coudes; also in a cavern in the Bourbonnais, with the Reindeer, Badger, &c.; but they belong to young individuals, and cannot therefore be characterized. The Rhinoceros is more abundant, and always with the short heavy proportions of *R. tichorhinus,* so abundant in the Diluvium of all Europe.

The Horse presents here, as elsewhere, the remarkable fact of its abundance in all the localities of this zoological system, under the form of two species, or races; the one tall and powerful, at Champeix, Paix, and Peyrolles; and the other smaller and slenderer, at Paix, La Tour de Boulade, Coudes, Neschers, Malbatu, &c., accompanied sometimes with remains of the same diluvial fauna. The bones at present known do not permit us to decide whether they belong to distinct species, or merely varieties; in which latter case they might be the parents of our existing Horse: however, the smaller species (or variety) seems to be characterized by a shorter lower jaw, which deserves to be noticed the rather, that of fifty individuals scarcely the most minute difference of size could be detected.

The most remarkable of the Ruminants (next to the Reindeer) is the *Bos primigenius*, which differs from the Aurochs in the mode of implanting of the horns and its thicker limbs: it is found, like the Horse, in almost every locality where fossil bones occur. Another *Bos*, less clumsy in form, resembling the existing species, has been found at Neschers and Coudes, and perhaps also at Peyrolles and Tormeil: a third species, still more doubtful, and found only at La Tour de Boulade, seems identical with the *B. minutus* of Clift, which bears great analogy to the existing Zebu.

A gigantic Goat, described by the author in a memoir read before the Institut in 1844, and named by him *Capra Rozeti*, occurs in the same deposit at Malbatu with the Elephant and Rhinoceros. A Sheep closely resembling the recent species is found at Coudes, Neschers, Obière, Chatelperron, and La Tour de Boulade. The author knows of but four *Cervi* of this fauna: 1st, the *C. intermedius* of Marcel de Serres, found in so many diluvial beds in Europe; 2nd, a Cervus of the subgenus *Hippelaphus* found at Peyrolles; 3rd, a species found at Coudes whose remains are very imperfect, but seem to refer it to the Roebuck; and 4th, a Reindeer, which is unquestionably the same as the recent, though named by M. Bravard *C. tarandoïdes*. The author considers the *C. pseudo-virginianus* and *C. coronatus* of Lunel-Vieil as individual forms of the Reindeer, that species being subject to considerable varieties of form in the teeth and antlers. The remains are found at Paix, La Tour de Boulade, St. Yvoine, Neschers, Coudes, and Clermont; also at Chatelperron, and perhaps under the basaltic scoriæ of St. Privat.

The Hare also existed at the same time with the Reindeer, but from the bad state of preservation of their remains no difference can be established except in size, in which they agree pretty well with the two existing species of this country. It is possible that the Lagomys also occurs, but the specimens are doubtful. Localities—Gresin, Coudes, Neschers, Obières.

The Marmots are represented by two species; one, resembling the alpine, has also been found near Paris by M. Duval; and the other, closely resembling the Spermophilus, is also found near Paris. The former is found at Champeix and Chatelperron; the second at Coudes, Neschers, and Paix.

The Hamster seems to be indicated by certain bones of a humerus pierced to the interior condyle; but this requires confirmation, from the want of the jaw. Localities—Coudes, Neschers.

Four species of Campagnols at least are found; one of the two largest is identical with that of the breccia of Cette, and the other resembles the Water Rat; while the two remaining seem identical with the small species of the country. The first is found at Coudes and Neschers; the second at those places and also at Champeix and Obière; and the third and fourth only at the first two places.

Insectivora of the genera *Talpa* and *Erinaceus* occur at Coudes and Neschers, but cannot be determined. However, a Hedgehog found at Peyrolles differs from the recent one by greater size, stronger limbs, and more powerful molars (*Erinaceus major*, Pomel).

M. Pomel says nothing of the remains of Batrachian and Ophidian reptiles, fishes, or birds, as they are not sufficiently marked.

In this association of genera and species it is easy to recognize the most recent fossil fauna, found in calcareous breccias, caverns, recent alluvia, and the true erratic diluvium subsequent to the most recent tertiary beds. Several of these species, it will be remarked, are common to the Elephantine and Diluvial faunas of M. Bravard, and these are often the very species which impart to the group its peculiar aspect; as for instance the *Arctomys citilus* and the Reindeer, which prove the conditions of climate during these two periods to have been identical; the *Canis spelæus* and *C. Neschersensis*, the Felis of the size of the Chittah, the *Cervus intermedius*, the Campagnols, the Sheep, the *Bos primigenius*, the Horse, &c. &c. If the large species are wanting, on whose absence M. Bravard lays stress as marking a distinction between his two faunas, that circumstance depends on the conditions under which the bones were buried and preserved. Thus, at Coudes the bones are found in a matrix of different degrees of coarseness, filling fissures of slight depth in a bed of travertine, which crevices are not of dimensions to admit any but small fragments of bones; so that it is impossible to expect to find in them the Elephant, Rhinoceros, Hippopotamus, &c. If any importance were laid upon the great number of small species which are found, unmixed with the remains of larger, at Neschers and Coudes, M. Pomel explains it by showing that their accumulation is due to birds of prey: at these places the bones of the Campagnol, Shrewmouse, Rat, Mole, birds, frogs and snakes are found agglutinated together in balls of the size of a small hen's egg, and crossing each other in all directions, in a manner exactly resembling the excrements of recent predaceous birds.

It has been stated that diluvial species are found under the lavas, in their crevices, and in the conglomerates which abut against their escarpments. It is clear therefore that these species lived both before and after the last volcanic eruptions. Nothing in the aspect of the country gives reason to believe that since those eruptions any important change in the surface has taken place: least of all is there ground to admit of those great catastrophes which are supposed to have changed the features of the surface of the globe, and to have destroyed its inhabitants. Nevertheless, it is at this period previous to all history that this race were driven from Auvergne. If Man were contemporary with them (of which there is no proof), it is impossible to attribute their destruction to him; since at the present day, with his improved arms and the powers which association gives him, he is unable to exterminate their living analogues. This only is certain, that the greater number of these species were not driven to other climates, but were destroyed by causes which it is difficult to appreciate.

M. Pomel then gives geological details of the sequence of formations as far as they can be traced. They admit of three divisions which may be designated by the name of the prevailing rock, viz. trachyte, basalt, and lava; the basalt having moreover triturated and worn down the trachytes, so as to have formed out of them pumiceous conglomerates. Now as Anciat has been enumerated by M. Pomel among the localities containing diluvial species in a pumiceous conglomerate, and as Pliocene species occur in a similar deposit on Mont Perrier, doubts had arisen as to the correctness of this identification, which M. Pomel proceeds to remove. The oldest basalts of the Issoire are those of Pardines, Broc, Perrier, &c., which repose on the lacustrine beds, or on alluvia containing quartz pebbles lying on trachyte. Against these basalts abut alluvia with volcanic debris, alternating with pumiceous tuffs containing immense blocks of trachyte. The plateau of the Col de Bonhomme is a detached part of the same conglomerate, as is proved by the alternations being the same. They form almost the whole top of the mountain, except on the north side, where a dyke occurs. The slope of the mountain on the north side is uniform and pretty abrupt: at its foot stands the small town of Champeix; and about halfway up are the remains of a bed of conglomerate at a much lower level than the lowest beds of the upper conglomerate: on the east side this bed is seen to abut against the slope of the soil which forms the base of the upper. The relations therefore between these two beds of conglomerate are the same as between the basalt and conglomerate of Mont Perrier: the lower bed, abutting against a slope formed subsequent to the deposition of the upper, must be the more recent. It is impossible to explain away this result by supposing the upper conglomerate to have been separated from the lower by an elevation of the soil; since the granite which forms the basis of the country is of nearly the same height on the two sides of the valley, and even slightly lower on the side where it passes under the north of the Bonhomme. Had the two deposits been basalts, they might by possibility be synchronous; the viscous nature and the cooling down of the border of the sheet of basalt arresting it even upon the edge of a slope; but it is a dynamical absurdity to make such a supposition for alluvia formed by running water at such different levels. These conglomerates therefore on the slope of the hills above Champeix are newer than those of the Croix de Bonhomme, which are identical with those of Pardines and Perrier; consequently newer than the basalts which these last contain; and *à fortiori* than the basalts which these last cover. M. Pomel includes in the locality of Anciat all this newer tufaceous conglomerate which extends from Montaigu-le-Blanc to beyond Coudes-Montpeyroux on the left bank of the Allier near its confluence with the valley of Champeix or Neschers. On the east of Perrier is a deposit related to that mountain as the Champeix conglomerates to those of the Bonhomme: it comprises the localities of Malbatu, Peyrolles, and Tormeil.

It follows that the alluvia and conglomerates of all these last-mentioned places form a system of deposits posterior to those of Perrier, from which they are also separated on zoological considerations.

It appears then that during the Diluvial period the centre of France has not only been deluged by lavas, but has been even still more violently convulsed by the later basaltic eruptions. It was therefore during that basaltic period that the extraordinary and complete change of animal life took place; a change respecting which we have sufficient data for asserting, that it did not result from the state of *local* disturbance to which central France was then subject. The phænomenon is of a *general* character, and connected most remarkably with the most curious physical fact that geological research has of late years brought to light.

From the Arctic countries to the most southern parts of Europe, diluvial beds frequently exhibit the singular phænomenon of the entombment of animals, identical with living species which now dwell only in the colder regions of our hemisphere. First of all the Reindeer, then the Lagomys, the Spermophilus, and less frequently the Glutton, and, what is not less remarkable, the Marmot, and a prodigious number of Bears, are found in the very lowest and most southern plains, where they could not exist at present, or only in very small numbers, from their habits and constitution being so opposed to the conditions of the climate. The Mollusca present the same remarkable fact of being found distant from their present habitats. But it is still more remarkable that, associated with these species now existing only in polar regions, we find other animals whose congeners at the present day belong exclusively to tropical countries. These last however, be it observed, are distinct from existing species, and the wonderful preservation of the soft parts of some shows them to have been organized so as to endure a rigorous climate. Besides, whenever species are not identical, it is impossible from a knowledge of those which exist, to predicate the habits and the conditions of climate necessary for the existence of those which are lost. This at least is undoubted, that species living at present only in snowy regions extended themselves during the diluvial period over all western Europe, in countries where it would be impossible for them now to exist. Is not this fact intimately connected with the greater extension of glaciers during that same diluvial period, and the consequent diminution of temperature in this hemisphere? Mr. Smith of Jordan Hill has made the same observation for the Mollusca contained in diluvial beds, which he looks upon as the results of ancient glaciers. M. Pictet had been struck with the same relations, when he considered that the Reindeer was the analogue of the living species; an important question which M. Pomel was the first to demonstrate rigorously. Independently of the support which these facts give to the theory of the greater extension of the ancient glaciers, we see in this diminished temperature the probable cause of the disappearance of the previous fauna which is of an eminently tropical character. It may be considered as established by these facts, that the same causes operated over a great part of Europe: and consequently the extension of the glaciers (which can be demonstrated to have taken place in some countries) was not the result of a greater altitude of those countries during the diluvial period; neither was their melting due to a local sinking, but the result of some general phænomenon, which has restored to these latitudes a higher temperature, and has banished glaciers and the animals which live in their neighbourhood to the extreme north, or to the summits of the highest mountains. Nevertheless, supposing the ancient glaciers to have prevailed to a greater extent, it is astonishing that no geological trace of them can be found in Auvergne, a country presenting much more elevated summits than others which bear traces of what are considered to be undeniable evidence of glacial action. M. Rozet has justly observed, that the scoriæ are all reposing in their places on the craters; the rough edges of the lavas, basalts and trachytes are as strongly marked as they could have been from their first formation; and the numerous heaps of detrital matter have none of the characters of moraines, but are such as would be produced by sudden, violent, and successive inundations.

Possibly volcanic action, which has been so intense on these mountains, has prevented the formation of glaciers by melting the accumulated snow: this would account for the many inundations this region has experienced, a phænomenon which is seen frequently to occur on the lofty mountains of both North and South America, where it occasions prodigious ravages.

From what has been said, it is evident that the climate of Europe, if not of the whole northern hemisphere, was very different during the alluvial period from that of the Pliocene, and also from that of the present time. It is impossible therefore to admit the opinion of M. Pictet, who considers the diluvian fauna as a transition to the creation of Man; for the admirable mechanism of the present order of things would be deranged in every part by a recurrence of the diluvial phænomena. The question of the introduction of Man into Europe before the end of the alluvial period might here be discussed; but the traces of his existence are so uncertain, and the bones described as human have so soon been shown to be erroneously named, that it is impossible to be too circumspect and cautious on a question so important.

We shall conclude this account of the characters of the animals that existed during the volcanic period of Auvergne by the following summary.

1°. In Auvergne three distinct faunas exist, which mark the Miocene, Pliocene, and Diluvian periods: the first is preserved in the lacustrine beds of Limagne; the second in the older pumiceous conglomerates; the third in the more recent conglomerates, under the newest of the basalts, in a great number of taluses at the foot or on the sides of the hills; and lastly under the lavas, in their fissures, and in the travertine and mud of some caverns.

2°. The Alluvial period commenced before the latest basaltic eruptions, and continued till after the formation of the volcanic craters and their lava-floods.

3°. This last period has been styled Diluvial, but improperly; since that name suggests an abrupt and instantaneous phænomenon, and not one continued for a great lapse of time. The erratic phænomena unquestionably occurred during this period; but it is no less certain that they are far from being universal, and that countries not affected by them (as for instance Auvergne) nevertheless contain alluvial deposits, resulting from little local inundations, which have been successive, and not contemporaneous. It would therefore be better to style this period 'alluvial,' since this name is more general, and is equally applicable to a diluvium, which is a particular and paroxysmal case of the former.

4°. The diluvial fauna cannot be divided into two distinct ones; for the characters on which it is proposed to distinguish them are arbitrary, or negative, and consequently erroneous.

5°. This fauna contains species still existing, though at present confined to the polar regions. The existence of these species in all western Europe indicates the temperature of that period to have been lower and more uniform than at present: it lends aid to the modern theory of the former extension of glaciers, when that theory does not exaggerate the consequences drawn from the co-ordination of facts, but remains within the modest limits of observation.

[J. C. M.]

Foraminifères Fossiles du Bassin Tertiaire de Vienne (*Autriche*), *découverts par* JOSEPH DE HAUER *et décrits par* ALCIDE D'ORBIGNY. Paris, 1846. 1 vol. 4to with 21 plates.

THE Chevalier von Hauer for many years employed his leisure in collecting the Foraminiferæ found in the tertiary strata around the Austrian capital. Having collected a very large number of species, he prevailed on M. A. d'Orbigny to undertake their description, when the Emperor of Austria agreed to furnish the funds necessary for preparing the plates and publishing the work. Besides an account of the species found in the locality mentioned, the work also contains some general views of the structure and classification of these microscopic shells, with some general palæontological considerations on their distribution in different formations. From these we extract a few particulars.

The Foraminiferæ have been found near Vienna in the beds of clay, or *tegel* as it is locally named, which occupy the lower part of the tertiary formation, and also in the marly limestones by which they are covered, but none have yet been procured from the fucoid sandstone (grès à fucoides) which overlies the whole. They have even been found in these beds 116 metres below the surface in boring an artesian well. It is not yet established whether each of the two beds has its peculiar species, but M. d'Orbigny thinks this probable, as the whole number from this basin is so very great. He has found 228 species in it, whilst in the fauna of the Antilles there are only 118 and in the Adriatic Sea 140, though these are the two places where they are most abundant at the present time.

Out of the 228 species at Vienna, thirty-three, or fourteen per cent., are also found in the subapennine tertiary beds near Siena in Italy. This fact would induce us to believe that the Vienna tertiaries belong to the same geological period, and on considering the agreement in forms and the general aspect of the species, they are found to be perfectly identical. In truth, as at Siena, the species of 'Stichostègues' prevail; the Bulimina are abundant, so also the Cristellaria, the Robulina, the Polystomella, the Rotalina, the Textularia, &c. &c.; and the whole characters of the species depend on the same series of external modifications. This view of the age of the beds is confirmed by the number of species, amounting to twenty-seven, or nearly twelve per cent., still living in the Adriatic or Mediterranean. This is a different view from that of M. Bronn of Heidelberg, who from the study of the mollusca places the tertiary formations of Vienna between the London clay of the English and the subapennine formations, or in the miocene of Mr. Lyell*. M. d'Orbigny has not yet had an opportunity of studying the mollusca in detail, and therefore refrains from giving any positive opinion.

Having given in this work the characters of all the genera which he knew, together with the geological and geographical distribution of the species, M. d'Orbigny concludes with some considerations on the history of these minute beings and their progressive development from the most ancient periods to the present. So far as then known, no Foraminiferæ had been observed in the Silurian or the Devonian formations. They first appear in the carboniferous beds in a single species, the *Fusulina cylindrica*, Fischer, but seem not to have survived their close. None are found in the Permian formation nor in the Trias, nor yet in the lower Jurassic beds. They again appear in the upper lias, in the marls of Saint-Maixent (Deux-Sèvres) and of Tuchan (Aude), in which he finds five species of the most simple forms. In the lower oolite again none are found, but eight species appear in the coralline beds (couches à polypiers) of Ranville (Calvados) which belong to the upper part of the great oolite or the Bathonien. In the Oxford beds again none occur, but they are pretty numerous in the coralline rock above, but again disappear in the Kimmeridge and Portland groups. On the whole, in the Jurassic formations only five genera, *Nodosaria*, *Vaginulina*, *Webbina*, *Cristellaria* and *Rotalina*, are found.

In the cretaceous formations new forms and species immediately appear in remarkable numbers, and go on augmenting in rapid succession. Instead of the five genera of the Jurassic rocks, the cretaceous contain thirty-two, of which eight are peculiar to them, having never been found either in the tertiary strata or recent. To the two orders of the Stichostègues and the Helicostègues found in the former, representatives of the Entomostègues and Enallostègues are now added. The whole order of the Agathistègues or Milioles are however want-

* In a notice of this work in his Journal, Prof. Bronn maintains his former opinion, at the same time stating that he has always considered the upper and middle tertiary formations as far more closely connected than the middle and lower, and that he has been confirmed in this by Grateloup's recent account of the nature of the beds near Bordeaux.

ing, and even in the very highest beds of the cretaceous formation the genus *Nummulina* does not occur.

In the tertiary the last-mentioned order with numerous genera, all, except two, the *Hauerina* and the *Fabularia,* likewise represented in our present seas, appear for the first time. They become more numerous both in genera and species as the beds are more recent, acquiring their maximum of development, both generic and specific, in the subapennine beds and the tertiary basin of Vienna. It is also remarkable that species analogous to those now living are only met with in the last stage of the tertiary formations.

M. d'Orbigny gives this tabular summary of the species peculiar to each geological epoch :—

Formations . .	Carboniferous.	Jurassic.	Cretaceous.	Tertiary.	Recent.
Genera	1	5	34	56	68
Species	1	20	280	450	1000

In conclusion he observes that the Foraminiferæ, few in number and of simple forms, first appear in the carboniferous beds. They become more numerous and complex in the Jurassic strata; still more so in the chalk. In the tertiary formations their diversity and number are greatly increased, and in the actual seas they attain the maximum of their numerical development. The generic forms exhibit a similar progression, many appearing and disappearing with the Jurassic, cretaceous and tertiary beds, as if to characterize precisely each grand epoch in the chronological history of the globe. Nothing can be more remarkable than the rapid and increasing succession of genera as the formations approach the present time, or rather, than that progress in perfection of these minute beings, which above all others have in their successive creations proceeded from the simple to the complex. The study of the Foraminiferæ, continued for twenty-eight years, has produced in M. d'Orbigny the complete conviction that the precise age of a geological formation may be determined from them alone, provided they are compared with the requisite precision. Many genera now live in the seas which are not found in the tertiary beds, yet it is easy to see that the relation between the existing fauna and that of the upper tertiary is far more close than that between the Jurassic and cretaceous faunas, or between the latter and the tertiary. In the present time they have also a peculiar geographical distribution, some genera being found only in warm, others only in cold regions, and each species generally confined to a special region. Of the 1000 existing species, 575 belong to the torrid, 350 to the temperate, and 75 to the frigid zone, so that, like the mollusca, they are more numerous and varied in their specific forms as the seas in which they live are warmer.

[J. N.]

On the Pterodactylus (Rhamphorhynchus) Gemmingi, *from the Calcareous Slates of Solenhofen.* By Hermann von Meyer.

[Extracted from 'Paleontographica: Beiträge zur Petrefaktenkunde' Herausgegeben von Dr. W. Dunker und Hermann von Meyer, 1 Heft.]

That period in the history of the earth whose records are preserved in the Oolite or Jura formations, from the Lias up to the Wealden, may be named the Middle Ages of geological chronology. This long epoch may be regarded as the time of Saurian dominion, these animals having then exhibited a richness of forms unequalled at any other period. For although these reptiles appear in many remarkable forms in the immediately preceding formations of the Trias, still in them we find no proofs of the existence of whole orders of Saurians which arose with the oolite group, and again vanished with its close; and in no period have the Saurians been poorer in forms than in the interval extending from the commencement of the tertiary deposits to the present time. This geological Middle Age is adorned by the Pterodactyles or Flying Saurians, whose earliest remains are found in the Lias, the latest in the Wealden, thus marking out the limits of this epoch.

Various views have been maintained regarding the nature of the Pterodactylus. Collini in 1784, when investigating the characters of the *Pt. longirostris*, was inclined to consider the animal as a fish. The Pterodactyles were however no more fish than they were birds, as Blumenbach in 1807 made them; or mammalia, among which they were placed by Sömmering three years later. Spix considered these animals as intermediate between Galeopitheci and the bats; Macleay as a connecting link between mammalia and birds; Wagler formed from the Monotremata together with Pterodactylus, Ichthyosaurus and Plesiosaurus, a fifth class of vertebrated animals, which he placed between the mammalia and birds; and in regard to the Pterodactylus he also believed that its feet were fin-shaped, like those in the marine tortoises or the small eared seal (*Otaria pusilla*). Even Agassiz believed it an error to consider the Pterodactylus as a flying reptile. According to his view the whole organization of the animal was such, that it must have lived in the water along with the Ichthyosaurus and Plesiosaurus; and from these beings, so very different in structure, he formed one family, that of the Palæosaurians. A long-continued study of the very interesting structure of these animals has only the more convinced me of the accuracy of the views published by Cuvier so early as the year 1800. The Pterodactyles were flying Saurians. The pneumatic structure of the bones, the connexion of the vertebral ribs with the sternum by means of osseous ribs, the osseous processes of the ribs in order to confer greater firmness on the chest, formed of the chief ribs, the sacral bone made up by the anchylosis of a great number of vertebræ, as well as the circumstance that in the posterior limbs the tibia is the longest bone, so strikingly recall the structure of birds, that it seems almost incomprehensible how any one can doubt that they were flying animals. This singular similarity to birds which have the most powerful flight is united with characters which more decisively connect the Pterodactyles with the Saurians, as appears in the structure of the skull, of the lower jaw, of the pelvis, in the teeth inserted in separate alveoli, as well as in the existence of abdominal ribs. The Pterodactyles thus form a long-extinct, independent class of Saurians, which had the power of flight, and also perhaps of moving on the surface of the water, yet not in the same manner as the tortoises, whose hand is differently constructed, and whose bones are not hollow but of a compact structure, as is also true of those birds which, like the Apteryx and Dinornis, were not adapted for flight. I therefore also believe that the Pterodactyles were not clothed with feathers like birds, nor yet with hair like the mammalia, but had a naked skin.

The name *Pterodactylus—wing-finger*—was well chosen by Cuvier. They are in reality distinguished from all other animals by this, that their finger gives them the power of flight; and indeed only one finger, the ear or little finger, as it is named from its small size in the hand of other creatures. In the Pterodactylus it acquires considerable length. The bats, which likewise are able to fly, can do so principally by means of their hand, in which four fingers are developed into instruments of flight, the thumb alone being excepted from this change. Besides, in the bat the lengthening of the hand takes place in the metacarpal bones, which in the Pterodactylus are not longer than ordinary. In the birds the hand is even more sparingly developed, and this is especially true of the fingers, which are never more than three in number even in young birds. In them the power of flight depends on the proportionate length of the fore-arm and upper-arm, and properly they are only enabled to fly by means of the wing-feathers, whose place is supplied in the Pterodactylus and bat by the fingers and connecting membrane.

A sufficient number of Pterodactyles are now known to induce us to attempt a plan for their classification. The wing-finger in these animals was always believed to consist of four phalanges. I was therefore surprised, in looking over the old collection of Lavater at Zurich, to find pieces of lithographic slate, with remains of a Pterodactylus, in which the wing-finger was composed of only two phalanges, like the long finger in birds, which this species likewise resembled in the wing-finger being articulated to a metacarpus formed of two strong bones; the hand otherwise being formed as in other Pterodactyles. Another peculiarity of certain Pterodactyles is, that the anterior extremity of the jaws was prolonged into a toothless point. Although this peculiarity seems to separate these Pterodactyles very widely from all others, yet *Pt. longicaudus* shows that it had no influence on the number of phalanges in the finger, which in this species always consists of four. On the other hand, the *Pt. Gemmingi* proves that the edentulous prolongation of the jaw was connected with a tail of remarkable length, with the anchylosing of the scapula and clavicle, and perhaps with the absence of an osseous ring in the eye. It is such characters that form the foundation of my scheme for classifying the Pterodactyli.

PTERODACTYLI.

Saurians with the little finger converted into a wing-finger by the remarkable prolongation of its phalanges. Peculiar to the Oolite or Jura formation of the European continent and of England.

A. Diarthri. Wing-finger with two phalanges (Ornithopterus, bird-finger).

Pterodactylus (Ornithopterus) Lavateri, *Myr.*—Solenhofen.

B. Tetrarthri. Wing-finger with four phalanges.

1. DENTIROSTRES. The jaw toothed to its anterior extremity; with an osseous ring in the eye, which is either simple or composed of a series of plates or scales; scapula and clavicle not anchylosed with each other; a short moveable tail (Pterodactylus).

Pterodactylus longirostris, *Cuv.*—Solenhofen.
—— brevirostris, *Cuv.*—Solenhofen.
—— crassirostris, *Goldf.*—Solenhofen.
—— Kochi, *Wagler.*—Kelheim.
—— medius, *Münst.*—Solenhofen.
—— Meyeri, *Münst.*—Kelheim.

Ob Dentirostres?

Pterodactylus dubius, *Münst.*—Solenhofen.
—— grandis, *Cuv.*—Solenhofen.
—— longipes, *Münst.*—Solenhofen.
—— secundarius, *Myr.*—Solenhofen.
—— ————, *Spix.*—Solenhofen.
—— Bucklandi, *Myr.*—Stonesfield, Tilgate, Solothurn.

2. SUBULIROSTRES. The anterior extremity of the jaw, with an edentulous prolongation to which a horny bill was attached; probably no osseous ring in the eye; scapula and clavicle anchylosed; a long stiff tail (Rhamphorhynchus, bill-nosed).

Pterodactylus (Rhamphorhynchus) macronyx, *Buckl.*—Lias in England and Franconia.
—— —— Munsteri, *Myr.*—Solenhofen.
—— —— longicaudus, *Münst.*—Solenhofen.
—— —— Gemmingi, *Myr.*—Solenhofen.

[J. N.]

Notes on the Geology of ASIA MINOR. By PETER VON TCHIHATCHEFF.

[From a Letter in Leonhard und Bronn's Neues Jahrbuch. Dritter Heft, 1847.]

Constantinople, 16th Feb. 1847.

I HAVE begun a new and dangerous undertaking, which has already engaged me for seven months. The object of my journey to the East is to complete a geological picture of Asia Minor and the neighbouring islands, with a general geological map of these regions. I have long wondered why the classic soil of Asia Minor, the object of so many archæological researches, has never been thoroughly explored in reference to its natural history in a detailed manner; as if Europe was so entirely occupied with the search after ruined cities, that it had not a thought to spare for the ground on which they stood, and on which many others equal to them may yet stand, and designedly endeavoured to forget the sublime works of nature by studying the ephemeral, dwarf-like card-houses of mankind. This omission I resolved to supply, and soon after the conclusion of my work*, which had occupied me full two years in Paris, I proceeded by Petersburg to Odessa, and thence to Constantinople. On my arrival here in last August, I wished to take advantage of the long beautiful autumn of this country, and set out immediately for Asia Minor, but could not leave Constantinople before September. This left me only three months, so that I limited my autumn campaign to Mœsia, Lydia, and part of Phrygia, which furnished employment enough till the end of December, when, on the approach of winter, only shown here by torrents of rain and inundations, I returned by Smyrna and the region of Troy to Constantinople. Here I mean to wait for spring, and again commencing my labours in the beginning of April, to traverse step by step all Asia Minor to the borders of Persia, an attempt requiring at least two whole years for its completion.

The country investigated during my three months' journey consists, first, of masses of blue or ash-grey, crystalline limestone, which in the total absence of fossils I may provisionally class in the "Transition period," partly from its analogy to the European and Siberian deposits of this formation, partly because it very often alternates with clay-slate, and still more so with mica-slate, and also passes into these rocks. Secondly, it contains formations of white limestone, marl and sandstone, which very probably belong to the cretaceous group, and indeed to the upper division of the chalk formation. Nummulites are the only fossils I could find in them, and these very partially distributed, being sometimes entirely wanting, sometimes accumulated in great numbers in certain very limited localities. Both the older limestone and the secondary deposits, here represented only by the chalk formation, are usually found in highly inclined strata. Thirdly, it presents tertiary deposits, with perfectly horizontal stratification, among which freshwater formations have by far the most important part. The whole plain of Troy along the Dardanelles has furnished me with a considerable collection of tertiary fossils, whilst on the other hand, the mountainous portions of this region consist of the "Transition limestone" and chalk, frequently broken through by plutonic rocks,—the latter generally forming the most prominent feature in the geological picture of Asia Minor. It is hardly possible to imagine the infinite variety of trachytes, diorites, dolerites, basalts, serpentines, melaphyres and similar rocks, which rivet the attention of the geologist at every step,

* Voyage scientifique dans l'Altai oriental.

and chaotically mingled together, have broken through and fractured the whole of Lesser Asia. Vast elevations seem also to owe their origin to plutonic action, and I have already had frequent occasion, for instance in the districts of Koutaya, Afiun, Karahissar, and Yalonetz, to observe extensive tracts, left white like level ground on all maps, and which actually appear like horizontal plains, which yet, according to my barometrical measurements, are from 5000 to 6000 Paris feet above the level of the sea. Indeed I expect my hypsometrical operations to furnish some very beautiful contributions to determine the plastic relations of Asia Minor. I employ for this purpose a thermo-barometer, improved by Regnault in Paris, and prepared for me under his directions, which is only about fifteen centimetres long. It is only by means of such a portable instrument that one can collect any considerable number of facts of this kind, in the midst of such a fanatical people, and whilst contending with difficulties of all kinds. The obstacles to the use of the common barometer, which cannot be preserved for any length of time in Asia, explain the reason of the height of so few points having been determined. I believe my own measurements, extending to about 165 points, which I hope to increase at least fourfold, exceed the sum of all those obtained by former travellers.

[J. N.]

On the Polished Rocks of SWEDEN. Extract from a Letter to PROFESSOR LEONHARD from JACOB BERZELIUS, dated Stockholm, Jan. 12, 1847.

THE controversy regarding the causes of the scratching and polishing of our rocks seems drawing to a conclusion. The memoir of Murchison in the Proceedings of the Geological Society of London has contributed greatly to this. Agassiz's friend Desor visited us in September last year, and on seeing the immense boulder deposits which in this country are named Åsars, stated without hesitation that these phænomena could not be explained by glaciers, and that they were not moraines. With this assertion the glacier theory falls to the ground. It is probable that Agassiz, who is now travelling in America, will also be convinced of its truth. When he formed his theory he had not seen these appearances on the majestic scale in which they frequently occur in the United States. But now, it is probable, a contest will arise of various opinions regarding the origin of such immense floods of water, and as nothing more than probable causes can ever be assigned, this conflict will never be decided. Whewell has already supposed a 'wave of translation' caused by the sudden elevation of a large tract of the bed of the sea. This indeed accounts for the violent but transitory motion of a large mass of water: our giant caldrons ('Riesentöpfe') however, often ten or fifteen feet deep, show that the flood which produced excavations of this kind could not have been so soon over.

[J. N.]

ALPHABETICAL INDEX

TO THE

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

The fossils referred to are described, and those of which the names are printed in italics are also figured.

THE END.

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