THE

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OF THE

GEOLOGICAL SOCIETY OF LONDON.

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THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

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1854.

PART THE FIRST.
PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:
LONGMAN, BROWN, GREEN, AND LONGMANS.

PARIS:—FRIED. KLINCKSIECK, 11 RUE DE LILLE; BAUDRY, 9 RUE DU COQ, PRES LE LOUVRE; LEIPZIG, T. O. WEIGEL.

SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.

MDCCCLIV.

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ERRATA.

Page 119, line 6 from the top, *for* L. Hopei and dubia *read* L. elegans, Hopei, and verticalis?

— 125, — 5 from the bottom, and p. 130, note, line 2, *for* Greyweathers *read* Greywethers.

— 127, — 14 from bottom, *for* Apchurch *read* Upchurch.

— 169, — 11 from bottom, *add* (magnified 15 diameters).

— 296, — 23 from bottom, *for* Fichtelgebirge *read* Vogelgebirge.

— 310, woodcut, *for* Atlantic *read* Pacific.

— 322, line 2 from top, *for* HEAPLEY *read* HEAPHY.

— 474, — 23 from top, for *breviceps* read *laticeps*.

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 17, 1854.

REPORT OF THE COUNCIL.

In laying their Annual Report before the Fellows of the Geological Society, the Council have again the satisfaction of congratulating them on its continued efficiency and prosperity. Its numbers have increased during the past year, its income has considerably exceeded its expenditure, and its publications have been more than usually demanded by foreign geologists.

During this period 26 new Fellows have been elected, and 5 elected in the preceding year have paid their admission-fees; making an increase of 31 new Members. On the other hand, there have been 13 deaths, 8 resignations, and 5 removals, viz. Fellows whose names have been struck off in accordance with the By-Laws of the Society; making the number of 26 to be deducted from 31, and leaving a total increase of 5. No change has taken place in the numbers of the Foreign Members; the Society has lost 2 by death, but this has been compensated by the election of 2 new Foreign Members. The total number of the Society has been thus raised from 866 in 1853 to 871 at the commencement of the present year.

The income of the Society during the past year (exclusive of composition-fees) has exceeded the expenditure by the sum of £112 3*s*. 3*d*.; an excess owing principally to the increased number of admission-fees. It will be remembered, that at the close of 1852 the excess of income over expenditure during that year was £70 12*s*. 3*d*.

The number of compounders at the close of 1852 was 133; at the close of 1853 it was increased to 134, three having died during the interval, and four Fellows having compounded; three of whose compositions, together with one received in 1852, but too late to be funded that year, have been invested in the funds. The total amount received from these 134 compositions is £4221. The amount of stock now held by the Society is £4014 15*s*. 8*d*., instead of £3888 10*s*. 6*d*., the amount held at the close of 1852; and its estimated value (taking Consols at 90) is £3613.

One composition remains unfunded, and the Council have to announce that, acting on the suggestion of some of its Members, who consider that the object recommended by the Auditors in 1833, viz. that all compositions should be funded until a capital sum should be created equal to the amount of compositions paid by the existing compounders, has been so nearly attained that a rigid adherence to the rule is no longer called for, they have resolved that the compositions for the year 1853 should not be funded. They trust that by investing these sums in the purchase of books and maps for the Library, in extending their publications, and in providing additional assistance in the Museum, the efficiency of the Society will be maintained, and its collections be rendered still more available to those engaged in the pursuit of geological investigation.

Acting on this principle, they have ordered that the sum of £50, out of the balance in favour of the Society during the past year, be applied to the purchase of books for the Library, and a further sum of £30 for the purpose of procuring assistance in the Museum.

The Council have to announce the completion of the 9th volume of the Journal and the publication of Part I. of Vol. X. They have also to announce, that, in consideration of the great importance attached to the Memoir of Mr. A. Geddes Bain, noticed in their last Annual Report, and the necessity of having the fossils engraved on a large scale,—in connection with the fact of Mr. Bain's former paper, with Professor Owen's description of the fossils, having been so printed,—they have resolved that Mr. Bain's last paper should also be printed in the 4to form, accompanied by a description of the fossils, prepared by the Committee appointed to report on the fossil shells. This will form Part IV. of the 7th Volume of the Transactions.

Since the publication of the Catalogue of books in the Society's Library, the increase has been so considerable both from purchases and donations, that the Council resolved at the close of last Session that a classed Supplement to the Library Catalogue should be forthwith prepared. Mr. Jones has since been as actively engaged in its preparation as his other duties will permit, and they trust that the Catalogue will be ready for the use of Fellows in a very short time. It will also contain a list of the principal MS. Maps and Sections which have come into the Society's possession in explanation of original papers and memoirs read at the evening meetings.

In conclusion, the Council have to inform the Society that they have awarded the Wollaston Palladium Medal for this year to Richard Griffith, Esq., LL.D., F.R.S.E., M.R.I.A., and F.G.S., Inspector-General of Her Majesty's Royal Mines in Ireland, and Chairman of the Board of Commissioners of Public Works in Ireland, for the valuable services rendered by him to Geological Science, and particularly for his Geological Map of Ireland, the result of his own laborious and judicious researches; the Council have further resolved, that the balance of the proceeds of the Wollaston Donation Fund be awarded to Mr. S. P. Woodward for his recent palæontographical labours, and to assist him in the publication of his researches on the Structure and Affinities of Brachiopoda and Rudista.

Report of the Library and Museum Committee.

Library.

The Museum and Library Committee report that the books that have been presented and purchased during the year have been catalogued, placed on the shelves, and bound as far as necessary. Amongst the presented books we have specially to refer to Dr. Carpenter's present of eight volumes of the "Annals and Magazine of Natural History," from 1841 to 1844. The shelves already provided are so nearly full, that it is probable that at no distant date further accommodation may be required.

The Supplemental Catalogue of Books, which Mr. Jones has been preparing, is almost ready to go to press, and that of the Maps and Charts, as well as the principal Manuscript Sections and Drawings in the Society's portfolios, will soon follow. These portfolios (referred to in the last Annual Report) now include most of the original drawings, sections, and maps which have accompanied the memoirs read to the Society. Additional room being required for portfolios to contain the MS. Sections and Drawings, we recommend that a new case be provided in one of the window-recesses in the Lower Museum.

All those maps and sections ordered by the Map Committee to be mounted, have been mounted and put in cases, so as to be easily accessible.

The Committee recommend to the Council that application should be made to the Board of Ordnance for copies of the new editions of such Maps of the Ordnance Survey as have been altered and republished, and also for a copy of the Survey of London.

Museum.

Additional glass-cases have been made for some Fishes from the Old Red Sandstone and for some Oolite Ammonites, in the Lower Museum. The Committee feel it their duty to suggest that the Collection would be rendered much more useful to the Members and Students consulting the Cabinets, if a person were engaged to work under Mr. Jones's direction in cleaning, arranging, labelling, and cataloguing the Fossils in the Museum. It would also greatly enhance the utility of the Collections, if the British species of Fossils contained in the Lower Museum were marked off in an interleaved copy of the forthcoming edition of Mr. Morris's "Catalogue of British Fossils;" which might possibly be effected, could several Fellows be induced to render temporary assistance in the departments of Palæontology with which they are most familiar.

Among the donations, the following are especially worthy of notice. Fossil Plants from the Great Oolite of the Cotswold Hills, Fossil Insects from the Lower Lias of Lyme, and Fossil Insects and Plants from the Wealden of Hastings, presented by Mr. W. R. Binfield. Also a Suite of Shells from the London Clay of Highgate, from Mr. N. T. Wetherell, F.G.S.

To the Foreign Collection have been added a series of fossils from Persia, presented by Mr. Kennett Loftus, F.G.S.; a series of freshwater fossils from Nagpoor, by the Rev. Messrs. Hislop and Hunter;

fossil shells from Panama, by Mr. Saunders, F.G.S.; and a valuable series of Tertiary, Cretaceous, and Jurassic fossils from Switzerland, presented by Mr. Greenough, F.G.S.

Signed, DANIEL SHARPE.
ANDREW C. RAMSAY.
February 1, 1854. JOHN M. CLABON.

Comparative Statement of the Number of the Society at the close of the years 1852 *and* 1853.

	Dec. 31, 1852.		Dec. 31, 1853.	
Compounders		133		134
Residents		213		204
Non-residents		450		463
		796		801
Honorary Members	16		16	
Foreign Members	50		50	
Personages of Royal Blood	4	—70	4	—70
		866		871

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1852 *and* 1853.

Number of Compounders, Residents, and Non-residents, December 31, 1852				796
Add, Fellows elected during former years, and paid in 1853	Resident	4		
	Non-resident	1		
		— 5		
Fellows elected, and paid, during 1853	Resident	11		
	Non-resident	15		
		—26		
			—	31
				827
Deduct, Compounders deceased			3	
Residents „			3	
Non-residents „			7	
Resigned			8	
Removed			5	
			—	26
Total number of Fellows, 31st Dec. 1853, as above				801
Number of Honorary Members, Foreign Members, and Personages of Royal Blood, December 31, 1852				70
Add, Foreign Members elected during 1853				2
				72
Deduct, Foreign Members deceased				2
			As above	70

Number of Fellows liable to Annual Contribution at the close of 1853, with the Alterations during the year.

Number at the close of 1852		213
Add, Elected in former years, and paid in 1853		4
Elected and paid in 1853		11
Non-residents who became Residents		3
		231
Deduct, Deceased	3	
Resigned	8	
Compounded	4	
Became Non-resident	7	
Removed	5	
	—	27
As above		204

Deceased Fellows.

Compounders (3).

Major-Gen. Colby. | The Earl of Shrewsbury.
Charles Stokes, Esq.

Residents (3).

J. H. Barchard, Esq. | G. O'Gorman, Esq.
H. W. Taylor, Esq.

Non-Residents (7).

William Baker, Esq.
James Foster, Esq.
Montague Gore, Esq.
Edward Horne, Esq.
A. Robertson, Esq.
H. E. Strickland, Esq.
Samuel Woods, Esq.

Foreign Members (2).

Baron L. von Buch. | Professor L. Herminier.

The following Persons were elected Fellows during the year 1853.

January 5th.—Edward Joseph Lowe, Esq., Nottingham; and Thomas Allinson Readwin, Esq., Beaumont Street, Marylebone.

—— 19th.—John Brogden, Jun., Esq., Gloucester Terrace.

February 23rd.—James Bright, M.D., Cambridge Square; David Forbes, Esq., Espedal, Norway; and Joachim Ottè, Esq., Hereford.

March 23.—Herbert F. Mackworth, Esq., Clifton; Lovell Reeve, Esq., Henrietta Street; Thomas H. Henry, Esq., Lincoln's Inn Fields; William Fairbairn, Esq., Ardwick, Manchester; Colonel T. S. Heneken, Ponton, San Domingo; H. H. Howell, Esq., Geological Survey of Great Britain, and John K. Blackwell, Esq., Westbourne Place.

April 6th.—J. Mainwaring Paine, Esq., Farnham.

—— 20th.—Robert Death, Esq., Camden Town; and Arthur Phillips, Esq., Stamford Street.

May 4th.—Philip Wm. Wall, Esq., Great George Street.

—— 18th.—Lord Moreton, M.P., Ennismore Place.

June 15th.—Robert P. Greg, Jun., Esq., Norcliffe Hall, near Manchester; Edward W. Whinfield, Esq., Hemel Hempstead; and Professor Robert Harkness, Queen's College, Cork.

November 2nd.—George Shaw, Esq., Birmingham.

—— 16th.—E. W. Binney, Esq., Manchester.

—— 30th.—John Lister, M.D., Sandown, Isle of Wight; Rev. W. L. Symonds, M.A., Pendock Rectory, Tewkesbury; David Page, Esq., St. Andrews; and Augustin Robinson, Esq., Eaton Square.

December 14th.—Rev. Professor Samuel Haughton, M.A., Trinity College, Dublin; Professor Isaac Newton Loomis, M.D., Georgia, U.S.; Rev. Francis F. Statham, M.A., Walworth; and Samuel Highley, Jun., Esq., Fleet Street.

The following Persons were elected Foreign Members.

June 1st.—Count Alexander Von Keyserling, Imperial Russian Mining Corps; and Laurent-Guillaume de Koninck, M.D., Professor of Chemistry and Palæontology in the University of Liège.

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

British Specimens.

Three specimens of *Hydnophora cyclostoma*, from the Carboniferous Limestone; presented by G. Tate, Esq., F.G.S.

Boulders from Scotland, &c.; presented by R. Chambers, Esq., F.G.S.

Suite of Fossils from the London Clay; presented by N. T. Wetherell, Esq., F.G.S.

Fossil Plants from the Cotswolds; Fossil Insects from Lyme Regis; Fossils from Cheltenham, &c.; presented by W. R. Binfield, Esq.

Stigmaria, from Wednesbury; presented by J. Hobbins, Esq., F.G.S.

Suite of Fossils from Farringdon; presented by D. Sharpe, Esq., Treas. G.S.

Suite of Fossil Insects, Plants, and Shells, from the Wealden of Hastings; presented by Messrs. W. R. and H. Binfield.

Specimen of Lias rock with Nummulites, from Fretherne Cliff, Gloucestershire; presented by the Rev. P. B. Brodie, F.G.S.

Foreign Specimens.

Two Cases of Rock Specimens from Ascension; presented by Lieut. Townsend, R.N.

Fossils from Gothland; presented by R. Chambers, Esq., F.G.S.

Series of Fossils from St. Domingo; presented by Colonel Heneken, F.G.S.
Series of Fossils from Central India; presented by the Rev. S. Hislop and the Rev. R. Hunter.
Suite of Fossils from Biaritz and Series of Nummulites from Bayonne; presented by S. P. Pratt, Esq., F.G.S.
Fossil Foot-tracks from Nova Scotia?; presented by Sir Charles Lyell, F.G.S.
Fossils, &c. from Egypt; presented by James Halford, Esq.
Fossils from Panama; presented by G. H. Saunders, Esq., F.G.S.
Series of Fossils from Persia; presented by W. K. Loftus, Esq., F.G.S.
Fossils from California; presented by F. Catherwood, Esq.
Copper and Lead Ores from Greenland; presented by A. Robinson, Esq., F.G.S.
Series of Tertiary, Cretaceous, and Jurassic Fossils from the Alps of Switzerland; presented by G. B. Greenough, Esq., F.G.S.
Series of Rock Specimens and Minerals from New South Wales; presented by Lieut.-Col. Sir Thomas Mitchell, LL.D., F.G.S.

Charts and Maps.

The Charts, &c., published by the Admiralty during the past year; presented by Rear-Admiral Sir Francis Beaufort, Hon. M.G.S., by direction of the Lords Commissioners of the Admiralty.
Geological Survey of Great Britain. Maps, Nos. 59 N.E., 62 N.W., S.W., 72 N.E., S.E. and S.W., 77 N.E., 78, 81 N.E. and S.E., 82 N.W. and S.W. Horizontal Sections, 19, 23, 24 and 25. Vertical Sections, 16, 17, 18, 26, 27, 28, 29, 30, 35 and 36. Indices to the Counties of Kildare, Carlow, Wexford, and Dublin; presented by Sir H. T. De la Beche, F.G.S., on the part of Her Majesty's Government.
17 Charts published by the Dépôt de la Marine; presented by the Director-General of the Dépôt de la Marine.
Carte Géologique de la Suisse, par MM. B. Studer et A. Escher, Dressée sur la Carte Géographique de la Suisse de M. J. M. Ziegler; presented by Daniel Sharpe, Esq., Treas. G.S.
Map of the Route between Pekin and Canton; presented by Sir G. Staunton, Bart., F.G.S.
Geognostische Karte von den Erz-Lagerstätten des Muschelkalksteins bei Tarnowitz und Benthen in Oberschlesien.
Geognostische Karte von Oberschlesien, entworfen von K. v. Carnall (2 sheets).
Karte der Bergwerks-Reviere an der Sieg. Sheets 1 to 8; presented by Messrs. Simon Schropp and Co.
Geological Map of the Northern Front of the Vindhya Hills, extending from Allahabad to Rajmahal, by Capt. W. S. Sherwill; presented by the Honourable East India Company.
Geological Map of Ireland, by Richard Griffith, Esq., LL.D., F.G.S.; presented by the author.

Geological Map of Ireland, reduced, by Richard Griffith, Esq., LL.D., F.G.S., Lithographed in Colours; presented by the author.

Marble Bust of Sir Roderick Impey Murchison, V.P.G.S., by Richard Westmacott, Esq., R.A., F.G.S.; presented by Lady Murchison.

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

Académie Royale des Sciences de Belgique.
Académie des Sciences de Dijon.
Académie des Sciences de Montpellier.
Academy of Sciences of Berlin.
Academy of Sciences of Breslau.
Academy of Sciences of Paris.
Admiralty, The Right Hon. the Lords Commissioners of the.
American Academy of Arts and Sciences.
American Philosophical Society.
Art Union of London.
Asiatic Society of Bengal.
Athenæum Journal, Editor of.

Ball, R., Esq., LL.D.
Barrande, M. J.
Basel Natural History Society.
Berwickshire Naturalists' Club.
Bigsby, John J., M.D., F.G.S.
Binfield, W. R., Esq.
Blackwell, J. K., Esq., F.G.S.
Bland, T., Esq., F.G.S.
Bombay Branch of the Royal Asiatic Society.
Bombay Geographical Society.
British Association for the Advancement of Science.
British Government.
Brodie, Rev. P. B., F.G.S.

Calcutta Library.
Calvert, J., Esq.
Canadian Journal, Editor of the.
Carpenter, Wm., M.D., F.G.S.
Catherwood, F., Esq.
Chambers, Robert, Esq., F.G.S.
Chemical Society of London.
Cheshire, E., Esq.
Civil Engineers' Journal, Editor of the.
Colonial Office.

Dana, J. D., Esq., For. M.G.S.
Daubeny, Prof., M.D., F.G.S.
Daubré, M. A.
Davidson, Thomas, Esq., F.G.S.
De la Beche, Sir H. T., F.G.S.
Delesse, M. Achille.
Dépôt Générale de la Marine de France.
Deslongchamps, M. E.
Desor, M. E.
Dewael, M. N.-Ch.
D'Halloy, M. J. J. D'Omalius, For. M.G.S.
D'Orbigny, M. C.
Dowler, B., M.D.

East India Company, The Hon.
École des Mines de Paris.
Enniskillen, Earl of, F.G.S.
Escher, M. A.

Forbes, Prof. E., Pres. G.S.
Force, P., Esq.
Forrester, J. J., Esq.
Francis, W., M.D.

Geological Institute of Vienna.
Geological Society of Berlin.
Geological Society of Dublin.
Geological Society of France.
Geological Society of the West Riding, Yorkshire.
Greenough, G. B., Esq., V.P.G.S.

Griffith, R., Esq., LL.D., F.G.S.

Halford, James, Esq.
Hall, James, Esq., For. M.G.S.
Halle Society of Natural Sciences.
Hare, Dr.
Heer, Prof. O.
Heneken, Col., F.G.S.
Hislop, Rev. S.
Hobbins, J., Esq.
Hogg, J., Esq.
Horsfield, Thomas, M.D., F.G.S.
Horticultural Society.
Hunter, Rev. R.

Imperial Academy of Sciences of Vienna.
Indian Archipelago Journal, Editor of the.
Institute of Actuaries.

Kopp, Herr H.

Leeds Philosophical Society.
Liebig, Prof. J.
Linnean Society.
Literary Gazette, Editor of.
Loftus, W. K., Esq., F.G.S.
London Institution.
Lowe, E. J., Esq., F.G.S.
Lyell, Sir Charles, F.G.S.
Lynch, W. F., Esq.

Maclear, Thomas, Esq.
Maury, Lieut. M. F.
Medical Circular, Editor of the.
Meneghini, Prof. G.
Meyer, Herr H. von, For. M.G.S.
Mitchell, Lieut.-Col. Sir T. L., LL.D., F.G.S.
Moore, J. C., Esq., V.P.G.S.
Morant, A. W., Esq., F.G.S.
Morton, Dr. W. T. G.
Murchison, Sir R. I., F.G.S.
Murchison, Lady.
Muséum d'Histoire Naturelle de Paris.
Museum of Practical Geology.

Nicol, Prof. J., F.G.S.
Norton, C. B., Esq.
Nyst, M. A.

Owen, D. Dale, Esq.
Owen, Prof. R., F.G.S.

Palæontographical Society.
Pfeil, Herr L. G. von.
Photographic Society.
Pictet, Prof. F. J.
Pole, William, Esq., F.G.S.
Ponzi, M. G.
Portlock, Lieut.-Col. J. E., R.E., F.G.S.
Pratt, S. P., Esq., F.G.S.
Puggaard, Herr C.

Quetelet, M. A.

Ringold, Commander.
Robinson, A., Esq., F.G.S.
Royal Academy of Belgium.
Royal Academy of Munich.
Royal Academy of Stockholm.
Royal Academy of Turin.
Royal Agricultural Society of England.
Royal Astronomical Society.
Royal Cornwall Polytechnic Society.
Royal Geological Society of Cornwall.
Royal Institution.
Royal Irish Academy.
Royal Society of Edinburgh.
Royal Society of Liège.
Royal Society of London.

Sabine, Colonel, F.G.S.
Salter, J. W., Esq., F.G.S.
Sandberger, Dr. G.
Saull, W. D., Esq., F.G.S.
Saunders, G. H., Esq., F.G.S.
Schropp and Co., Messrs.
Sedgwick, Rev. Prof., F.G.S.
Sharpe, D., Esq., Treas. G.S.
Silliman, Prof., M.D., For. M.G.S.
Smithsonian Institution.
Société Hollandaise des Sciences à Haarlem.

Société Impériale des Naturalistes de Moscou.
Société Météorologique de France.
Société des Sciences Naturelles de Neuchâtel.
Society of Arts.
Sorby, H. C., Esq., F.G.S.
Staunton, Sir G. Thomas, Bart., D.C.L., M.P., F.G.S.
Stewart, Lieut.-Gen. G. N.
St. Petersburg, Imperial Academy of.
Studer, Prof. B., For. M.G.S.
Sutherland, P. C., M.D.
Sydney University.

Tate, G., Esq., F.G.S.
Taylor, R., Esq., F.G.S.
Tennant, Prof. J., F.G.S.
Townsend, Lieut., R.N.
Tylor, A., Esq., F.G.S.

Vaudoise Société des Sciences Naturelles.
Venetian Society.
Verneuil, M. M. de, For. M.G.S.

Westwood, J. O., Esq.
Wetherell, N. T., Esq., F.G.S.
Wiesbaden Natural History Society.
Wrottesley, Lord.

Ziegler, M. J. M.
Zoological Society.

List of Papers *read since the last Anniversary Meeting, February 18th,* 1853.

1853.

Feb. 23rd.—On the Microscopical Structure of the Skin of the Ichthyosaurus, by Henry Coles, Esq., F.G.S.

———— On the Geology of the neighbourhood of Quebec, by John J. Bigsby, M.D., F.G.S.

March 9th.—On the Albert Coal Mine, Hilsborough, New Brunswick, by J. W. Dawson, Esq.; communicated by Sir Charles Lyell, V.P.G.S.

———— On the Carcharodon and other Fish Remains of the Red Crag, by Serles Valentine Wood, Esq., F.G.S.

March 23rd.—On the Geology of St. Domingo, by Colonel T. S. Heneken, F.G.S., with Notices of the Corals, by William Lonsdale, Esq., F.G.S., and of the Molluscs, by John Carrick Moore, Esq., F.G.S.

———— On the Upper Palæozoic Series of Strata of the Boulonnais, by R. A. C. Austen, Esq., Sec. G.S.

April 6th.—On the Carboniferous and Silurian Rocks of Busaco, Portugal, by Senhor C. Ribiero and Daniel Sharpe, Esq., Treas. G.S.; with notices of the Fossil Molluscs, by D. Sharpe, Esq., F.G.S.; of the Fossil Plants, by C. J. F. Bunbury, Esq., For. Sec. G.S.; of the Trilobites, by J. W. Salter, Esq., F.G.S.; and of the Entomostraca, by T. Rupert Jones, Esq., F.G.S.

———— On the Granitic District of Inverary, Argyleshire, by His Grace the Duke of Argyll, F.G.S.

April 20th.—On the Physical Structure and Succession of the Lower Palæozoic Rocks of North Wales and Part of Shropshire, by Prof. Andrew C. Ramsay, F.G.S.

———— On the Silurian Rocks of Kirkcudbright Bay, by Prof. Robert Harkness, F.G.S.

1853.

April 20th.—On the Occurrence of Caradoc Sandstone at Great Burr, in South Staffordshire, by J. B. Jukes, Esq., F.G.S.

May 4th.—On a Freshwater Deposit in the Drift, in Huntingdonshire, by the Rev. H. M. De la Condamine, F.G.S.

——— On the Fluvio-Marine Tertiaries of the Isle of Wight, by Prof. E. Forbes, Pres. G.S.

May 18th.—Palichthyologic Notes, Nos. IV. and V., by Sir P. G. Egerton, Bart., M.P., F.G.S.

——— On the Structure of the Strata between the London Clay and the Chalk; Part II., the Woolwich and Reading Series, by Joseph Prestwich, Jun. Esq., F.G.S.; with Notices of the Fossil Molluscs, by Prof. Morris, F.G.S.; and of the Fossil Entomostraca, by T. Rupert Jones, Esq., F.G.S.

June 1st.—On the Southern Termination of the Erratic Tertiaries; and on the remains of a Bed of Gravel on Clevedon Down, by Joshua Trimmer, Esq., F.G.S.

——— On the Origin of the Soils on the Chalk of Kent, Part III., by Joshua Trimmer, Esq., F.G.S.

——— On the Geological and Glacial Phenomena of the Coasts of Baffin's Bay and Davis' Straits, by P. C. Sutherland, M.D.; communicated by Prof. A. C. Ramsay, F.G.S.

June 15th.—On some Sections through the Oolite district of Lincolnshire, by Prof. John Morris, F.G.S.; with descriptions of some new species of Molluscs from the Lincolnshire Oolites, by J. Lycett, Esq.

——— On the Insect Beds in the Purbeck Formation of Dorset and Wilts, by the Rev. P. B. Brodie, F.G.S.

——— On the Occurrence of the remains of a Neuropterous Insect in the Stonesfield Slate of Gloucestershire, by the Rev. P. B. Brodie, F.G.S.

——— Description of some Fossil Insects from the Purbeck Formation of Dorset and Wilts, by J. O. Westwood, Esq.; communicated by the Rev. P. B. Brodie, F.G.S.

——— Description of the Remains of Neuropterous and Coleopterous Insects from the Stonesfield Slate of Gloucestershire, by J. O. Westwood, Esq.; communicated by the Rev. P. B. Brodie, F.G.S.

——— On the Microscopic Structure of some Freshwater Marls and Limestones, by H. C. Sorby, Esq., F.G.S.

——— On the Sooliman Range, by Dr. A. Fleming; communicated by Sir R. I. Murchison, F.G.S.

——— On the Geology of a Part of Sinde, by H. B. Frere, Esq.; communicated by Lieut.-Col. Sykes, F.G.S.

——— Notice of an Ichthyolite from Kotah, Deccan, by Dr. T. L. Bell; communicated by Lieut.-Col. Sykes, F.G.S.

——— On the Erratic Tertiaries bordering the Pennine Chain, Part II., by Joshua Trimmer, Esq., F.G.S.

——— On some Fossil Brachiopods of Devonian Age, from China, by Thomas Davidson, Esq., F.G.S.

——— On the Caradoc Sandstone of Shropshire, by J. W. Salter, Esq., F.G.S., and W. T. Aveline, Esq., F.G.S.

1853.

November 2nd.—On the Coal Measures of the South Joggins, Nova Scotia, by J. W. Dawson, Esq.; communicated by Sir Charles Lyell, V.P.G.S.

———— On the Coal Measures at the Albion Mines, Pictou, Nova Scotia, by H. Poole, Esq., and J. W. Dawson, Esq.; communicated by Sir Charles Lyell, V.P.G.S.

November 16th.—The Superficial Deposits of the Isle of Wight, by Joshua Trimmer, Esq., F.G.S.

———— On the Geology of some Parts of Central India, below lat. 22° N., by Lieut. R. H. Sankey, H.E.I.C.S.; communicated by Prof. Ansted, F.G.S.

November 30th.—On the Occurrence of Insects in the Wealden Strata of the Sussex Coast, by W. R. Binfield, Esq., and H. Binfield, Esq.; communicated by Prof. J. Morris, F.G.S.

———— On the Age of the Fossiliferous Gravels at Farringdon, by Daniel Sharpe, Esq., Treas. G.S.

December 14th.—On a Specimen of *Volkmannia Morrisii*, from the Glasgow Coal Shale, by J. D. Hooker, M.D., F.G.S.

———— On the Structure of *Chonetes comoides*, by Thomas Davidson, Esq., F.G.S.

———— On a Batrachian Fossil from the Pictou Coal Field, Nova Scotia, by Prof. Owen, F.G.S.

———— On Track-Prints in the Lower Lingula Flags of North Wales, by J. W. Salter, Esq., F.G.S.

1854.

January 4th.—On the superior limits of the Pleistocene Deposits in the Isle of Man, by the Rev. J. G. Cumming, F.G.S.

———— On the Geology of Rainy Lake, by J. J. Bigsby, M.D., F.G.S.

———— On some Swallow-holes in the Chalk near Canterbury, by Joseph Prestwich, Jun., Esq., F.G.S.

January 18th.—On the Structure and Origin of Sand-Pipes in the Chalk, by Joseph Prestwich, Jun., Esq., F.G.S.

———— On Pipes and Furrows in Calcareous and Non-Calcareous Strata, by Joshua Trimmer, Esq., F.G.S.

February 1st.—On the Geology of the Gold-bearing district of Merionethshire, North Wales, by Prof. A. C. Ramsay, F.G.S.

———— On Auriferous Quartz-rock in North Cornwall, by S. R. Pattison, Esq., F.G.S.

———— On the Physical Geology of the Himalayas, by Capt. R. Strachey, F.G.S.

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

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

It was afterwards resolved,—

1. That the thanks of the Society be given to Sir Charles Lyell and Prof. Owen, retiring from the office of Vice-President.

2. That the thanks of the Society be given to C. J. F. Bunbury, Esq., retiring from the office of Foreign Secretary.

3. That the thanks of the Society be given to C. J. F. Bunbury, Esq., W. Hopkins, Esq., Sir C. Lyell, Prof. Owen, and S. V. Wood, Esq., retiring from the Council.

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

OFFICERS.

PRESIDENT.

Prof. E. Forbes, F.R.S. and L.S.

VICE-PRESIDENTS.

John Carrick Moore, Esq., M.A.
Sir R. I. Murchison, G.C.St.S., F.R.S. and L.S.
Prof. John Phillips, F.R.S.
Lieut.-Col. Portlock, R.E., F.R.S.

SECRETARIES.

R. A. C. Austen, Esq,, B.A., F.R.S.
William John Hamilton, Esq.

FOREIGN SECRETARY.

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

TREASURER.

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

COUNCIL.

R. A. C. Austen, Esq., B.A., F.R.S.
John J. Bigsby, M.D.
James S. Bowerbank, Esq., F.R.S. and L.S.
Rev. H. M. De la Condamine, M.A.
Sir P. G. Egerton, Bart., M.P., F.R.S.
Earl of Enniskillen, D.C.L., F.R.S.
Prof. E. Forbes, F.R.S. and L.S.
G. B. Greenough, Esq., F.R.S. and L.S.
William John Hamilton, Esq.
J. D. Hooker, M.D., F.R.S. and L.S.
Leonard Horner, Esq., F.R.S.L. and E.
P. N. Johnson, Esq., F.R.S.
John C. Moore, Esq., M.A.
Prof. John Morris.
Sir R. I. Murchison, G.C.St.S., F.R.S. and L.S.
R. W. Mylne, Esq.
John Percy, M.D., F.R.S.
Prof. John Phillips, F.R.S.
Lieut.-Col. Portlock, R.E., F.R.S.
Samuel Peace Pratt, Esq., F.R.S. and L.S.
J. W. Salter, Esq.
D. Sharpe, Esq., F.R.S. and L.S.
Capt. Richard Strachey.

Trust Accounts.

Receipts.

	£	s.	d.	£	s.	d.
Balance at Banker's, 1st of January 1853, on the Wollaston Donation Fund	31	11	6			
Balance at Banker's, Geological Map Fund	19	0	0			
Total at Banker's, Jan. 1st, 1853				50	11	6
Received on account of the Geological Map (sold)	11	15	0			
Dividends on the Donation Fund of 1084*l.* 1*s.* 1*d.* Red. 3 per Cents.	31	11	6			
				43	6	6
				£93	18	0

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

(Signed) JOHN J. BIGSBY, ALFRED TYLOR, } *Auditors.*

Jan. 25, 1854.

Payments.

	£	s.	d.
Award to M. L. de Koninck	29	17	6
Cost of Striking Six Wollaston Medals, and Engraving two, awarded to MM. d'Archiac and E. de Verneuil	4	4	0
Paid on account of Geological Map:			
Mr. Greenough, Balance of 1852	19	0	0
Balance at Banker's, Trust Account	40	16	6
	£93	18	0

Valuation *of the Society's Property; 31st December*, 1853.

Property.

	£	s.	d.	£	s.	d.
Due from Messrs. Longman and Co., on Journal, Vol. IX.				62	4	5
Due for Subscriptions to Journal				40	11	0
Balance in Banker's hands				412	11	2
Balance in Clerk's hands				13	16	9
Funded Property, 4014*l.* 15*s.* 8*d.* Consols, at 90				3613	0	0
Arrears of Admission Fees (considered good)	65	2	0			
Arrears of Ann. Contributions prior to 1853 (considered good)	6	6	0			
Arrears of Ann. Contributions of 1853	28	7	0			
				99	15	0
				£4241	18	4

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

Jan. 27, 1854. (Signed) DANIEL SHARPE, *Treas.*

Debts.

	£	s.	d.
Balance in favour of the Society	4241	18	4
	£4241	18	4

INCOME.

	£	s.	d.	£	s.	d.
Balance at Banker's, January 1, 1853	268	12	7			
Balance in Clerk's hands	21	9	5			
				290	2	0
Composition at Banker's, Jan. 1, 1853				31	10	0
Compositions received				126	0	0
Arrears of Admission Fees	35	14	0			
Arrears of Annual Contributions	37	16	0			
				73	10	0
Admission Fees of 1853				226	16	0
Annual Contributions of 1853				656	15	6
Dividends on 3 per cent. Consols..................				115	1	10
Publications:						
Longman & Co. for Sale of Journal in 1852 .	54	17	1			
Sale of Transactions	11	6	0			
Sale of Proceedings	2	8	3			
Journal, Vol. I., allowance on Sale from Publisher	0	5	0			
Sale of Journal, Vol. II..........................	5	7	6			
Sale of Journal, Vol. III.	3	18	0			
Sale of Journal, Vol. IV.	4	2	6			
Sale of Journal, Vol. V...........................	5	4	6			
Sale of Journal, Vol. VI.	6	13	6			
Sale of Journal, Vol. VII.	14	13	6			
Sale of Journal, Vol. VIII........................	58	2	0			
Sale of Journal, Vol. IX.*.......................	141	14	7			
				308	12	5
Sale of Library Catalogue				1	17	6
				£1830	5	3

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

(Signed) JOHN J. BIGSBY, } *Auditors.*
Jan. 25, 1854. ALFRED TYLOR, }

* Due from Messrs. Longman and Co., in addition to the above, on Journal, Vol. IX. £62 4 5

Year ending December 31st, 1853.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Compositions invested				126	0	0
General Expenditure:						
Taxes	23	19	3			
Fire Insurance	3	0	0			
House Repairs	12	1	6			
Furniture Repairs	13	17	5			
New Furniture	32	15	8			
Fuel	33	16	0			
Light	23	10	3			
Miscellaneous House Expenses, including Postages	51	1	3			
Stationery	28	10	9			
Miscellaneous Printing	25	13	6			
Tea for Meetings	22	8	4			
				270	13	11
Salaries and Wages:						
Assistant Secretary and Curator	200	0	0			
Clerk	120	0	0			
Porter	80	0	0			
House Maid	38	12	6			
Occasional Attendants	10	0	0			
Collector	21	7	6			
				470	0	0
Library				45	17	3
Museum				11	15	11
Diagrams at Meetings				16	2	0
Miscellaneous Scientific Expenses				4	4	4
Contributions of 1853 repaid				9	9	0
Publications:						
Transactions	25	12	10			
Journal, Vol. VI.	0	9	0			
Journal, Vol. VII.	21	12	0			
Journal, Vol. VIII.	7	6	1			
Journal, Vol. IX.	389	18	3			
Journal, Vol. X.	4	6	9			
Proceedings	0	10	0			
				449	14	11
*Balance at Banker's, Dec. 31, 1853	412	11	2			
Balance in Clerk's hands	13	16	9			
				426	7	11
				£1830	5	3

* The Council have resolved to apply a part of this sum in the purchase of books, and in the employment of an Assistant in the Museum.

Estimates *for the Year* 1854.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Due for Subscriptions on Quarterly Journal				40	11	0
Arrears (See Valuation-sheet)				99	15	0
Ordinary Income for 1854 estimated:						
Annual Contributions (200 Fellows)				630	0	0
Admission Fees:						
Residents (10)	105	0	0			
Non-residents (10)	63	0	0			
				168	0	0
Compositions				94	10	0
Dividends on 3 per Cent. Consols				116	18	8
Sale of Transactions, Proceedings, Library Catalogue and Supplement				20	0	0
Sale of Quarterly Journal	240	0	0			
Due by Messrs. Longman and Co. in June, for sale of Journal in 1853	62	4	5			
				302	4	5
				£1471	19	1

(Signed) DANIEL SHARPE, Treas.

Jan. 27, 1854.

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes	25	9	0			
Fire Insurance	3	0	0			
House Repairs	12	0	0			
Furniture Repairs	15	0	0			
New Furniture	25	0	0			
Fuel	35	0	0			
Light	23	0	0			
Miscellaneous House Expenses	50	0	0			
Stationery	30	0	0			
Miscellaneous Printing	25	0	0			
Tea for Meetings	22	0	0			
				265	9	0
Salaries and Wages:						
Assistant Secretary	200	0	0			
Clerk	120	0	0			
Porter	80	0	0			
House Maid	33	4	0			
Occasional Attendants	10	0	0			
Collector	20	0	0			
				463	4	0
Library, New Books, Printing Supplem. Catalogue, &c.				110	0	0
Museum, including Assistant				45	0	0
Diagrams at Meetings				16	0	0
Miscellaneous Scientific Expenses				5	0	0
Publications: Quarterly Journal				450	0	0
" Transactions, &c.				75	0	0
Balance in favour of the Society				42	6	1
				£1471	19	1

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

17TH FEBRUARY, 1854.

AWARD OF THE WOLLASTON MEDAL AND DONATION FUND.

AFTER the Reports of the Council had been read, the President, Prof. E. Forbes, on delivering to R. Griffith, Esq., LL.D., F.G.S., the Wollaston Palladium Medal, addressed him as follows:—

DR. GRIFFITH,—It is my privilege, and one that I value most highly, to deliver to you the Wollaston Palladium Medal, awarded this year by the Council of the Society to yourself, "for the valuable services rendered by you to geological science, and particularly for your Geological Map of Ireland, the result of your own laborious and judicious researches."

It has been my fortune to go over no small proportion of the geology of Ireland, and to visit districts in the sister kingdom of the structure of which our information was wholly derived from your labours. I can therefore bear personal testimony to the value and extent of your researches, and express, from my own knowledge of the facts, the admiration that I feel for one of the most remarkable geological maps ever produced by a single geologist. The more your country is explored the more will men of science be astonished by the minuteness of detail contained in that famous work. You have investigated a country that in great part was, previously to your labours, a geologically unknown land. The formations with which you had to deal presented in many places peculiarities that demanded original thought, and precluded the usually safe guide of analogical comparison. You bravely grappled with your difficulty and showed your powers of generalization and systematization in an arrangement and nomenclature of the Irish rocks, which in many points were highly original, and have been of great use to labourers in the sister kingdom. These will be of more use still, and every year's research convinces those who are now officially engaged in the exploration of Ireland—Sir Henry De la Beche and Mr. Jukes, who are the best witnesses, can bear out what I say—that your great work is a surprising monument of observation and skill. The terms "calp" and "yellow sandstone" are important geological divisions of your founding, and you first showed that the Old Red of Ireland was not Silurian. Let me thank you too for the constant attention that you have paid throughout your labours to the observation and collection of organic remains, and the accuracy with which, in every case, their geological and topographical positions were noted by you. The collection you made of Irish fossils is the finest of proofs of your success, and the works descriptive of them by Professor M'Coy, issued under your auspices, and distributed by your liberality, are most valuable contributions to palæontological science.

In thus addressing you I speak reverentially to one of the earliest members of this Society, and to a geologist who appeared in print before I was born. From the commencement of your labours the economic bearings of the science were kept constantly in view by you, and your earliest memoirs are upon the coal-fields of Ireland,—that on the Leinster coal-field having been published so long ago as 1814. You proposed, in a letter to the Dublin Society, to construct a geological map of Ireland as long ago as 1821. I need not say, on this occasion, how you have since carried out that wise proposition. Twice President of the Geological Society of Ireland, your spirit and presence has done much to promote the study of our science in your country. May your good influence long continue.

Dr. Griffith replied in these words:—

Mr. President,—I receive, with much gratification, the Wollaston Medal for the present year, which has been conferred upon me by the vote of the Council of the Geological Society.

It is an honour to which I never aspired, but which, I confess, I receive with pride and satisfaction, as a proof that my labours in the geological field of Ireland are appreciated by those who are best able to judge of their accuracy and importance.

The construction by me of a Geological Map of Ireland is now an old story, as upwards of forty years have elapsed since I commenced it at the pressing instance of Mr. Greenough, one of my oldest and most valued friends. It was in the summer of the year 1812 that the first outline of the Geological Map was attempted, when, to my own then limited observations, were added the hasty notes of my friend Mr. Greenough. Since that period I have never lost sight of the work, though public avocations have occasionally so much interfered with its progress, that only trifling additions to the general data were made during several years.

The meeting of the British Association for the Advancement of Science, at Dublin, in the year 1835, gave a fresh impulse to my labours, which from that time to the present have never flagged; and I have now the pleasure of presenting the result of my labours in as complete a form as time and opportunity have enabled me to produce.

The Topographical Map, on which the geological boundaries have been engraved, was constructed at the Ordnance Survey Office, Dublin, under the superintendence of my friend Major Larcom, Royal Engineer, in the year 1838, and is the most accurate Map of Ireland that has hitherto been published. It is laid down to a scale of four miles to an inch, and, although on that scale it appears in many parts to be crowded with geological details, yet, even in those places, if we look to the scale of nature, it is meagre indeed; in fact my labours must be considered only in the light of an outline and precursor, which may facilitate the labours of Sir Henry De la Beche and his unrivalled corps of zealous and enlightened colleagues, who, in the true spirit of English scientific honesty, will at all times award the full meed of credit due to an antecedent labourer.

In a work which has been forty years in hand, during which time Geology has made such rapid strides, as might be expected, the first outlines and divisions into systems have been frequently revised and changed, and I may say, I have found it necessary to revisit every district, nay nearly every parish, in Ireland at least three times.

I may allude to the subdivisions of the Carboniferous system, from the Old Red Sandstone, or Devonian, to the Coal-formation inclusive: this system, originally given as one undivided suite, is at present subdivided into seven series, five belonging to the Carboniferous limestone and two to the Coal. I now look back with wonder at the labour, and perhaps danger in a scientific view, of attempting subdivisions, some of which at the time were new to geologists.

Next I may point to the subdivision, or at least attempted subdivision of the Slate-series, formerly called Transition or Greywacké slates, into Cambrian and Silurian, rendered necessary by the wondrous labours of my friends, Professor Sedgwick and Sir Roderick Murchison.

But I fear and feel I am trespassing on valuable time, and shall conclude by thanking you, Mr. President, for the very flattering manner in which you have had the kindness to express yourself in presenting to me the Wollaston Medal.

On presenting to S. P. Woodward, Esq., the Proceeds of the Wollaston Fund, the President addressed him as follows:—

Mr. Woodward,—It is with no small pleasure that I announce to you that the Council of the Geological Society have awarded to you the proceeds of the Wollaston Fund for the present year. They do so "in acknowledgement of the value of your recent Palæontological labours, and to assist you in the publication of your researches into the structure and affinities of Brachiopoda and Rudista." You and I have worked together officially within these walls, and I know well how thoroughly you have mastered the details and the generalities of those branches of Palæontology to which you have directed your attention. Every naturalist who has made himself acquainted with the admirable manner in which you have worked out the difficult palæontological problem of the structure and affinities of the Rudista, and how many anomalies have been definitely cleared away by your labours, will be glad to hear of this award. We trust that the results of your researches will before long be made accessible through publication, and that you will continue to pursue a course which is sure to gain you honourable fame and secure for you a high position in the world of science, worthy of the son of one who did much good service to British Geology in his time.

Mr. Woodward replied—

Sir, I beg to thank you, and the Council, for the valuable compliment you have conferred upon me. It is well known to many gentlemen now present, that I commenced life in the service of this Society, as assistant to Mr. Lonsdale, whose name is still so highly esteemed within these walls; and I enjoyed the good fortune of remaining here during the whole time of your former official connection with the Society. In the position which I have held, it has been my duty rather to assist others than to conduct investigations of my own; and I have been amply rewarded by the kind and liberal manner in which the slightest services have always been acknowledged by Fellows of this Society.

ANNIVERSARY ADDRESS OF THE PRESIDENT.

Gentlemen,—Whilst we rejoice in our continued prosperity and look forward confidently to the future progress of Geology, we must not forget, that the year just gone by has been one of mourning for science and of heavy losses by death, abroad and at home, for our Society. First in the list of the departed, who were among our eminent members, is the name of

Leopold Von Buch. The death of this illustrious philosopher and pre-eminent geologist took place, after a few days' illness, at Berlin, in March 1853. He had attained the age of 79 years, and to the last preserved his unrivalled energy and scientific enthusiasm.

Baron Von Buch was a member of an ancient and noble Prussian family, and was a Royal Chamberlain of Prussia; knighthoods and distinctions of all kinds had been showered upon him unsought, for his merits. He was one of the eight Foreign members of the Institute of France, and a foreign or honorary fellow of almost every great scientific academy out of his own country. At home he was one of the most active members of the Berlin Academy of Sciences. Fortunate in the possession of a sufficient, if not ample income, untied by the trammels of office or routine duties, he was enabled to devote the whole of his long life to the search after scientific truth. Nobly did he fulfil his mission. Unselfish, free from envy, anxious and able to aid, he sought not only to advance science by his own exertions, but to assist by advice at all times, by purse where necessary, every younger man who worked earnestly in the same course. There is an old Jewish proverb which says, "He who seeks a name loses fame;" Leopold Von Buch scorned fame and gained it.

He was a pupil of Werner; one of the youths destined afterwards to be illustrious, who studied under the instruction of the renowned professor of Freiberg. However serious the demerits of many of the views promulgated by that distinguished teacher, his eloquence and inspiration effected mighty services for geology, through the love for the science with which it imbued his disciples. Errors vanish in the course of time—they are like unpreservable species in geological formations,—but merits last for ever, for through them science cannot fail to advance. Von Buch was one of the first to repudiate the mistaken views of his master, but he avowedly did so by the very spirit and method of research which he had cherished and learned at the school of Freiberg.

Von Buch was only eighteen years of age when he commenced his long series of contributions to the literature of science. His first paper was "A Mineralogical Description of the Carlsbad Region," printed anonymously in 1792. Four years afterwards he produced his "Contribution to a Mineralogical Description of Landeck," and soon after a similar treatise for Silesia, accompanied by a geological map. His merits as an accurate observer and clear describer were manifested in these early productions.

In the now venerable and ever-illustrious Humboldt he found a friend and fellow-student, with a kindred mind and genius, and these two great men worked together early in life. At the close of the last century they visited the Alps and Italy in company, and there it was that Von Buch commenced those researches into the geological phænomena of volcanoes that alone would have immortalized his name. He founded a great part of what may be termed the Science of Volcanoes, and gradually divesting himself, by the legitimate process of extended observation, of Wernerian theories, worked out this most interesting section of geology in the countries most likely to enable him to solve the many problems it presents. Italy, Central France, the trap districts of Germany and Scotland, and eventually, in 1815, the Canary Islands were submitted by him to close personal inspection; with what results I need not, in this place, recall. Suffice to say, that his great work, 'The Physical Description of the Canary Islands,' will long remain an enduring monument of his labours and his generalizations. The theory of Craters of Elevation was one of the most influential of the doctrines broached by him after his careful and prolonged study of igneous phænomena.

But during the course of these peculiar studies his mind was not confined to them, and other subjects of equal importance engaged a portion of his attention with as valuable results. In 1806, whilst Europe was torn by revolutions among men, Von Buch retired to the wilds of Scandinavia, there to study the greater revolutions of Nature. During a two-years' travel in Norway, Sweden, and Lapland, his inquisitive spirit did not fail to evolve new subjects for its speculations. What he saw there forced him to abandon the belief in the necessarily primitive date of granites, and his observation of the gradual rise of the Scandinavian area and its attendant phænomena, previously only imperfectly noticed and quite misunderstood, has been a fruitful source of fresh chapters in geology. How many of the best disquisitions of our time could trace their roots to these observations of Von Buch!

The first Geological Map of Germany appeared in 1824. Von Buch's name is not appended to it, but it is known that he was the compiler and author. The impulse to local geology given by a first map, and the difficulties with which the constructor has necessarily to contend, cannot be too highly appreciated. The first step, in this as in many other things, is the chief difficulty, and one apt to be underrated by those who come afterwards.

After his return from the Canaries, Switzerland,—always the favourite region with Von Buch,—again became the scene of his travels. The mode and epochs of the upheaval of mountain chains were, among other subjects, the themes of his inquiries and essays. The famous doctrines of Elie de Beaumont bear witness to the influence and suggestiveness of Von Buch's observations. His theories concerning Dolomite, though not so productive of rich results, excited general attention and caused much wholesome controversy.

Twenty-five years ago, when already past the fiftieth year of his age, Von Buch seemed to enter upon an entirely fresh career, and to take up a line of inquiry in a totally different direction from that which he had previously followed, for he commenced those brilliant palæontological researches that have secured for him a permanent fame among the cultivators of the natural history side of geology, and even among pure naturalists. I say "seemed" to enter upon this course, for the thought and study had long been working in his mind, as is evident from the essay 'On the Progress of Forms in Nature,' printed by him as early as 1806. The ideas, then conceived imperfectly, had been silently and steadily growing within him, nourished by continual observations, and in 1828 they took a definite form, when he published his observations on Ammonites, followed at intervals by his monographs upon the Goniatites, Brachiopoda, and Cystidea. There are two distinct aspects of Palæontology, a geological side and a physiological side. Cuvier was the true architect of the latter, but Von Buch erected the former. It was he who first developed the idea of the chronomorphosis of genera, the great leading principle of natural history applied to geology. He arrived at it fairly and inductively, and demonstrated it monographically and practically. He gave a grand impulse to the study of stratified rocks, an impulse only now beginning to be felt in its full force. With his usual sagacity he saw clearly its value and bearings, as is plainly indicated by his essays on comparative or geographical geology, and the latest of his numerous memoirs, those on the Cretaceous and Jurassic formations. If I am not greatly mistaken, the future progress of comparative geology will depend mainly on the following up of the palæontological doctrines that were originated by Von Buch. Viewed, too, entirely apart from their geological merits, and considered under a purely natural-history aspect, the monographs on fossils by Von Buch are most remarkable productions, both as descriptive and as philosophic essays. Not long before he died he directed his attention to fossil botany, and endeavoured to evolve guiding principles from the study of the nervation of leaves. He did not rashly enter upon this fresh subject, for botanical inquiries had long before interested him in their details, as his Scandinavian and Canarian researches testify.

Philosophers may be divided into two great natural orders, those who sow and those who reap—the originators and the demonstrators. Von Buch was a sower. He went about the world casting the seeds of new researches and fresh ideas, wherever his prophetic spirit perceived a soil adapted for their germination. The world of science has gathered a rich harvest through his foresight. He is the only geologist who has attained an equal fame in the physical, the descriptive, and the natural history departments of his science. In all three he has been an originator and a discoverer. In every subdivision of all three he has been a suggester — a high merit in itself.

Von Buch never married. Personally he had his peculiarities and eccentricities, odd ways of his own that amused the stranger and endeared him to his many friends. Probably no geologist had ever so general an acquaintance. He went everywhere to take the measure of the workers in his favourite science, and knew them, bodily and mentally, almost all. I shall ever esteem it a good fortune to have seen him, to have received a lesson from him, and to have deserved his published commendation. Though gone from among us, his ubiquitous spirit is with us, and in the Report which I shall have to give of geological progress during the past year, I could point out the influence of his ideas at almost every step.

A short half year has passed away since among the most active and vigorous of our younger members, Hugh Edwin Strickland took a prominent part in our meetings and discussions. Healthy, earnest, and indefatigable, his life promised to be one of long services to natural science. In the best period of manhood, when experience and energy meet and work together, when well-sustained exertions in the cause of truth, and the proofs of an equal capacity for scientific learning and original research have raised our expectations and cherished our hopes, Mr. Strickland was taken from amongst us awfully and immediately, falling literally a martyr to geological science. He had been engaging, with his customary zeal, in the discussions of the Meeting of the British Association at Hull, when at the termination of the sittings he proceeded to the neighbourhood of East Retford, to examine the cuttings on the line of railway at the mouth of the Clanborough Tunnel. Intent upon his observations, note-book in hand, unhappily unaware of the danger of his position, he stepped from one line to another to avoid an approaching coal-train, just at the moment that the Great Northern passenger-train was issuing from the tunnel. Instantaneous death terminated his earthly career.

Mr. Strickland was in the forty-second year of his age. He was a native of Righton in Yorkshire, and inherited scientific tastes from his father, Mr. H. E. Strickland of Apperley, and his maternal grandfather, the eminent Dr. Edmund Cartwright. Part of his education was conducted by the late Dr. Arnold, who took a warm interest in the talents of his distinguished pupil. His training was completed at Oxford, where he studied at Oriel College, and where doubtless, under the lectures of Dr. Buckland, he acquired and ripened those geological tastes which eventually led to his appointment as successor of his illustrious master in the Geological Chair of the University.

His acquirements in natural science were singularly diversified, embracing more or less all departments of natural history, and there are few sections of the science upon which at one time or other he did not publish observations or memoirs. His knowledge of the literature of natural history was remarkably extensive, exceeding probably that of any living naturalist; and the 'Bibliographia Zoologiæ et Geologiæ,' based on the manuscripts of Professor Agassiz, and published by the Ray Society, owes much of its value to his editorial care and unrivalled acquaintance with authors and their works. As a zoologist, the greater share of his attention was devoted to ornithology, in which department he enjoyed a world-wide fame. His work, written jointly with Dr. Melville, on extinct birds, especially the Dodo, was an application of his ornithological knowledge to geology.

Mr. Strickland's geological researches were confined to no single locality or group of formations, and his name will be ever recorded in histories of geology. In the British Islands his favourite subjects were the New Red Sandstones, Lias, and Pleistocene beds. In conjunction with Sir Roderick Murchison, he described the geology of the neighbourhood of Cheltenham, and communicated to our Transactions the well-known important memoir "On the Upper Formations of the New Red Sandstone system in Gloucestershire, Worcestershire, and Warwickshire." Many papers on the geology of various points in these counties are contained in our Journals and Proceedings. He contributed also to a knowledge of the geology of portions of Scotland and of the Isle of Man. In company with Mr. Hamilton, he travelled in the Mediterranean and Levant, and explored the geology of parts of Asia Minor, the Thracian Bosphorus, and the Island of Zante. Their joint memoirs on those countries are printed in our Transactions, and contributed materially to extend our knowledge of the structure of Eastern Europe and Western Asia. The demonstration of the existence of Palæozoic strata on the shores of the Bosphorus was one of the many fruits of this expedition.

Earnestness, energy, and simplicity were the distinguishing features of Mr. Strickland's character. He was thoroughly a man of science, and as thorough a gentleman. Fearless in his maintenance of his convictions, whether by speech or pen, his freedom from animosity and evident straightforwardness invariably converted his opponents into friends. Mr. Strickland was most happily married, but has left no family. His father-in-law, the eminent naturalist Sir William Jardine of Applegarth, has undertaken to complete the editing of the remaining volumes of the 'Bibliographia.'

One of the warmest and wisest friends of the Society, and during many years an active member of it and constant attendant at its meetings, was Charles Stokes, whose name will be long borne in mind with affection and gratitude by many geologists and naturalists. Although constantly and assiduously engaged in business, Mr. Stokes contrived, whilst passing his days in the City and on the Stock Exchange, of which he was a most respected member, to acquire a vast amount of minute and accurate scientific information, and to pursue original, though, alas, too seldom published researches; and there was scarcely any department of the natural history sciences with which his acquaintance was not considerable. Careless of fame and brimful of benevolence, he laboured incessantly, whenever a moment of leisure permitted, to advance science by every means that lay within his power. He collected rare and interesting specimens at any cost, not for their own sakes, but to place at the disposal of any competent person who had the requisite knowledge and determination to investigate the subjects they could serve to elucidate. Before microscopic science was in fashion, he was at work encouraging the makers of microscopes, suggesting improvements, purchasing beautiful instruments, and testing their application. When lithography was in its infancy in England, he foresaw what could be done with the rising art; and, sparing no expense, found a zealous and talented ally in the late Mr. Hullmandel for experimenting on his suggestions. His knowledge of some branches of zoology and palæontology was minute and curious, as well as of parts of botany. Trilobites and Zoophytes were among his favourite subjects; upon the former he communicated valuable materials and information to the great work of Alexander Brongniart on the Fossil Crustacea; about the latter he possessed a store of novel and original information, which I fear is in great part lost with him. The subject of the fossilization of wood was one which he pursued even to the last; and only two months before his death I received a letter from him, accompanying some specimens illustrative of his views, and inquiring about others. In the 5th volume of the 2nd series of our Transactions is published a valuable paper by him on this subject, containing an explanation of the phænomena exhibited by partially silicified wood, and of the progressive steps in the process of petrifaction. In the same volume is a memoir upon "Some Species of Orthocerata," with an account of the siphon of Actinoceras and the foundation of the genus *Ormoceras*. The many curious researches concerning the Orthoceratites that have interested palæontologists of late years had their origin in his discoveries. Some time before he had made mineralogical communications to the Society. His name is constantly cited in numerous foreign treatises. But the scantiness of his writings can give no true notion of his learning and his influence on the progress of science during his time. Not an expedition started for foreign discovery, but he was in at the commencement to advise and direct the natural history arrangements. I am one of many who owe much to the sound sense and surprising knowledge of Charles Stokes. He was the Ellis of our times. I have spoken only of his scientific learning; he was as remarkable for literary, antiquarian, musical, and artistic knowledge. He died in London, deeply regretted, in the last week of December 1853, at the age of 70. His pleasant and wise presence will be missed for many a year.

Mr. Alexander Robertson, whose name as a geologist was best known to us with the affix "of Elgin," was born at Aberdeen in the year 1816, and after an education, conducted partly in England and partly in Scotland, became a pupil of Professor Syme, and studied medicine at Edinburgh. Disliking his intended profession, he soon abandoned it, and after studying science in Germany, returned to Scotland and settled in Morayshire, to pursue farming, I regret to say without success, since his death left a widow and four children unprovided for. Mr. Robertson's name is familiar to you as that of the discoverer of Freshwater beds intercalated in the Oolites of Brora. He communicated his observations on this subject to our Society, and subsequently (May 1846) a longer memoir "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 Strata above the Portland Stone;" an essay remarkable for its thoughtful and suggestive character. In this paper he pleaded forcibly for Sir Roderick Murchison's view of the Oolitic relations of the Wealden; some recent discoveries have in great part supported the argument maintained by Mr. Robertson.

Mr. Henry William Taylor was well known to the Members of our Society for his fine collection of Chalk fossils, which he spared neither time nor expense to bring together.

I shall not venture, Gentlemen, in the following Address to discuss fully and in all its details any one subject, in the manner so admirably and usefully done by my immediate predecessor, but follow the plan pursued by not a few of the distinguished men who have filled this Chair, of presenting to you in brief a summary of the leading features of geological progress during the year just passed, and a commentary on the aspects and aspirations of our science as manifested and indicated by the more salient labours of geologists during 1853. To do this thoroughly would require more leisure and a greater command of foreign languages than, unfortunately, I possess; but without professing to furnish a complete report, I hope to be useful by indicating the merits of that which has principally been done during the period I have had the distinguished honour of filling your presidency. If I claim the privilege of occasional criticism and difference of opinion, the responsibility of objections must fall entirely on myself, and if, through inadvertence, I commit injustice, by passing unnoticed any essay of merit and consequence, I trust on a future occasion to rectify the mistake and to render the acknowledgement that is due.

That the greater part of my report will take cognizance of Geology under its palæontological aspects, is a circumstance not dependent on my own predilections or peculiar line of study; it so happens that the majority of important papers published during the past year have been more or less of this character, and some of the most valuable of recent contributions to our science concern principally the natural history department of Geology. The economics of the science have, it is true, received more than their usual share of attention, gold and coal forming the themes of not a few volumes and essays. But geology, properly so called, of a scientific character, is thinly diffused through auriferous treatises, although a great deal is often written in them about geology,—in the sense however of *round about* it. Descriptive Geology is constantly progressing, although the number of memoirs in this department has not been great during 1853. Knowing how much is in progress in this most important section of the science, we cannot regard the deficiency in the number of publications upon it as any indication of halting. The same remark may be made on the section of Geological Dynamics. Mineralogy, under its geological aspects is making decided progress in France and in America, but, to our shame be it said, continues to be neglected in England. There are numerous cultivators of it, it is true, for its own sake, learned and able mineralogists, who however, on this side of the Tweed at least, do not often put the results of their observations into print. In Scotland and in Ireland the pens of the mineralogists are much more active, and the investigation of mineral species ardently pursued, though not to the extent that we find these inquiries followed in Germany and the United States.

In the course of study of the many lately-published memoirs from which the materials of my Address are derived, the question of the meaning of the difference and contrast that are evident when we compare the faunas and floras of the more ancient or palæozoic with those of later epochs, has, in consequence of fresh accumulation of relevant facts, forced itself vividly upon my attention. It is a subject that, in common with most geologists, I have often earnestly thought over, and more than once published opinions upon. It has been the originator of not a few theories and speculations, not one of which can be said to have borne the test of searching inquiry into facts. Yet I think I am not wrong in saying, that a belief is as strongly impressed as ever on the minds of geologists who take interest in the philosophy of their science, that some law lies at the foundation of this difference. If I venture to add one speculation more, although its predecessors have either subsided into azoic oblivion, or linger, retaining but a weak hold upon our minds, I do so in the hope that there is a vitality in my offspring, which may enable it, when it becomes developed, though as yet only a suggestion, to endure; and I ask your indulgence for introducing it on this occasion, on the plea that it owes its birth to reflections arising out of this discourse.

The publication of the first volume of M. Barrande's great work on the Silurian System of Bohemia is a leading event of the geological year just completed, and from its importance commands our first attention. The researches, the results of which are embodied in this elaborate and beautiful treatise, were commenced twenty years ago, but have been more especially prosecuted during the last thirteen years. From time to time we have had more or less detailed notices of the fruits of M. Barrande's assiduous labours, but could scarcely judge of their minuteness and importance until he commenced to send them forth in full. He now takes his place definitely in the foremost rank of geologists and palæontologists. He combines in a remarkable degree both qualifications,—no small advantage when the wide general views and the classification of great formations, such as are dealt with by this eminent man, have to be fully considered and put forth with ample arguments. Division of labour is good for the accumulation of sound and abundant materials, but experience has shown in both geology and the other sciences, that the greatest advances are to be made by combinations of kinds of knowledge in those who deal with the greater problems. M. Barrande has done well, it seems to me, by pursuing assiduously the double course he has chosen. The main body of the purely geological portion of his work he proposes to publish when the palæontological details, which constitute most of the evidence upon which his views are founded, have been laid before the geological world in all their completeness. The task he has before him in this respect is a laborious one; no less than the detailed description and critical investigation of some 1200 species of fossils,—for such is the number that has rewarded his search in Bohemia. The natural history and principal part of his first volume, a bulky work in itself, is devoted to the order of Trilobites. It is prefaced, however, by a general outline of the geology of Bohemia, which first deserves our notice, both on account of the interest it must present to British geologists dealing with palæozoic strata, and also because of certain original and peculiar views put forth in it.

The Silurian formation of the centre of Bohemia constitutes a well defined basin of an elongated oval shape, the great axis of which is directed nearly N.E. and S.W., and has a length of about 20 German geographical miles with a maximum breadth of 10. It is from 55 to 60 miles in circumference. Towards the N.E. and N. a small portion is bounded by the Trias, the Quader-sandstone, the Planer-kalk, or by the Carboniferous formation. Elsewhere, for two-thirds of its margin, granite or primordial crystalline rocks, such as gneiss and mica-slate, constitute its base and its boundary. A few small carboniferous basins are sprinkled over the Silurian surface, as well as a few isolated outliers of cretaceous beds. The dip in the two halves of the basin, the one to the N.E. and the other to the S.E. of the chief diameter, is towards the principal axis. The beds ordinarily lie at an angle of from 30° to 45°, often 70°, and are not unfrequently vertical.

M. Barrande distinguishes eight stages of strata to which he assigns a Silurian age; four of them he regards as Lower Silurian, and four as Upper Silurian. Of his Lower Silurian stages the two lowermost are azoic, the distinctions between them being founded on mineral characters, the first being composed of crystalline rocks, and the second of clay-slates and conglomerates, similar to the fossiliferous Silurian above them, but wholly void of organic remains. They are rich in lead mines. These azoic stages pass into each other, and the upper section passes gradually into the fossiliferous beds above.

The third stage of his Lower Silurian, and the first of his fossiliferous horizons, includes his "Schiste protozoique," and attains a thickness of 1200 feet. It contains no beds of limestone. The fauna of this section is very peculiar; it is composed almost totally of Trilobites, the other fossils being a Pteropod, some Cystideæ, and an Orthis. These constitute an assemblage upon which he lays great stress and designates *primordial*. All its species, without exception, are peculiar to itself, and of the Trilobites, all the genera are so, with the exception of *Agnostus*. The peculiar genera are either low and rudimentary types, or members of the Olenoid or Calymenoid families; not typical or highly developed forms. They are *Paradoxides, Conocephalus, Ellipsocephalus, Sao, Arionellus, Hydrocephalus*, and *Agnostus*. Of the first of these genera there are no fewer than twelve species, some of them exceedingly prolific. These primordial Trilobites have a peculiar facies of their own, dependent on the multiplication of their thoracic segments, and the diminution of their caudal shield or pygidium. M. Barrande compares this primordial fauna of Bohemia with certain fossiliferous assemblages similarly placed at the base of the fossiliferous Silurians in Wales, Norway, and Sweden, in which last country, indeed, the peculiarities of its fossils long ago attracted the attention of naturalists and the notice of Linnæus.

The isolation of this primordial zone, as distinguished from the mass of the Lower Silurian, is chiefly maintained by the grouping in it of the Olenoid family of Trilobites, almost to the exclusion of all others. It is not quite certain that more than one of the genera of Trilobites distinctive of this zone are found in any higher beds. The exception is *Agnostus*, the lowest and most rudimentary type of its tribe. Yet even this has its metropolis in the primordial zone, and sends but a few stragglers into the division immediately above. The same, or a very similar distribution, has been observed of late years by Angelin, who during 1852 commenced illustrating the fauna of the Swedish rocks.

In Wales the existence of this primordial fauna has been clearly made out. The rocks which contain it are those designated by Professor Sedgwick, who recognized their importance, as the "Lingula beds," a name adopted by the Geological Survey. Fossils were first I believe, found in them by Mr. Davis, who discovered the *Lingula*, from which they received this name. They have been thoroughly examined by my colleagues of the Geological Survey, and are stated in the *resumé* on the Lower Palæozoics of N. Wales, communicated by Professor Ramsay to the Society last April, to be about 7000 feet thick. Their importance has been fully recognized for some time by the surveyors, and the additional evidence accumulated last autumn by Mr. Salter goes to support the stress laid upon them by M. Barrande. In the prosecution of the search, a further result has been obtained in the way of a subdivision of the group, and a palæontological distinction of importance has been indicated. They prove capable of division into two well-marked sections, viz. a lower, of which *Agnostus* (probably the identical species described from the alum slates of Sweden), an *Olenus*, and *Conocephalus* occur along with the characteristic *Lingulæ* of the deposit; and an upper, where the same genera are accompanied by a few Brachiopoda and Bryozoa, as in Bohemia. But whereas in the latter country no passage can be shown of this fauna into the Silurian stage above, in Wales a palæontological passage from the Lingula beds into the Bala or Llandeilo group appears to be indicated. This is marked by the association in the upper part of the igneous series of two large species of *Olenus* with *Agnostus* and *Lingulæ*, and with types unquestionably characteristic of the Llandeilo beds, such as *Asaphus*, *Calymene*, and *Ogygia*, and Graptolites of species undistinguishable from those of the Llandeilo flags.

The interesting memoir of Dale Owen leaves no doubt upon the equivalence to these beds of the Potsdam sandstone of North America, in which Trilobites of the Paradoxides type are mingled with the Lingulæ, so characteristic of this formation.

The demonstration of this important zone of life, the earliest as yet distinctly traced, is a great step in Palæozoic Geology, one firmly established during the past year.

The extinction of the primordial fauna in Bohemia is attributed by M. Barrande to the effects of the igneous eruptions manifested by the masses of porphyries interposed between his lowest fossiliferous and the succeeding stage. The destroying influence of trappean eruptions are more than once laid stress upon by him. Similar phænomena appear to have terminated the Lingula-flag epoch in the Welsh area; volcanic outbursts, as remarked by Professor Ramsay, "in consequence of which great ashy deposits were found interstratified with ordinary muddy sediment, and here and there associated with thick beds of felspathic lava." But these outbursts do not always appear to have had so decided an influence upon the faunas of ancient seas, for, in the instance of Wales, the great eruptions that occurred during the epoch of the deposition of the succeeding Bala beds did not materially affect the population of the oceanic area in which they broke out. For my part I am strongly inclined to think that the influence of volcanic outbursts upon life through the destructive agency of the products of eruptions has often been overrated. Igneous overflows, showers of ashes, and exhalations of deleterious vapours are necessarily destructive, but as necessarily local, and scarcely likely, arguing at least from all cases of which we have sufficient knowledge, to extinguish the fauna and flora of a whole natural-history province, much less of many provinces. But they are the certain indications of far more powerful though less conspicuous and less traceable enemies of life. They are often the indices of epochs of excessive disturbances of the earth's crust, and of elevations and depressions of the surface of the sea-bed. Changes of level and consequent changes of surrounding conditions, even to the extent of change of medium, are the great life-extinguishers. The degree of substitution in an ancient fauna should rather be accepted as an evidence of the extent of the movements that have taken place during an age of volcanic energy, than as a measure of the intensity of the local outbursts, the products of which at first glance seem to us the most efficient engines of destruction. It is not the ferocity of battles, but the organic changes among nations that afford us the measure of value or importance of a great war.

The fourth and uppermost division of M. Barrande's Lower Silurians is his "Etage D;" strata chiefly composed of quartzites with schistose alternations. Cephalopoda represented by *Orthoceras*, Pteropoda by *Conularia* and *Pugiunculus*, Heteropoda by *Bellerophon*, Gasteropoda by *Pleurotomaria* and *Holopea*, Acephala by *Avicula* and *Nucula*, Brachiopoda by *Orbicula*, *Lingula*, *Spirifer*, *Leptæna*, and *Terebratula*; also Crinoids, Cystideans, Starfishes, and a few Corals and Graptolites make up, with *Trilobites*, the fauna of this group in Bohemia. Trilobites and Cystideans prevail above all other forms, and it is in this zone that the former (and the latter probably also) attain their maximum. This fact has a strong significance in its bearing on the hypothesis concerning the relation of Palæozoic life to the life of all after-periods which I shall hereafter bring out in this discourse. The assemblage of animals found in this stage of quartzites constitute M. Barrande's second fauna. He compares the stage with our Llandeilos and Caradocs, with the Lower Silurians of Ireland, Russia, France, Spain, Portugal, and Thuringia, the regions C and D of M. Angelin in Sweden and Norway, and the formations from the Potsdam sandstone to Hudson's River group inclusive, of the United States. The great geographical diffusion of its fauna is in accordance with its vertical extent. But though widely diffused as a well-marked fauna, exhibiting everywhere a characteristic and easily-recognized facies, the species are by no means universally diffused, and the resemblance between distant regions is maintained rather by representation than by identical forms: thus early in the world's history do we find the partitioning of the earth's surface into natural-history provinces. More and more evident does it become every day that the old notion of a universal primæval fauna is untenable, and that at all epochs, from the earliest preserved to us to the latest, there were natural-history provinces in geographical space. And indeed, if we consider for a moment upon what causes the existence of these provinces depends, how they are not the mere results of various climatal conditions only, but are regulated in their extent in the sea by orographical and hydrographical conditions, and on the land by the inequalities and arrangement of the surface, and thus call to mind that the vast and varying sedimentary accumulations, found at every epoch in great mineral dissimilarity, necessarily indicate the existence of those very inequalities and peculiarities on sea and on land that determine the existence and extent of geographical provinces and limit the diffusion of animal and vegetable species, it seems strange to us how the notion of the universal diffusion of a uniform specific fauna could ever have been accepted for a moment, even as an *à priori* hypothesis. It was imperfect recognition of the phænomena of *facies* in time, that beautiful idea that first seems to have dawned on the mind of Von Buch, which appears to have given rise to the error.

In one of the subdivisions of this "Etage D" of his Lower Silurians, M. Barrande describes the occurrence of isolated patches, as it were, of fossiliferous strata, the population of which consists not of Lower Silurian fossils, but of organic remains characteristic of the Upper Silurian. M. Barrande designates these assemblages by the appellation of "colonies." This colonial fauna, becoming extinguished after a short existence, does not reappear until after the extinction, by trappean eruptions, of the normal fauna of the epoch, and the cessation of the formations amid which the colony is an intruder. In these colonies, he states, there are as many as 63 species, of which 4 are exclusively peculiar, 2 (viz. *Trinucleus ornatus* and *Dalmanites socialis*) common to the colonies and the true fauna of the beds in which they are intercalated, and 57 common to the colonies and third fauna, or that of the lowermost section of his Upper Silurians.

This doctrine of colonies is original with M. Barrande and demands our serious consideration. It is one that materially affects the value of the evidence of organic remains as determining the age and sequence of formations. The proposition that it involves asserts the introduction of a group of species that experience has shown normally to belong to a later and distinct formation, not merely among and mixed with the fauna of an earlier stage, but amid and separate from that fauna. We can conceive, indeed we have ample proofs in many instances, of the fact of the appearance of many species earlier in one geographical region than another, and we can understand how under temporary favouring circumstances any one or a number of such species might be laterally diffused, so as for a time to become a component part of the fauna of a neighbouring region, at an epoch previous to that in which, after having for a time retired, they returned to play a more conspicuous and characteristic part in a later formation. But in any such instance they would be mingled with the ordinary inhabitants of the region they colonized. Yet we can scarcely conceive a colony, composed entirely of strangers and of species known in beds of a later epoch, only in the exclusive association presented by their being intercalated without admixture in the midst of an earlier fauna. On the other hand, in a disturbed Silurian country, where the strata lie at very high angles, and where there are probably numerous convolutions, contortions, and rollings of the beds, there is a probability of the occurrence of overturns and truncated crumplings, that until traced out would cause the appearance of strata containing newer fossils lying under and amid those containing older ones. Such deceptive appearances are not unfrequent in the Alps, and some well-known cases occur in our own country. With these instances vivid in our memory, I feel warranted in objecting to a theory which seems to me as dangerous as it is ingenious, and ask first for the minute local details of the course of the Silurian beds in Bohemia, before accepting a doctrine so repugnant to received belief.

M. Barrande, it is true, endeavours to show most ingeniously that the currents which determined the immigration of his colonies came from the N.E., and that the fauna of his Upper Silurians arrived by the same direction; whereas the fauna of the Lower Silurians of

Bohemia, if not created in place, arrived by currents having their origin in the S.W. If, however, as now suggested, contortions of the strata have deceived this able observer, an argument of this kind can have no weight.

Of the four stages of Upper Silurians in Bohemia, the three lower divisions are typically calcareous, and the culminant section schistose. The lowermost has a base consisting of traps alternating with black slates containing Graptolites, and including occasional concretionary limestones. It attains a thickness of not more than 900 feet, but has a fauna superlatively rich and prolific in fossil treasures. Between 500 and 600 species of organic remains have been collected in this formation. In it is found the maximum number of species of Trilobites, no fewer than 78; and several genera, including *Harpes*, *Bronteus*, and *Proetus*, appear for the first time in Bohemia. Cephalopoda abound; as many as 200 species, of which half are Orthocerata, have rewarded the collector. *Ascoceras*, *Gomphoceras*, and *Phragmoceras* are the characteristic types. Gasteropods, Lamellibranchs, and Brachiopods are numerous, and there are not a few Zoophytes.

The second or middle stage of Upper Silurian limestones presents a decreasing fauna, but at the same time exhibits the maximum of Brachiopoda. Bryozoa and Tentaculites appear, and Cephalopoda rapidly diminish in numbers.

Between the third or upper stage of these limestones and the last there is a gradual passage, and in these fishes commence and Brachiopods have become rare. A considerable number of species in this division are enumerated as common to it and the two last.

In the uppermost stage of culminating schists the community of species is reduced to two Trilobites, and the entire fauna is poverty-stricken. Traces of vegetables indicate some considerable changes in the conditions of the sea-bed.

The four upper stages, constituting in their aggregate the Upper Silurians of Bohemia, contain a fauna (the third fauna of Barrande), which, as a whole, is regarded by its describer as of equal importance with the first or primordial fauna, and the second or chief Lower Silurian fauna. The strongest relations of identity of species between the Bohemian Silurians and those of other regions, are exhibited by the third or Upper Silurian fauna. A curious point concerns the second, viz. that it is represented in France not only by the same genera but also by identical species, whilst in England and Sweden it is represented by the same generic types and a great analogy of distinct specific forms. Of the different classes of animals it would appear that but few Crustacea are common to other countries, whilst the Cephalopoda, Brachiopoda, and Corals are widely diffused. The evidences of communication between the Silurian series of different regions are clearly indicated, and everywhere the distinction between his three great faunas is maintained by M. Barrande to be plainly exhibited. At the same time he pronounces definitely for the unity of the Silurian group as a well-characterized whole.

I would now call attention to the results of his inquiries into the distribution of Trilobites, and its bearings on the view of the arrangement and phænomena of the Silurian formations, as stated above.

Out of 45 genera of these typically Silurian Crustaceans, 35 are Bohemian, and of the 10 that are not so, 2 (viz. *Olenus* and *Peltura*) belong to the primordial fauna, not exclusively however, for *Olenus*, in our country, ascends higher in the series. Of the second fauna, 6 genera are not Bohemian. And out of the entire list 7 genera have been recognized only in Bohemia. Of the species of Trilobites, the number characterizing each of the stages goes on increasing from the primordial fauna to the lower portion of the Upper Silurians, but one species only is common to as many as four of his stages, and, a fact that is worthy of notice, varies in each. The causes of destruction of species are not always clear. M. Barrande attributes due influence to physical changes as regulating their duration, but I must strongly protest against his belief in the doctrine of a limited vitality for each species ("une quantité limitée de force vital"), so that, independent of all other circumstances, each race will necessarily become extinct after a certain lapse of time. I have elsewhere exposed the groundless fallacy of this pernicious hypothesis,—a favourite one with palæontologists, although it can find but few physiologists to give it support. A curious remark is made by M. Barrande, that the species of the more ancient epochs appear to have been more prolific than those of later ages,—a remark doubtless suggested by local phænomena.

When commenting on the general distribution of Trilobites in Palæozoic rocks, M. Barrande calls attention to the fact, that of the 44 Silurian genera, three-fourths do not range upwards above the Upper Silurian stages; 11 reach the Devonian epoch, with notable diminution of specific richness, and one only is found in Carboniferous rocks. The generic maximum of Trilobites is concentrated in the Lower, the specific maximum in the Upper Silurians. The direction of the development of the Trilobites is as clearly backwards, so to speak, in time, as that of the Malacostraca is forwards. The same remark may be made on the Brachiopoda as contrasted with the Lamellibranchiata, and the Nautiloida as contrasted with the Ammonitoida. On these oppositions I shall have more to say at the termination of this discourse. Most worthy of remark is the fact confirmed by M. Barrande, that the geological position of a species in one region is not necessarily that which it holds in another. This observation is independent of his colonial theory. Thus certain Trilobites are common to the second and third faunas in England that are confined to one horizon in Bohemia, and others that are members of the Lower Silurian only in the British islands, are present in the Upper Silurian only in Bohemia.

An interesting point is the anamorphosis or change of characters within genera in their course through time. M. Barrande's remarks on this matter are highly original and deserving of study. As instances among Trilobites, I may cite the changes in the course of the grand suture; the progressive development of the eyes; the reduction of the thorax; the increase of the caudal shield; the change in the ornaments in the test, striation mainly preceding granulation. Features, however insignificant, of this kind chiefly give a distinguishing facies to the fauna of an epoch. Well was it said by Von Buch, that "the smallest difference acquires value by constancy."

I shall not attempt an analysis of the elaborate general zoological division of M. Barrande's work, or of the complete treatise on Trilobitic species that follows it. Suffice to say, that no student of Crustacea can be absolved from a close perusal of this most admirable monograph, and that every Silurian geologist should endeavour to understand and master its luxuriant details. In justice to the author, there is one section of this part of his work that cannot be passed without a remark, and that is, his chapter concerning the metamorphoses and modes of existence of Trilobites.

For years, ever since 1828, palæontologists have dreamt of Trilobitic metamorphoses, and some have pronounced definitely for, some as definitely against, the probability of the Trilobite undergoing changes in the course of its existence as an individual. The full discovery and statement of the fact was reserved for Barrande in 1849. In the same year Mr. Salter showed that the young individuals of *Ogygia Portlockii* presented 4–7 segments, and finally 8. Milne-Edwards and Burmeister, naturalists thoroughly versed in the history of living Crustacea, had previously speculated freely from analogy on the probability of their transformations. M. Barrande in the work before us demonstrates a metamorphosis in no fewer than 16 genera and 28 species. The degree of change is variable; its intensity comparable with the phænomenon in existing Crustacea. The successive and progressive elaboration of all the elements in the pygidium before becoming free and passing into the thorax, holds good in all known metamorphosing Trilobites. The number of species in which a change has been proved diminishes as we ascend in time. Among other points M. Barrande has made out the probable eggs of these animals. As to their mode of life he opposes the conclusion of Burmeister and others, that Trilobites lived in shallow water along the coast; and distinctly pronounces against the supposition of their parasitic nature.

The Geology of the British Isles.

The well and often explored mine of British geology has not yet been worked out, and there are still rich lodes to discover, as well as old workings, that yield profitable returns when re-examined. Our Journal has had its full and usual share of papers on British strata during the past year, and, judging from what I know of memoirs in hand, the coming sessions are likely to be quite as well provided for.

Our Palæozoic rocks have received their usual share of attention. Old though they be, they are as attractive as ever, and their warmest admirers during preceding years remain constant to their antiquated yet ever fresh charms. The often discussed question of their classification has been made the subject of a communication by Professor Sedgwick to the Geological Section of the British Association at Hull, explanatory of his views concerning the nomenclature of the Primary formations. The division of the Palæozoic strata into an Upper, Middle, and Lower series is a natural classification, although some may prefer a twofold instead of a threefold partition. The question concerning the appellations to be given to the subdivisions of these three sections, is one which will in the end be determined by custom and the authority of general use. Convenience is eventually the settler of all differences about nomenclature, and even in Zoology and Botany, sciences in which many definite rules are observed with laudable strictness, convenience every now and then overrides all our arbitrary regulations. Professor Sedgwick had previously, during the course of our last session, communicated, in association with Professor M'Coy, certain views of consequence concerning a proposed subdivision of the Caradoc sandstones, which demand a special notice on account of their importance, and because there have been more than one paper on this subject lately read before the Society. The result of these inquiries on the part of several observers is to place the relations of the Caradoc sandstone in a clearer light, both as to strata above and those below it.

The Caradoc was originally considered by Sir Roderick Murchison as the sandy and upper portion of the Lower Silurian strata. The rocks east of Caer Caradoc presented the best types, and those shown in ascending sections through what are generally called "the Pentamerus beds," to the Upper Silurian, and the arenaceous masses which occupied this position in the Malvern and May Hill districts, were considered by the founder of the Silurian system to be equivalents of at least a part of this series, while they graduated into the Wenlock shale.

But while our Caradoc sandstone, so constituted, contained in some parts numerous fossils that were Llandeilo species, in its upper portion it was supposed to contain these species mingled with the characteristic Pentameri. In America the latter fossils were found associated only with species characteristic of the Upper Silurians, and the group of strata containing this assemblage appeared to be cut off distinctly from the underlying Llandeilo rocks.

The unravelling of this anomaly is in part due to Professor Sedgwick, and in part to the officers of the Geological Survey. In a communication contained in the fourth volume of our Journal, Mr. Ramsay and Mr. Aveline have shown that the Pentamerus beds around the Longmynd repose unconformably upon the Llandeilo flags, whilst they graduated upwards, as Sir Roderick Murchison had stated, into the Wenlock shale. But here only the upper part of the Caradoc was developed, and this portion contained but few of the Lower Silurian species. In a subsequent paper in our eighth volume, the physical connection of the Upper Caradoc with the base of the Wenlock shale was definitely and fully stated. In the meantime, and quite independently, Professors Sedgwick and M'Coy examined the Caradoc beds of May Hill and the Malverns, and became convinced that these beds, containing as they did only Upper Silurian species, must be regarded as the base of the Upper Silurians, and that the Caradoc sandstone, as then understood, comprised two distinct formations; that east of Caer Caradoc (Horderly, &c.) being equivalent to the Bala rocks, while the group of May Hill, and probably the Coniston grits of Westmoreland, should be associated with the Wenlock and Ludlow series.

It became necessary for the officers of the Survey to test these views by an appeal to the county originally described, viz. Shropshire. The result of their labours is reported by Mr. Salter and Mr. Aveline, who undertook the task, in the first part of our tenth volume. They have shown that Professor Sedgwick's view is substantially correct, and that the typical district contains not only the equivalents of the Bala and Llandeilo rocks, but also the upper portion of the Caradoc, lying unconformably on the lower, and everywhere characterized by the Pentameri, and full of Upper instead of Lower Silurian species. These latter strata are therefore the exact equivalents of the May Hill, &c. beds. But although these rocks are thus evidently brought into a nearer comparison with the 'Clinton group' of North America and with the Pentamerus beds of Russia, they are still regarded by the Government surveyors as forming a bed of passage from the Lower to the Upper Silurians, inasmuch as several species which characterize the Lower Silurians are common in them, and especially since their distinguishing fossils, the Pentameri and Atrypæ, are found in certain portions of the Llandeilo flags, but are not known to rise into the overlying Wenlock strata. They propose to retain the name of "Caradoc sandstone" for these beds.

This evidence of intermixture of fossil species has received unexpected confirmation from America. In the second part of his 'Palæontology of New York,' Professor Hall has announced the fact, that a few of the most characteristic of the fossils of the Trenton limestones are now found in the upper part of the Medina sandstone, a formation as intimately connected with the Clinton group, as in our own country the conglomerates that skirt the Longmynds are with the overlying Pentamerus limestones and shales, and the analogy of these beds in the two continents is therefore complete.

Of the vast thickness and striking geognostic phænomena of our Lower Silurians, a concise but clear and most interesting statement is presented in Prof. Ramsay's paper "On the Physical Structure and Succession of the Lower Palæozoics of North Wales and part of Shropshire"—the prodromus of a more extensive memoir, now in preparation. These rocks, in the region described, include the prodigious amount of 42,000 feet of apparently conformable strata, including the Cambrian, in the sense in which the term is used on the maps published by the Geological Survey,—the Lingula and Bala series,—and the Caradoc sandstone. The grand facts of Silurian Geology will soon be presented in a complete and consistent picture by Sir Roderick Murchison, whose forthcoming work is anxiously expected, and is sure to fulfil all our anticipations.

The attention bestowed upon the Older Palæozoics of England has not of late been extended to the Middle and Upper. Through the kindness of my colleague, Professor Ramsay, however, I am enabled to notice an important, though as yet unpublished, contribution to the geology of the Permian districts of the Midland Counties, one with considerable economic bearings.

In all existing published maps the actual upper limit of the Permian rocks south of Derby and North Staffordshire is merely guessed at. These beds are often inserted where they do not exist, and omitted over large areas where they should be inserted.

They have now been clearly mapped and accurately defined around the Tamworth, the Coalbrook Dale, the Forest of Wyre, the Shrewsbury, and part of the North Wales coal-fields. A large area has in consequence been taken from the supposed Bunter sandstone and mapped by Mr. Ramsay and Mr. Howell as belonging to the Permian rocks in the country lying between Tamworth and Leamington, in part of which, at Exhall, a Permian Calamite, and casts of shells having Permian affinities, have been found; by these means, then, geologists have been able to support palæontologically what previously was maintained by Professor Ramsay on purely physical grounds. These facts are also important, since they prove that the Labyrinthodon described by Dr. Lloyd in the Reports of the British Association (Birmingham) 1849, is a Permian reptile, and not, as he supposed, from the Bunter sandstone.

Through the course of last year important additions have been made to our knowledge of the Bunter sandstone, by working it out in four subdivisions in the districts that lie between Chester, the Abberleys, Warwick and Nottingham. Over large parts of this area there is found to be great constancy in the lithological character of these divisions, and by their aid the surveyors have been enabled to determine numerous faults hitherto unknown, which frequently repeat the same strata for many miles.

The supposed thickness of the New Red Sandstone will consequently be much reduced in places, and this, taken in connection with accurate measurements of the extent and thickness of the Permian strata, may at no distant date lead to important economic results, in the determination of the depth at which the coal-measures lie under large tracts of the New Red Sandstone area, where there can be little doubt that it will by and by be successfully sought for.

A great step has been made towards an explanation of some of the organic phænomena of the Oolites by Professor Morris, whose memoir "On some Sections in the Oolitic District of Lincolnshire," communicated to the Society in June last year, throws new and valuable light on the relations of the southern to the northern oolites in England, and rectifies several misconceptions about the comparative order of the strata in different districts. As this paper, one of the most important in its general bearings laid before us during the past year, is printed entire in our Journal, I shall make no abstract of its details, but merely offer a few remarks on its general bearings.

The marine faunas of the Oolitic epoch indicate at least three great and widely-spread assemblages of types, each exhibiting a general and easily recognizable facies. These aspects may be termed respectively the Liassic, the Bathonian, and the Oxfordian; the two latter terms being used for want of better, and being adopted in a wide and general sense, and not in the restricted meaning in which they are used by M. Alcide d'Orbigny. The horizon of change of facies at the boundary between each is a horizon, to a considerable extent, of change of species. I believe that every year's research will make it more and more evident that the perishing of species is simply the result of the influence of physical changes in specific areas, and depends upon no law of inherent limitation of power to exist in time. If so, we should expect to find indications of the cause of the greater changes in the oolitic and marine fauna in the shape of strata bearing evidence of a wide-spread change of physical conditions within the great oolitic area. An extensive change of species within a marine area in all likelihood is dependent on an extensive conversion of that area into a terrestrial surface.

Now it is becoming more and more clear that such a change of condition occurred over a very wide area in the interval between the main mass of the middle and upper jurassic types. The researches of Mr. Morris do much towards completing the demonstration of the nature and extent of these changes in the area now occupied by the British Islands, and it will be seen hereafter, how, even as far away as Italy, we have clear proofs of a similar change of conditions about the same epoch. Much may be done towards clearing up the details of this matter by more extensive and careful investigations of the Scottish oolites, guided by the light that is opening gradually upon us. Indeed I know of no field more likely to yield fresh laurels to the British geological observer than the thorough exploration of Scottish secondary geology.

In a paper by Professor Buckman, published in the 'Annals of Natural History' for November last, and one of the many interesting contributions to British geology which we owe to that active assembly of provincial observers, the Cotteswold Naturalists' Club, the Cornbrash and associated strata of the neighbourhood of Cirencester are described in detail, and under an economical point of view not always attended to, viz. the agricultural value of the soils formed by the several oolitic rocks. Through the predominance of phosphoric acid and sulphate of lime in the Cornbrash, as compared with the 'stone brashes' of the Great and Inferior Oolite, the value of the soils in the former rock is considerably greater, as shown by the analyses of Professor Vœlcker. Mr. Buckman presents some good facts concerning the distribution of fossils in these beds, and enumerates twenty-one species of lamellibranchiate bivalves common to the Inferior Oolite and Cornbrash in Gloucestershire, and rare or wanting in the Great Oolite of the district. The recurrence of the species in this instance, as indeed in every similar case, is dependent on the recurrence of similar conditions. In every such case we may, *à priori*, assume that the intermediate strata, formed under different conditions, somewhere within the area of the ancient marine region to which they belong, change their character, putting on the mineral aspect and containing the peculiar fossils of the superior and inferior beds. Phænomena like those recorded by Professor Buckman should therefore serve as pilot facts, and guide us to fresh discoveries.

The upper Mesozoic rocks of Britain have been of late left undisturbed, with the exception of that very moveable and problematical deposit, the sands and gravels of Farringdon, which Mr. Sharpe would elevate to a considerably higher position in the cretaceous series than has hitherto been assigned them. The time is probably fast approaching when the conflicting views upon this disputed question will be tested by fresh data. For the present I abstain from taking up this critical subject.

Our Tertiaries, on the other hand, have been treated with much favour, and form the subject of several memoirs, at the head of which stands Mr. Prestwich's account of the Woolwich and Reading series. This paper completes the series of memoirs by that eminent geologist descriptive of the Lower and Middle Eocene strata of England. These remarkable essays embody the results of many years' careful observation, and are unexcelled for completeness, minuteness of detail, and excellence of generalization. They have a further merit, and a very great one, to wit, that whilst in themselves essentially local and topographical, the examination of the British strata which they profess to describe has been conducted *pari passu* with personal comparisons and examinations of corresponding formations on the continent. This method of treatment, broad and catholic in its spirit, has made the essays of Mr. Prestwich as useful to foreign as to British geologists, and secured for their author a European renown. The special subject of the last of these papers is the series of strata constituting what is usually known as the Plastic Clay formation, the mutual relations of whose several local beds had never been clearly determined, and the relative position of the beds of the Reculvers and Herne Bay to those of Woolwich and Reading were quite unsettled. This condition of things can be said to exist no longer, and we have now, instead of confusion and uncertainty, a clear statement and correlation of the local phænomena at numerous points, with a thorough revision of the lists of organic remains, and most interesting generalizations respecting the geographical and dynamical changes that affected the area during the epoch under review. Since the memoir is printed at length in the first number of our Journal for 1854, I need attempt no detailed analysis here, or enter upon the many important questions and suggestions that are in it discussed.

It has been my own lot to investigate the fluvio-marine series that terminate the Eocenes in the Hampshire basin, and to lay before you a preliminary statement of the results at which I have arrived. The demonstration that a considerable and hitherto unplaced portion of these beds in the Isle of Wight represents the Limburg series of Belgium and the Upper Eocene or Lower Miocene of France, as well as other continental formations, of which we were supposed to have no equivalent in England, will, I trust, prove acceptable to all who take interest in Tertiary geology. Since I communicated my paper to the Society, I have revisited and carefully re-examined the fluvio-marines of Hempstead and those west of Yarmouth; also the sections at Cowes and Osborne. At the latter locality, and there alone, the peculiar series to which I gave provisionally the inconvenient name of St. Helens, form a part of the surface of the island, so as to admit of being delineated on the map, for which reason I would, in accordance with the remainder of my nomenclature, designate them by the name of the district, and style them, in preference, the Osborne Series. Here also, in consequence of a considerable fault that runs in the course of the Medina, the Headon beds proper are brought up on the shore at East Cowes. A visit to the French tertiaries during last autumn has gone far to confirm the scheme of continental equivalents that I submitted to the Society, and the view which I maintained of the essentially Eocene affinities of our Hempstead and Bembridge series. I am inclined still to maintain that our succession of Middle and Upper Eocenes is more complete and continuous than that met with in either France or Belgium, the equivalents of our Bembridge marls and Lower Hempsteads being probably deficient in the former country, whilst those of our Headon series are absent in the latter. It is through the over-estimated value assigned to these breaks that the discordance in the opinions of geologists respecting the degree of relation between the Middle and Upper Eocenes in a great manner would seem to depend.

We owe to the Marchioness of Hastings an excellent detailed account of the Hordwell fluvio-marine section, the scene of the diligent researches during several years of that distinguished and zealous lady-geologist, whose contributions to British eocene palæontology have been among the most valuable and interesting made of late years.

The newer tertiaries and superficial deposits have received of late a considerable share of attention, but not more than they deserve. As yet we are scarcely in a condition to generalize upon them with safety, but are evidently fast advancing towards that desired point. Minute and repeated local observations constitute the soundest data for our guidance. Mr. Trimmer, who for years has devoted a considerable portion of his attention to this important, though not generally attractive department of geology, has communicated several papers to the Society, among which that constituting the third part of his essay, "On the origin of the soils which cover the Chalk of Kent," is peculiarly interesting and instructive. Mr. Morris and the Rev. Mr. De la Condamine have also contributed valuable notes. The whole subject may be reported upon as in progress, and, for the present, I reserve my comments. In the mean time, I would strongly urge upon British geologists the propriety of a careful comparison of the phænomena and features of the drifts, gravels, and superficial deposits of our southern districts with those of the neighbouring provinces of the continent. I believe that an investigation of this kind, which must be done personally, since continental memoirs scarcely afford sufficient data for the work, would tend to rectify many of our prevailing notions respecting their deposits. I would especially suggest a fresh examination of the fragments of older and igneous rocks met with in some of the drifts of the southern half of England, and hitherto too generally assumed to be of northern derivation. There are sources to the south or south-east, from whence similar rock-fragments might have come, and from whence, indeed, they have found their way into the gravels that lie beneath the probable equivalents of our northern drift in France. The consideration is at least worthy of notice and inquiry, the more so since there are anomalies, some of them palæontological, which at present tend to make myself, I believe among others, inclined to object to the usually received notions. We are evidently on the eve of a revival of the study of what used to be called 'diluvial' deposits—one in which I trust our continental brethren will take more part than at present they seem inclined to. The older and firmer strata, rich in definite sections and fossil treasures, doubtless present greater attractions than the inconstant charms of gravel beds and sand pits, which, however, if perseveringly studied, are sure to yield their votaries abundant reward and ample results.

The gravels of Yorkshire and Nottinghamshire have been noticed by the Rev. W. Thorp, in a paper published in the Proceedings of the West Riding Geological and Polytechnic Society. He distinguishes three sets of gravels derived from different transporting currents, and notices the existence of considerable tracts that are quite bare. The first and most considerable of these gravels belongs to the northern drift, and contains fragments of rocks now *in situ* in Cumberland. It reaches considerable elevations; masses of granite from Shap Fells having passed over Stanmoor Forest at an altitude of 1400 feet, and over oolitic hills 1500 feet high, down to the east coast. The second range of gravel constitutes in one place a narrow tract, from one to two miles in breadth, touching the northern drift near the river Humber, and extending from Leeds by Ferrybridge to Goole. It contains pebbles derived almost wholly from sandstones of the coal districts of Yorkshire, mingled with fragments from the mountain limestone, and does not extend much north or south of the valleys of the Aire and Calder. Leeds stands upon it. The direction of the transporting current was from west to east. A similar east and west range extends from Doncaster to the south bank of the Humber, formed of coal sandstone pebbles, mingled with others from the mountain limestone of Derbyshire. He places other east and west gravels composed of magnesian limestone pebbles in the same category. The third set of gravels noticed by Mr. Thorp is peculiar to Nottinghamshire. It extends uninterruptedly southwards from Doncaster to the town of Nottingham, lying on the back of the new red sandstone, spreading in a thickness of from 3 to 8 feet, but not present on very abrupt hill sides. South of Nottingham and Derby it becomes intermingled with the northern drift, but in several places is capped by the magnesian limestone gravels of the second set. This third gravel contains no pebbles derived from the neighbouring strata, but is almost entirely made up of quartz fragments, smaller, more even, and more spherical than the boulders of the northern drift. Their drifting currents flowed north and south. Mr. Thorp maintains that this gravel constituted the ancient sea-bottom left by the waters which deposited the new red sandstone itself. The gravels of his second kind he believes to have been exported from the Yorkshire coal-field during the epoch of emergence of the British area from the glacial sea; the waters being driven eastwards down the lines of valley which formed the course of easiest retreat. The absence of gravels in many districts he attributes to the protecting influence of high bluffs of land to the north of these bare areas.

The leading features of the northern drift in Yorkshire, as well as the other geological phænomena of the district, are sketched in a masterly style by Professor Phillips, in his lately published volume on the Mountains, Rivers, and Coasts of his native county. In the geological chapter of this work, the subject of the nomenclature of epochs is considered, and a scheme of terms suggested, founded chiefly on the leading organic characters of each section of time. A very neat and clear map of the geology of Yorkshire, by the same eminent observer, has been published during the year, and is remarkable for being printed by chromo-lithography, a process that is fast advancing to an astonishing degree of perfection. And here I may incidentally congratulate our science on the recent appointment of our illustrious associate to the Professorship of Geology in the University of Oxford; one that confers equal honour on the receiver and the givers. In this instance that famous school of learning has endeavoured earnestly and conscientiously to forward the true interests of science; and every geologist in the world will applaud the choice. A University that has boasted for ages of having held in especial honour our great master in Natural History, Aristotle, and that now possesses magnificent collections in all its departments, invaluable for study, may yet become a favoured home of Geology and Biology.

The Geology of Scotland has not received many descriptive contributions during the past year. One of the most interesting is the memoir on the Granitic district of Inverary, in Argyleshire, read before us by the Duke of Argyll. His Grace has rendered good service to the geology of his country before, for to him we owe the discovery of its older tertiary beds. In the paper he has now given, he deals with igneous and azoic rocks. The chief problem which he seeks to solve in the district under description, is the cause of the regular alternations of mica-slate and granite, the beds of which rocks lie conformable to each other at a considerable angle. After showing the insufficiency of any other mode of explanation, the noble author argues that the mica-slates, already completely consolidated and metamorphosed, fell in from a horizontal to an inclined position, and by falling forced the molten igneous matter between the loosened planes of stratification. The considerations put forward in this memoir are highly worthy of attention, and it is to be hoped that they will give rise to not a few minute examinations of the crystalline rocks of the Highlands, in localities where similar phænomena present themselves.

The Silurians of the south-west of Scotland have been described in detail, so far as Kirkcudbrightshire is concerned, by Professor Harkness, who considers these beds to represent successively the Llandeilo flags, the Caradoc sandstone, and the lower portion of the Upper

Silurians. The scantiness of palæontological evidence renders the exact determination of their equivalents peculiarly difficult.

In Scotland the subject of glacial phænomena continues to be discussed and investigated with unabated interest. Mr. Robert Chambers has been actively engaged in the collection of facts concerning the glaciation of Britain and the attendant phænomena. His views have been communicated at some length to the Royal Society of Edinburgh, and may be found printed at full in the fifty-fourth volume (for 1853) of the Edinburgh New Philosophical Journal. He recalls attention to the evidences of the presence of local systems of glaciers, of ordinary and typical constitution, in the mountain districts of North Wales, Cumbria, and Scotland, and notices fresh instances of this phænomenon. From it, however, he distinguishes the evidences of what he considers glacial action of a more general kind, manifested in Scotland in every part of the Highlands, and much of the Lowlands, in the rounding, smoothing, and striation of rocks, generally in the line of valley, and also in elevations to as much as 2000 feet above the sea-level. Professor Ramsay had previously demonstrated two distinct epochs of glaciers in North Wales. The direction of the icy agent in these cases Mr. Chambers maintains to have come from the north-west, and to have acted with little regard to the inequalities of the surface. He interprets the phænomena as indicating the passage over wide areas of an abrading agent, at the same time plastic and of volume sufficient to fill valleys several miles in breadth, and from one to two thousand feet in depth, and he maintains the probability of this agent being ice much water-charged and more mobile than as presented in an ordinary glacier. He holds the power of the denuding force of this agent to have been very considerable. The older boulder clay he regards as the detritus of this general glaciation, which he believes to have taken place at a period anterior to the epoch of the northern drift, which itself preceded the epoch of local glacier systems. There is much that is highly interesting and suggestive in Mr. Chambers' paper, even though we may not be inclined to go along with him unhesitatingly in his speculations. The subject of the ancient glacial phænomena of Britain, Scandinavia, and America, is evidently fast advancing towards new combinations, and the multiplication of local observations, of which many good examples are contributed by Mr. Chambers, will most effectually promote our progress towards definite conclusions. In the mean time those who occupy themselves with these inquiries should closely study the admirable and beautiful work on the existing glaciers of Norway, just contributed to science by Professor James D. Forbes of Edinburgh. The thorough knowledge and science of the author, his great experience, his searching and logical treatment of his subject, and the excellence of his style render all his works on this difficult matter models and guides.

The condition of the surface of the emerged land of the Scottish area during the epoch of general glaciation, the existence of which is inferred by Mr. Chambers, must have been very comparable with that noticed by Dr. Rink, in his late paper "On the Continental Ice of Greenland *," and by Dr. Sutherland in his researches, published in our Journal, on the western coasts of Northern Greenland. In Greenland at the present moment we have a vast extent of land "covered," to use Dr. Rink's words, "with ice to a certain elevation; mountains and valleys levelled to an uniform plane; river-beds concealed, as well as every vestige of the original form of the country." The movement commencing far inland, which that able observer describes as thrusting the outward edge of this mass of ice forward towards the sea, would doubtless produce over a large area effects of general smoothing, grooving, and striation similar to those presented by the surface of Scotland. To every student of ancient glacial action, Dr. Rink's interesting paper must be of considerable value.

In Ireland the members of the Geological Society of Dublin have sent forth an interesting part of their Journal, containing the proceedings of the last session. Mr. Willson of the Geological Survey contributes an outline of his observations on the Geology of the Southern portion of the County of Cork, chiefly concerning the thickness of the rocks that intervene between the old red sandstone and the carboniferous limestone in that district. To some of the facts stated in this paper, I would direct attention for the sake of English investigators of the middle palæozoic strata. At Bally-cotten bay, shales, slates, grits, and flagstones alternate, and occupy the interval between the carboniferous limestone and Old Red, to the thickness of 2000 feet. At Monkstown similar beds are 2600 feet. More to the south, between the neighbourhood of Bandon and the Seven Heads, 3800 feet of strata were measured without reaching the limestone, and at the Seven Heads, the intermediate beds are 4500 feet, with no certainty of their uppermost portion being reached. Mr. J. Kelly, in an interesting paper "On the Quartz Rocks of the Northern Part of the County of Wicklow," combats the view adopted in some sections, published by the Geological Survey, to the effect that they are beds interstratified with slaty rocks, and maintains the amorphous character of the masses, and their intrusive origin. Considerable difficulties doubtless attend the certain delineation of the relations of these quartz rocks, in some measure owing to the state of the country, which is much obscured by drift. A compact and well-worked memoir on the Geology of Portraine, an isolated district in the neighbourhood of Dublin, famous for the interest of the Silurian fossils that have been procured from a small patch of strata of the Llandeilo type, contains the particulars of a highly interesting tract, previously undescribed in detail. The paper is by Mr. Henry Medlicott, a young geologist of varied accomplishments and much promise, who has lately gone out to India to join the Geological Survey under the direction of Mr. Oldham. Professor Haughton, of Trinity College, Dublin, commences a series of notes on the Irish mines, and, combining his eminent mathematical and physical acquirements with practical field geology, has read a memoir on the newer palæozoic rocks which border the Menai Straits. In this essay, after describing the physical structure

* Journal of the Royal Geographical Society, vol. xxiii. for 1853.

of the south-east side of the Menai, he enters into palæontological details, and connects his subject with the geology of Ireland, by showing at some length the analogy in lithological character and fossil contents, between the lower parts of the series of strata in question, and the 'yellow sandstone' of Mr. Griffith, as seen in the North of Ireland. He maintains that in this Welsh district no distinction exists between the Devonian and Carboniferous deposits, and that the entire series of beds, including the red sandstone conglomerates and yellow sandstones at its base, must be considered as a continuous whole. It must be borne in mind, however, by English geologists, that the so-called Irish Devonians alluded to belong to the neutral ground, between the typical Devonians and Carboniferous limestones, and that for many reasons their affinities may be regarded rather as appertaining to the latter than to the former palæozoic group.

A paper of a strictly Irish character, but bearing importantly on our own Silurian Geology, has been read by Messrs. Jukes and Wyley, on the structure of the northern part of the county of Wicklow. The authors show that the Lower Silurians rest unconformably on the edges of the Cambrian rocks of that locality, and that the granite does not bring up the Cambrian rocks on its flanks, but cuts up through the Silurian; the general dip to the rocks being towards the granite for a considerable space on each side of it.

The new edition of Mr. Griffith's beautiful map has this day been presented to us, enriched by many improvements. The Geological Survey of Ireland has completed the examination of the counties of Dublin, Wicklow, Wexford, Kildare, Carlow, and Waterford, and more than half of Kilkenny and Cork, with parts of the adjacent counties. All the observable data have been laid down on the six-inch maps, and the results published on the index maps of the five first counties. The sheet inch-map of Ireland having now been commenced, and four quarter-sheets, including the northern half of the county of Wicklow, &c., being nearly ready for publication, the early geological work of that portion has been revised and the lines laid down upon the new maps. The publication of these inch-maps may shortly be looked for, and it is to be hoped that the furtherance of this good work, by the aid of the Ordnance, will receive every encouragement from Government.

Geology of British Colonies and Possessions.

In noticing the progress that has been made during 1853 in this highly important branch of my theme, I shall confine myself almost entirely to remarks upon memoirs not contained in our own Journal. That publication is rich this year in contributions to colonial geology, essays of unquestionable value, and whose merits speak for themselves. Thus from the East we have received accounts of the researches in various parts of India of Dr. Andrew Fleming, Capt. Vicary, Mr. Frere, Lieut. Sankey, and Dr. Bell; and a notice of the geology of Labuan by Mr. Motley. Captain Nelson has given us the results of his researches among the coral formations of the Bahamas, supplementary to those formerly communicated from the Bermudas by this distinguished officer. To Canadian geology Dr. Bigsby has added his account of the structure of the Quebec district. Mr. Dawson and Mr. Poole have added to our knowledge of the details of the Carboniferous formations of Nova Scotia. Dr. Sutherland has given us a full account of his observations in Baffin's Bay and among our inhospitable Arctic possessions, as well as notes on the neighbouring coasts of Greenland. Mr. Wathen has described the gold fields of Victoria; and to return to the Atlantic, Colonel Heneken has offered a contribution to the geology of the West Indies. On this last-named subject I would venture to offer a few remarks.

It is much to be desired that some able and active geologist, practised in the observation of the newer formations of Europe, would visit and explore the West Indian archipelago. There is no finer field for fresh research, and all that has hitherto been done, from the early labours of Sir Henry De la Beche in Jamaica, to the latest memoir, that of Colonel Heneken on San Domingo, communicated to the Society in March last, holds out a rich promise of reward to the man able and willing for the work. Colonel Heneken's account of San Domingo, with the accompanying palæontological comments by Mr. Moore and Mr. Lonsdale, is one of singular interest for the tertiary geologist and the inquirer into the geographical arrangements of the later epochs. The demonstration of something more than a relation of analogy between the fauna of the San Domingo and Panama tertiaries on the one hand, and that of the existing Panamian and Indo-Pacific regions on the other, is a significant advance, and points to an ancient disjunction between the masses of land in the North American area and those of the South, dating probably about the epoch of the middle tertiaries; whilst the indication of some identifications, even though few, of ground-living mollusks, not likely to enjoy a deep vertical range, with species living on the European side of the North Atlantic during the Miocene epoch, would seem to indicate an extensive stretch of land or of shallows from the West Indian region Europe-wards, that remarkably accords with some well-known indications afforded by the distribution of existing creatures.

The number of papers on East Indian geology, referred to as contained in our Journal, would of itself be ample evidence of the diligence and zeal of Indian geologists. But the student of the structure of the East must not confine his studies to the transactions of societies at home; in the journals of Indian Societies he will find many papers of great interest. The excellent report on the geological structure and mineral wealth of the salt range in the Punjaub, by Dr. Andrew Fleming, is an instance. It may be found in the Journal of the Asiatic Society of Bengal; in which work are some remarks by Capt. Young on the much-disputed subject of Laterite. The last-named paper contains interesting notices on the geology of Burmah. Dr. Kelaart, in another eastern periodical, has published his observations on the Laterite of Ceylon. The Journal of the Bombay branch of the Asiatic Society not unfrequently contains essays of geological interest. Among these, in the last year, is one of the most valuable of recent additions to our knowledge of the geology of India, a memoir on the Geology of the Nagpur State, by the Rev. S. Hislop. A good deal had been done for the investigation of this interesting district, and in a paper communicated to the Society by Lieut. Sankey of the Madras Engineers, a detailed history was given of the results of the researches there of geologists and collectors, more especially Messrs. Hislop and Hunter, who had previously transmitted to us an extensive suite of fossils. Mr. Hislop maintains, supporting his opinion by forcible arguments, that the overlying trap of Central and Western India cannot have been poured out in the bed of the ocean, but must have been erupted in a lake or chain of lakes. The freshwater tertiaries that underlie the trap he considers to be of Eocene age, perhaps too positively, although his view is consistent with some indications afforded by the shells that occur in them; but it should be borne in mind by all describers of fluviatile and lacustrine formations, that mere analogy of form is a very bad guide in the determination of the epoch of freshwater mollusks. "The sandstone of Central India, which appears to be identical with the diamond sandstone of Southern India, belongs with its associated shale and the Indian Coal-measures to the Lower Oolitic formation." He suggests the probability of these sandstones being of freshwater origin, and maintains that the Deccan exhibits no evidence of having been submerged by the ocean since a period anterior to the Oolite.

The description of the fossil animals of the nummulitic rocks of India, by Vicomte d'Archiac and Jules Haime, elsewhere alluded to when the monograph of Nummulites was mentioned, will, when completed, form a manual of the highest value for the study of this extensive formation in the East. The part already published contains the account of the Corals and Echinoderms (as well as the Nummulites), and is preceded by a review of the geology of the nummulitic region of India. This chapter is not a mere summary of what had previously been known and published. It contains much that is new, facts of high value derived from the researches of our associates, Vicary, A. Fleming, Oldham, R. Strachey, Thomson, and J. D. Hooker. Sir Roderick Murchison has been the means of placing these fresh data at the disposal of M. d'Archiac. The result of these studies has been the confirmation of the complete independence of the nummulitic in regard to the Cretaceous formations. "In the province of Cutch, in Scinde, Beloochistan, the Punjaub, and along the slopes of the Himalaya," remarks M. d'Archiac, "the beds beneath the nummulitic limestones exhibit nowhere the characters of any stage whatsoever of the chalk, whilst, wherever the substratum has been recognized, it exhibits those of carbonaceous deposits with clays and sandstones belonging to the lower tertiary formation, and resting either on Jurassic strata, or on more ancient rocks of which the age is yet unsettled."

Every student of Indian geology will be delighted at the appearance of the 'Himalayan Journals' of Dr. Joseph Hooker, a work that will do much to sustain the reputation of the British school of

Natural History. The geologist will find in it a rich store of facts of the highest interest, and for the inquirer into glacial phænomena it abounds with new and invaluable data. I may say the same for the geographical memoir of Capt. Richard Strachey on Western Thibet; and we all look forward anxiously to the publication of the detailed account, now in progress, of his geological researches, knowing as we do, how rich a store of new and important facts was accumulated during his adventurous journeys.

It is most gratifying to think that at the present moment no small proportion of our foreign possessions is being surveyed geologically by able and trained observers, and that the vague and often incomprehensible statements of self-satisfied and shrewd though ignorant miners and unqualified travellers, are fast being supplanted by the results of careful and accurate research. In Canada Mr. Logan pursues his great work, with able assistants, as zealously and successfully as during former years. In Eastern India Mr. Oldham is similarly engaged, and has gathered around him several young geologists of promise, trained in the methods of European research. In the provinces of Australia, mineral exploration is not abandoned to mere gold-seekers, and the government reports are now scientific documents. Mr. Stutchbury and Mr. Clark are at work in New South Wales, and Mr. Selwyn has undertaken the exploration of Victoria, with the advantage of having previously passed through a strict geological discipline in the survey of North Wales. In our colony of the Cape of Good Hope a geological survey is being regularly conducted by Mr. Geddes Bain, whose private researches had previously produced remarkable discoveries; and in that of Natal, a similar official exploration is, I believe, about to be conducted by the Surveyor-general, Dr. Stanger, whose perfect qualifications for the office are well-known to many Members of our Society.

Progress of Geology abroad.

Of late years the literature of our science has annually received so enormous an increase, that to keep pace with the progress of the details of local geological research is a labour almost beyond the ability of a single individual. In every civilized country the number of pursuers of geology is rapidly multiplying, and the transactions of foreign societies have become prolific in memoirs treating on all departments of our science. France, Prussia, Austria, Russia, Italy, and Scandinavia have all, during the past year, contributed largely through their geological and other societies as well as by separate treatises. In the New World a like manifestation of scientific activity is exhibited, so it would be presumptuous to pretend to report, in an address of reasonable dimensions, the particulars of geological progress abroad during 1853. I shall therefore confine myself almost entirely to the noticing of a few papers and works upon foreign geology that bear more or less directly upon questions of peculiar interest to workers at home. One of the most important, the great work of Barrande, I have already noticed at some length. The date

(1852) of the excellent and truly valuable works of Dale Owen (on Wisconsin, &c.) and James Hall (Palæontology of New York), places them out of my plan; both are of the highest merit, and ought to be carefully perused by every British student of palæozoic formations. The beautiful and laborious map of Belgium by Dumont, one of the great works of our day, has only just come to hand in England; as likewise have the very welcome second volume of Professor Studer's 'Geology of Switzerland,' and the commencement of a national work on the geological survey of the Netherlands.

The admirable 'History of the Progress of Geology from 1834 to 1852,' by Vicomte d'Archiac, a work that does equal honour to the Geological Society of France and the French government, under whose auspices it is published, continues to advance steadily, though still far from its completion. During 1853 the second part of the fifth volume has been issued. This part is devoted, like the last, to the Cretaceous formations; the regions treated of being the Iberian peninsula, Italy, the countries around the Levant, those around the Baltic, the north-west and centre of Germany, Poland, Gallicia, the Carpathians, Russia, Asia, Africa, and America. A prefatory chapter is occupied with the discussion of some general principles involved in the consideration of the phænomena afterwards described, and in a concluding essay the author reviews the geographical and stratigraphical distribution of the Cretaceous formation considered as a whole. The essential characters of this work are such as to preclude any analysis in an Address of this kind. I feel bound, however, as one of the many who feel grateful to M. d'Archiac for the inappreciable assistance afforded by this labour of love on his part, to bear the strongest testimony to the ability, learning, philosophical spirit, and impartiality with which he has executed so far the difficult and delicate task undertaken by him in the composition of this History.

The accession to our ranks of a new and able observer is always a subject of commemoration and congratulation; still more so ought it to be, when our gain is in some partially-explored region, and one where men of science are few and far between. We can boast of such an accession in Senhor Carlos Ribeiro, whose excellent notices of the Carboniferous and Silurian formations of the neighbourhood of Busaço in Portugal have been communicated to us in an ably-condensed memoir by Mr. Sharpe, with notes of high value from several of our Members. We may hope that this paper, a valuable addition to the series of contributions to the geology of Portugal, mostly due to the personal labours of our Treasurer, is a precursor of a full and detailed exploration, by native observers, of a region in great part as yet virgin ground for our science.

The geological structure of a large portion of Spain has been outlined in masterly style by MM. de Verneuil and Collomb in a memoir entitled "Coup d'œil sur la Constitution Géologique de plusieurs Provinces de l'Espagne," communicated to the Geological Society of France. To every scientific traveller visiting the Peninsula hereafter this excellent treatise will be indispensable. It is illustrated by sections and figures of organic remains; a geological map of Spain is promised. The authors, ever ready to acknowledge and do justice to the labours of those who have gone before them, not only satisfactorily show that the spirit of geological research is active and working among Spanish men of science, but also demonstrate, by a detailed catalogue of no fewer than 154 works and memoirs, that Spanish geology is not so unexplored as many of us are apt to fancy. Among the names of British contributors in his long list are those of Lyell, Silverton, Cook, Traill, Daubeny, Pratt, and Smith of Jordan Hill.

Although when British geologists make raids into the neighbouring regions of the Continent, especially France, Belgium, and Germany, where so many able and eminent brethren of the hammer are exploring with success the structure of their native countries, the object and purpose of their predatory incursions are chiefly to benefit by the experience and teaching of their scientific neighbours, occasionally they feel bound to differ and attempt to correct. There are some provinces, indeed, so closely allied in their geological constitution to well-explored portions of our own archipelago that they seem as outliers of our own geology, and therefore fair fields for critical inquiry. One of these lies almost beside our shores, and is well worthy of examination and study by every geologist engaged in the examination of the upper and middle palæozoics. I allude to the country about Marquise in the neighbourhood of Boulogne. Although not unfrequently described by both French and English observers, much obscurity hangs over the chronological affinities of the palæozoic rocks of this district; and although latterly the demonstration of these relations was being more nearly approached than a few years ago, there still remained much to be done, and none among our countrymen is fitter to undertake their exploration and elucidation than Mr. Austen, whose knowledge of the palæozoics of Devon peculiarly qualify him for this task. The valuable memoir communicated to us in March last is the account of his researches. Leaving its details, as published in our Journal, to explain themselves, I will merely call attention to two or three results of leading interest. Mr. Austen clearly proves that all the Palæozoics of this district belong to the Carboniferous and Devonian series. If any doubt could be entertained respecting any portion of these beds, it would fall upon the black schist of Caffiers, the lowest visible member, and hitherto regarded as unquestionably Silurian; this he sets provisionally aside. But Mr Sharpe, in his excellent appended note, places the supposed lower palæozoic nature of this schist in an extremely doubtful position, by showing that the so-called Graptolites contained in it are really plants. The determination of the true relations of the yellow sandstone belts, with their characteristic contained bivalves, is an important step, and gives us a zone of division between the carboniferous and Devonian limestones, the true equivalents of which are evident and similar in our own regions of Devon and in Ireland. In the latter country this horizon marks distinctly what may be regarded as the line of division between the lower carboniferous rocks—the carboniferous slates, &c. of Dr. Griffith—and the upper portion of what may be considered the Devonian series proper, that part in which the Kilkenny beds, containing *Cyclopteris hibernicus*, *Anodon Jukesii*, and other fossils indicative of shallow and probably estuary or fluviatile conditions, occur. The Marwood sandstones of North Devon (and the Pilton and Petherwin groups) correspond with it. To what extent the comparison of the beds at Marquise lying below this band, the Ferques and Fiennes groups, and the underlying beds are to be regarded as representing the whole Devonian series, is a question about which Mr. Austen and Mr. Sharpe are at variance, though the much-wished-for publication of M. Bouchard's lists of Ferques fossils would possibly go far towards settling the matter in Mr. Austen's favour, his view being that the Eifelian, Ahrian, and Rhenane series of Dumont are here represented. These are points that time will certainly clear up. In the meanwhile a good stride onwards has been made towards assisting our own students of Devonians, who would do well to study carefully this memoir upon the Marquise beds, and to ponder over the excellent and highly suggestive comparative table of the succession of mineral characters and physical conditions that is appended to it.

The Devonians of the Rhenish provinces have lately received a full share of attention, chiefly, however, in a palæontological point of view. I shall have hereafter to call attention to several memoirs bearing upon their organic history. A fresh geological description of the Eifel has been published by the veteran Steininger, illustrated by sections and figures of new fossils. It is very questionable, however, how far the identification of Devonian with Silurian species, put forth in this work, can be accepted. The author's mistakes have arisen chiefly from his retaining the old but now untenable notion of the Silurian place of the German Spirifer-Sandstones. The most valuable contributions to the elucidation of the German Devonians are the works of the brothers Sandberger, who have done much towards the definition and precise classification of this series of rock-formations.

The problem of the true relations of the Calcaire pisolitique of the Paris basin is likely before long to receive some satisfactory solution. Hitherto the balance of opinion has inclined in the direction of the view so ably advocated by M. d'Archiac, and urged also by Sir Charles Lyell, to the effect that the fauna of this formation and its stratigraphical relations warrant the reference of it to the tertiary series. M. Hébert, on the other hand, and with much show of reason, insists not only on its connection with the cretaceous series, but also of its equivalence to the yellow chalk of Maestricht. This question is becoming one of general interest, and has already had its influence in debated portions of our own geology. The views of M. Hébert are stated at some length in a note on the synchronism of the Calcaire pisolitique of the environs of Paris and the Upper Chalk of Maestricht, published in the Bulletin of the Royal Academy of Belgium. The English geologists must bear in mind that the term "Upper Chalk" thus used by M. Hébert, and proposed by him as a denomination for that highest portion of the cretaceous series in which he would place as synchronous the Calcaire pisolitique, the Faxoe chalk or

Terrain Danien, and the baculite limestone of the Cotentin, is not to be understood as embracing the beds which we are accustomed to call "Upper Chalk" in England, and which are especially developed in Norfolk and the east of Kent. The equivalents of the latter, of which the *Cardiaster granulosus* may be mentioned as a characteristic, widely diffused, and guiding fossil, may be seen at Cipley and near Maestricht underlying the yellow chalk with *Hemipneustes radiatus*, i. e., the "Craie supérieure" of Hébert. I have never seen in England any beds which could satisfactorily be assigned to the last-mentioned series, but think it extremely probable that the chalk of Antrim in Ireland, which assuredly should be regarded in its greater part as equivalent to our English Upper or Norwich chalk, will be found to include equivalents of the Maestricht or yellow chalk of the continent. I make this suggestion in consequence of having carefully examined the fine collection of Irish fossils brought together and first described by Colonel Portlock, and the still more extensive suite in the Belfast Museum collected by Mr. MacAdam, for the publication of whose long-continued labours among the formations of the North-west of Ireland, all geologists acquainted with that able observer's perseverance and careful inquiries, now continued over many years, impatiently await.

Mr. Prestwich has communicated to the Geological Society of France his views respecting the position of the tertiary sands and lacustrine limestone of Rilly (Marne). The true place of these beds in the series of lower sands of the Paris basin had not been determined with certainty. Much general interest attaches to the question, since, if, as has been maintained by some eminent French geologists, the freshwater limestone of Rilly is more ancient than any known tertiary deposit (providing the reference of the Calcaire pisolitique to the Cretaceous group, as proposed by M. Hébert, be accepted), then we have clear proof of the entering in of the Tertiary epoch in the area under dispute with terrestrial and fluviatile or lacustrine conditions; the Rilly limestone in this case having been deposited in lakes upon the emerged Cretaceous surface. Mr. Prestwich maintains, however, the independence of the sands and the limestones, and the superposition of the latter on the former. He, for the first time, records the presence of fossils in these sands, apparently much in the same condition as they appear in the similar, though not homologous Headon sands in the Isle of Wight. As in the latter case, they are marine. He holds these sands to belong to the same deposits with those of Chalons-sur-Vesle and Chenay, both marine sands below the lignites. He concludes that the Rilly limestone was preceded by a marine deposit of tertiary age, and was not the most ancient of the tertiaries. On many and good grounds, he maintains that it was a local travertine formed in a small lake, swamp, or marsh; a view supported by the fact that out of forty-five species of Rilly shells, no fewer than thirty are of terrestrial habits, whilst most of those that are aquatic are pulmoniferous types. The presence of *Aviculæ* in these beds would seem to indicate the neighbourhood of salt water.

The treatise on the Tertiaries of the Mayence basin, by the brothers Sandberger, is for all who study the relations of the middle to the lower tertiaries, one of the most valuable contributions to our science during the year. Since, however, we are shortly to have presented to us the results of Mr. Hamilton's prolonged and careful labours in the same region, I shall abstain for the present from any comments on an essay of peculiar interest to myself, as well as on other recent German papers, especially those by Beyrich and Dunker, affecting the same, or closely allied localities.

Organic Remains.

The enormous increase of palæontological observations may be measured by a comparison between the number of species recorded in the first edition of Professor Morris's Catalogue of British fossils, and the number mentioned in those portions of the new edition that have gone through the press, and will shortly be published.

The number of plants recorded in 1843 was 510; in 1853, 652 are cited. The increase is chiefly among Mesozoic and Tertiary types. A great deal has been done to elucidate the structure and affinities of fossil plants in the interval, especially by Dr. Hooker, Mr. Charles Bunbury, Prof. King, Mr. Dawes, and Mr. Binney, but not so much towards adding new names to our lists of species. In Fossil Botany this course of proceeding is a sign of advance of knowledge. The most marked increase in number of recorded species is among the oolitic and Wealden beds. The late lamented Dr. Mantell did much of late years towards increasing the latter list. Were all the known fragments of distinct vegetables found in our tertiaries monographed and named in the manner of those I shall have presently to mention, described and figured in the lately published memoirs by Austrian botanists, our lists would be considerably increased. They certainly ought to be made the subject of a treatise, and might be advantageously taken up by the Palæontographical Society, which, as yet, has given us no separate memoir on British fossil plants.

The Amorphozoa come next. In 1843, 76 named forms were recorded. In 1853, the number is increased to 116. The increase is in a great measure due to the labours of Mr. Toulmin Smith among the Ventriculidæ, which, notwithstanding the arguments of their investigator in advocacy of their Polyzoan, and consequently Molluscan origin, naturalists are generally of accord to keep in their old place beside the Sponges.

The Foraminifera, 82 of which are mentioned as named types in the list of 1843, have increased to 168, besides numerous indications of unpublished and, as yet, unnamed forms. The next ten years will probably triple the amount of named fossil species of these exquisite minims of creation. The additions are chiefly new identifications of British fossils, with species described by continental authors, especially by Alcide d'Orbigny and Reuss. The merit of determining these is, I believe, in great part due to our Assistant-secretary, Mr. Rupert Jones, whose authority stands very high in all departments of microscopic palæozoology. Mr. Jones himself is an addition to the list of British Palæontologists during the last ten years, and one we all welcome. The labours of Dr. Williamson and Dr. Carpenter have also done much towards clearing up our fossil Foraminifera; and the untiring exertions of Mr. Harris, of Charing, though inconspicuous in print, have, I believe, been a chief source of fresh materials towards the history of our cretaceous species.

In the first edition, the Zoophyta are combined with the Bryozoa. When the latter are eliminated there remain 183 zoophytes, chiefly corals. This number has been prodigiously added to within the last ten years, no fewer than 438 species being enumerated in the new catalogue. The increase, in this instance, is due to an entirely new treatment of the subject. To Milne-Edwards and Jules Haime a large proportion of the additions are indebted for their place. Mr. Lonsdale and Professor M'Coy have also contributed extensively.

The Bryozoa, a few years ago regarded as Zoophytes, but now known to be low forms of the subkingdom Mollusca, amounted to about 132 in the first edition. In the new catalogue, they constitute a roll of no fewer than 249 species. This extended list is due to many investigations, and the newly-recorded types come from formations of all ages. Attention seems to have been suddenly directed to these curious bodies both at home and abroad. The study of the British fossil species, vast as is the increase of the recorded numbers, can be regarded only as in its commencement. I trust that geologists who may direct their attention to these bodies hereafter, will bear in mind the complete and searching analysis of the existing species drawn up by Mr. Busk for the British Museum, and guide themselves in describing the fossils by the example of that valuable treatise.

The Echinodermata, 266 in number in 1843, are now 479; the record of species is daily increasing, but I do not think likely eventually to extend beyond 500 British forms. Major Austin, Professor M'Coy, Dr. Wright, and myself have been the principal workers in this beautiful, and in a geological point of view, invaluable order. The additions of the entire family, including not a few genera and species, of Cystidea to the list, (for the Sphæronites of the former catalogue is probably not a cystidean,) a group as characteristic of the lower palæozoic formation, as the Graptolites or myriads of Trilobites are, is one of the most striking instances of the progress of palæontological research, and one due for several of its most curious facts to the exertions of Mr. Fletcher, and Mr. John Gray of Dudley.

The named Annelida were 79 in 1843, they are now 129. The most interesting additions are among palæozoic forms.

The Cirripedia, 21 in 1843, are now 42. The value of the increase in this instance is not to be estimated by the merely doubling of the number. They have been thoroughly sifted by a master-hand, analysed with incomparable care, and by a combination of unsurpassed labour with judgement and knowledge of the highest kind, have been brought to a state which may be regarded as, at least for many years to come, the epoch of maximum in their investigation. To Charles Darwin we are indebted for this service.

The Crustacea are now 291; in 1843, they were 159. This is an enormous advance, and curious, since in great part it has arisen from additions to the list of palæozoic species. It marks, moreover, not merely an advance of names, but one of knowledge, as may be judged from an inspection of the changes in the generic list. The Trilobites have undergone a complete revision, and the number of species of those singular animals is vastly increased, thanks more especially to the work done by Salter and by M'Coy. The Cytheridæ and Cyprididæ have become a feature in the catalogue, mainly in consequence of the researches of Rupert Jones. Professor M'Coy has largely added also to the list of these tribes, and to the catalogue of the higher crustacea from our mesozoic and lower tertiary strata.

The additions to the list of fossil insects more than double this portion of the catalogue. They are due to the Rev. P. Brodie, and are entirely derived from mesozoic strata, chiefly from the Purbecks and Lias. In this department there is a considerable amount of unpublished materials existing in collections.

The number of Brachiopoda has swollen from 459 to 668, an addition of more than 200 species! In the mean time they have been undergoing complete and thorough revision. Mr. Davidson, whose appearance among us as a British palæontologist has taken place in the interval between the two editions, is foremost among the workers in this department, one greatly increased also by the labours of King, M'Coy, and Salter. Some very interesting contributions have come from Mr. D. Sharpe, and Mr. C. Moore of Ilminster. The important discovery of Liassic species of Leptæna and Thecidium in Britain is due to the last-named observer.

The catalogue included 318 Monomyarian Bivalves in 1843; in the new edition 577 are recorded. The additions in this instance come from numerous sources. Both in this and the following group we owe much to the labours of Mr. Morris and Mr. Lycett among the Oolites.

The lists of the remaining groups of fossil animals will, when completed, show a comparable increase in almost every section. In the highest, a large accession as well as a revision of species, will give a new value to the catalogue; many of the researches of Professor Owen among the reptiles and the warm-blooded Vertebrata, and of Sir Philip Egerton among the Fishes, having been given to the world in the interval. Indeed, scarcely a month now passes without the appearance of some published contribution to British palæontology.

The volume, or rather fasciculus of volumes, for the year 1853 issued by the Palæontographical Society is, in respect of richness of illustration and value of matter, one of the finest productions of this useful union. In its distinctive features it differs somewhat from its predecessors, inasmuch as a considerable portion of it is occupied by a series of elaborate treatises on the anatomy, microscopic structure, and systematic arrangement of the Brachiopoda, respectively contributed by Professor Owen, Dr. Carpenter, and Mr. Davidson. The anatomical plates attached to this memoir are, without exception, the most beautiful engravings that ever illuminated a natural-history treatise. The lithographic plates illustrative of the genera of Brachiopoda are also excellent specimens of their kind, both in execution and arrangement. They are remarkable, not only for their fidelity, but also for their artistic merits, the more so since they are the work of an amateur in art, our accomplished associate, Mr. Davidson, to whose generosity and zeal for science, the world of geologists is deeply indebted for these admirable drawings. The former annual volumes issued by the Palæontographical Society have scarcely, owing to acccidental circumstances, received notice in the Anniversary addresses, and I take this opportunity of offering a word of congratulation to the geologists of Great Britain, on the services rendered to their science through this remarkable series of monographs,—products of disinterested zeal and earnest co-operation.

When the Palæontographical Society was started, its founders could not have anticipated the success that has crowned its exertions, or the facility with which able and enthusiastic labourers in the field of science it proposed to cultivate, would have been found willing to devote their gratuitous exertions to the work. Hence there has arisen an inequality of plan and difference of treatment in the several monographs published annually, much to be regretted, but scarcely now to be remedied. Where a subject mainly of importance to a branch of zoology that chiefly concerns the geologist, such as that of the Brachiopodous Mollusks, is treated fully and completely as in the volume for 1853, we are grateful for the boon, even though such a treatise was foreign to the original intentions of the Society. But in the majority of instances it is doubtful how far it is desirable to expend the resources of the Society on printing purely zoological matter mixed up with the palæontological descriptions, and necessarily imperfect, and causing much repetition. Good figures and good descriptions of fossils are the true ends to be kept in view. It is also to be regretted that the Society had not started with a definite scheme of monographs; each and all should have been either stratigraphical, or else systematic; but we have now a mixture of both, which sooner or later will be the cause of not a little clashing and confusion.

The more strictly palæontographical portion of this volume is occupied by the continuations of the Monographs of British Fossil Corals, by Milne-Edwards and Jules Haime; of Mollusca of the Great Oolite, by Morris and Lycett; of the Crag Mollusca, by Searles Wood; and of the British Fossil Reptilia, by Owen. About 250 species of fossils of various orders are described and figured. Of these about two-fifths are either wholly new to science, or else new to the British Fossil Fauna—no small addition to our knowledge of extinct animals to come from one Society in a year.

In this part of the monograph of the Corals our Devonian species are described and figured, British examples only being selected for delineation, a precaution in a work of this character that cannot be too strictly attended to, since on its essentially local or topographical features much of the peculiar interest and value attached to it must depend. Sad mistakes in other works have been committed through the neglect of this precaution by more authors than one, and many a dispute might have been prevented, had the exact locality, or if none was known for certain, the fact of the want of knowledge, of the specimen figured, been precisely stated. Forty-six corals occur in the British Devonian strata, being rather less than one-third of all known Devonian corals. Almost half of these are as yet peculiarly British, and of the others only six (five of them being also continental in Europe) occur on the other side of the Atlantic, a fact which, when we call to mind the wide latitudinal range of the Anthozoa, has an important significance in its bearing upon the determination of the geography of the northern hemisphere during the Devonian epoch. Three only of our Devonian corals are regarded by Milne-Edwards and Jules Haime as identical with Silurian species, whilst they consider all the others as peculiar to their epoch. All the species described belong to the groups *Zoantharia tabulata* and *Zoantharia rugosa*, and the most conspicuous and recent-looking corals of the Devonian reefs and banks were members of the latter suborder, one of which there are no living representatives. Hence all inductions drawn from the presence and forms of these zoophytes respecting the prevalence of a warm or tropical climate within our area during the epoch of their flourishing must be set aside, since they have been founded on the mistaking of analogies for affinities. If we accept the views promulgated concerning the structure and classification of corals by Milne-Edwards and Haime—numerous facts in whose support are accumulated in the several parts of this monograph—the prevailing opinions concerning the physical condition of the palæozoic epochs must be very considerably modified or subdued, and the separation of those vast and infinitely remote periods from the stages in time that succeeded them be made even more manifest than was indicated by the phænomena presented by other groups of palæozoic creatures.

The appearance of the first part of the "Description of the Fossil remains of Mollusca found in the Chalk of England," by our valued Treasurer, Mr. Daniel Sharpe, will be hailed with pleasure by students of cretaceous beds all over Europe. The portion published embraces the Belemnites, the Nautili, and part of the Ammonites, and contains descriptions and figures of 24 species, of which two are wholly new, and six new to British lists. The range of cretaceous strata from whence the specimens described have been procured, extends from the Upper Chalk of Norfolk and Gravesend, to the Chloritic marl of the Isle of Wight, and "Chalk with green grains" of Somersetshire. It is worthy of notice that of the Nautili described, several are recorded as having an extensive vertical distribution; thus *Nautilus lævigatus* ranges from the Upper Greensand to the Upper Chalk, whilst *Nautilus pseudo-elegans*, *N. radiatus*, *N. neocomiensis*, and *N. undulatus* occur in both the upper and lower divisions of the Cretaceous system; in others words, both above and below the Gault. Every fact of this kind well ascertained, is of no small interest at present, when there is an extreme and unwholesome tendency on the part of many palæontologists to insist *à priori* upon the distinctness of species coming from different stages, and to force their diagnoses accordingly.

The part of the "Monograph of the Mollusca from the Great Oolite," issued for 1853, is devoted to the Lamellibranchiate Bivalves (not yet completed), of which 116 species are here described and figured. Of these 36 are new to science, and 24 continental forms new to British lists. The authors remark that a large proportion of the Oolitic Lamellibranchiata had shells whose hinges were either a lengthened hinge-plate with a parallel series of transverse or oblique teeth, *i. e.* a hinge of the Arcoid type; or a toothless hinge of the Mytiloid and Myoid types; or a hinge with a ligamentary fossa only (as *Pecten* and its allies); or with the ligament inserted in distinct pits (*Perna* and its allies). Shells with cardinal teeth constituted only a minority: hence the *Veneroid* forms of the oolites are especially few in number. The preceding parts of this valuable monograph were equally rich in facts of a general character, and consequently now so well known that they need not be recalled here.

Professor Owen's instalment for 1853 towards his great monograph of the British Fossil Reptiles includes the Chelonia Paludinosa of the Wealden and Purbeck beds. Eight species are described and figured (six of them new), members of the genera *Pleurosternon*, *Chelone*, and *Platemys*. Those of the first named genus (four species) are all from the Purbecks, those of the two latter from the Wealden beds, properly so called. So far, then, the Reptilia tend to support the views that I have promulgated, after a careful and extended study of the Dorsetshire Purbecks and Wealdens, to the effect that these groups are not members of one series of freshwater beds, but perfectly distinct, and indeed belonging in part (the Purbecks) to the Lower, and in part (the Wealdens) to the Upper Mesozoic epoch. During the past summer I have had occasion again to go over the sections in the Isle of Purbeck, deliberately and in minute detail, and I remain confidently of the opinion which I put forth at the Edinburgh Meeting of the British Association in 1850. The detailed memoir on this subject, to be amply illustrated, is in progress, and if possible will be published in the course of the present year. In the mean time I do not regret the delay, since I have thereby been enabled to work out deliberately numerous points requiring time for their elucidation.

The monograph of the Crag Mollusca is fast advancing towards completion, and the fresh part is as remarkable as the former ones for the fulness of knowledge of the subject that has throughout characterized this important contribution to British Palæontology. Mr. Wood has spared no pains, and has worked from the most ample materials. The genera of Bivalves with cardinal teeth occupy this portion of his treatise. Of these 57 species are enumerated; not a few are now fully described and figured as British fossils for the first time, the previous notices of them having been restricted to a bare mention. I would earnestly urge upon continental geologists the consideration of the results at which Mr. Searles Wood has arrived in this most careful monograph. There cannot be a doubt that the epoch (or rather epochs) of the Crag, was as distinct from that of the present stage in the world's history,—whether we consider the physical conditions of the area from whence our data are derived, either under a climatal or an orographical aspect, or the natural-history features of the population of that area,—as any "étage" of the upper or lower Mesozoic period was from any proximate "étage." Nay, the difference was even greater; for the physical and natural-history characters of the Pleistocene epoch that intervened were quite of as much differential importance as those of either "étage." Yet now that we know the Crag Molluscan fauna, we might almost say perfectly, no sane naturalist can for a moment deny that a large proportion of the species are positively identical with living types. Let those who would hastily draw a line of death between the faunas of proximate "étages," and regulate their geological conclusions accordingly, ponder well over this significant fact.

The essay on the classification of the Brachiopoda, by Mr. Davidson, contains the conclusions arrived at after many years of conscientious labour, mainly devoted to this interesting order of Mollusks, for whose illustration we owe so much to his pen and pencil. No other palæontologist has ever had so great an amount of perfect materials for his particular task at his command, and neither expense nor labour has been spared by our indefatigable associate to render his monograph as perfect as possible. If any of our brethren dissent from some of his specific decisions, they must all admit that they have been arrived at on no superficial grounds. The portion of Mr. Davidson's work now sent forth is entirely systematic, and is devoted chiefly to an exposition of the characters and definition of the families and genera of Brachiopoda. He admits 33 genera assembled under 10 principal families, with some intermediate and doubtful or provisional groups. As he has endeavoured to define his genera on the strictest natural characters, and appears to have succeeded in arriving at an arrangement, in the main sound and near to the truth, it becomes an inquiry of considerable interest to ascertain how far the ranges of these genera are continuous in time; in other words, whether the theory of unique generic time-areas be borne out among the Brachiopoda, now that we may be said to have attained so extensive a knowledge of their generic and specific types. This was doubtless the idea working in the mind of Von Buch, when with indifferent materials, he attempted to fix the characters of the fossil Brachiopoda, and plainly has often influenced the numerous attempts at their classification made by subsequent palæontologists. I have no reason to suppose that an *à priori* hypothesis, connected with either time- or space-distribution, influenced Mr. Davidson in coming to his final arrangement, and therefore I have been the more curious to see how far that arrangement accorded with geological considerations.

In the first family, *Terebratulidæ*, the typical genus *Terebratula* (of which *Terebratulina* and *Waldheimia* are regarded as subgenera), the succession of types is continuous from the middle palæozoic or Devonian epoch to the present time; whilst the other genera are either Upper Mesozoic, Tertiary, and recent (as *Terebratella* and

Argiope), exclusively Upper Mesozoic (as *Magas*), or exclusively recent (as *Bouchardia*, *Kraussia*, and *Morrisia*).

Stringocephalus follows as the type of a provisional family, exclusively Devonian.

The *Thecididæ*, represented by *Thecidium* alone, range continuously from the Trias to the present time.

The *Spiriferidæ* concentrate towards the palæozoic pole. In this family Mr. Davidson includes *Spirifer* (with *Spiriferina* and *Cyrtia* as sections), *Athyris*, *Spirigera*, *Uncites* and *Atrypa*.

Rhynchonella, with *Camerophoria* and *Pentamerus*, form a family under the name of *Rhynchonellidæ*. The absence of perforations in the shell is the rule in this group. The typical genus is one of the links between the palæozoic and present epoch, and has its maximum in the Mesozoic.

The *Strophomenidæ*, *Productidæ*, and *Calceolidæ* all concentrate in the Palæozoics; *Leptæna* only, in the first named family, extending into the lower Jurassic strata.

In the *Craniadæ*, represented by the single genus *Crania*, we have a type of Brachiopod almost equally present at all epochs. The nearly allied group of *Discinidæ*, though extending to the present, is generically concentrated in the Lower Palæozoics. The same remark may be made respecting the *Lingulidæ*.

Accepting the genera adopted by Mr. Davidson as mutually equivalent groups, and regarding their distribution in time as determined by him from a vast amount of specific materials, enough to induce us to believe that future discoveries will not materially disturb any inferences drawn from the numbers as now presented to us, then we arrive at several striking conclusions concerning the entire sub-class. Regarding the Present and the Lower Palæozoic epochs as opposite poles of time, we find the generic types among the Brachiopoda concentrate as it were around or towards each, whilst they depauperate towards the equatorial region of the scheme, about which indeed no generic types originate. The loop-armed types are regnant, as it were, anteally, the spiral-armed types posteally; and the latter are in the main so dominant, that the Brachiopoda, as a great assemblage of types, has its major development towards the past, its minor towards the present, and its zero in the parting epoch between the palæozoic and after-ages.

Some special memoirs on fossil Brachiopoda may here be noticed. Mr. Davidson has communicated an excellent tabular view of the classification and distribution of the genera to the 'Bulletin' of the Geological Society of France; and in our own Journal he has described and figured a number of species from the Devonian rocks of China, a region where some future palæontologist is likely to reap a rich palæozoic harvest. The remarkable discoveries in the lias of our own country by Mr. Moore of Ilminster, have found a parallel in France, where M. Eugene Eudes-Deslongchamps, who promises to be worthy of the distinguished name of his father, has found numerous species of *Leptæna* and *Thecidea* in the Liassac beds of several localities in Calvados. His essay, amply illustrated, forms part of the newly published volume (the ninth) of the Mémoires de la Société Linnéenne de Normandie, a work in which not a few geological notices of interest may be found. It is indeed remarkable that the two genera in question, the one until lately regarded as characteristically and peculiarly palæozoic, and the other as principally cretaceous, should have their epochs of cessation and commencement thus as it were in contact.

One of the distinctive features of our science during the year just past, is the monograph of Nummulites by Vicomte d'Archiac, constituting a portion of the "Description des Animaux Fossiles du Groupe Nummulitique de l'Inde." For some time geologists have looked forward anxiously to the appearance of this treatise, the fruit of careful and conscientious researches, conducted amid abundant materials, and guided by the wise, logical and truth-seeking spirit, so characteristic of its illustrious author. They have not been disappointed; the result of his labours is the production of a most valuable memoir, illustrated by figures of the highest excellence. Every natural group of organized beings, whether existing or extinct, would seem to have its epoch of elucidation, a point of maximum in the history of its study, and the accumulation of facts towards that history. When the time comes, the man is present for the work; but the right moment is ever preceded by long series of preliminary labours, necessarily more or less imperfect, but not the less essential for the eventual right and full understanding of the subject. We are apt to forget when all is made clear to us, apparently as if in a moment, how we have been progressing step by step towards that hill-top from whence we are enabled to command a full and fair view, and how every movement, though not always a straight one, summit-wards, was requisite for the attainment of an eventual position, even though what we sought to see was hidden from us during our upward course. The so-called "discoverer" is too apt to attribute to his own individual efforts what is really but the fruit of time, and the produce of the less fortunate labours of his predecessors. This is not a fault of M. d'Archiac; conscientiously and carefully does he analyse and assign due credit to the essays of those who have gone before him in the difficult and curious study to which his monograph is devoted. Not fewer than 200 volumes, papers, or separate notes upon Nummulites (the work of 128 authors) are analysed in his treatise. First in the list is the ancient and venerable name of Strabo; among the latest are our countrymen Carpenter, Carter, and Williamson, who have independently striven with remarkable ability and success to elucidate the structure of recent and extinct Rhizopoda, attracted to the study by the same mysterious but fortunate impulse that has simultaneously directed the attention of D'Archiac, Rutimeyer, and numerous continental observers to the same interesting subject.

The author describes and figures 52 species of true Nummulites. Of these 20 are entirely new. But these numbers give no idea of the laborious task performed in sifting and rectifying synonymes, reconciling species in duplicate, and abolishing useless names. The confusion that prevailed is instanced by the state of knowledge and nomenclature of some 22 species that were best known before. Of these 5 were placed in 2 genera, 3 in 5 genera, 2 in 4, 1 in 3, 1 in 6, 1 in 7, and 1 in 8 different genera. Among the species, 4 had received 2 names, 4 others 3 names, 1 four, 3 five, 2 six, 1 seven, 1 nine, 2 ten, and 1 eleven names; so that out of 22 true species of Nummulites no fewer than 98 reputed ones had been constructed!

M. d'Archiac divides the history of the study of Nummulites into five epochs. The first, or fabulous period, and by far the longest though of least importance, commenced with the writers of antiquity, and, after a long interruption during the middle ages, was resumed after the middle of the sixteenth century to extend into that of the eighteenth. The second period, more scientific than the first, but scarcely nearer the truth, extended from 1770 to 1804, when the sagacity of the illustrious Lamarck commenced to shed a new light on the affinities of the lower animals. The third period, from 1804 to 1825, was marked by numerous attempts towards a classification of the Rhizopoda, and Nummulites were described and figured with considerable care, the opinion of their Molluscan and Cephalopodous position prevailing in the writings of naturalists. The fourth epoch extended from 1825 to 1835, when zoologists seem to have settled into a fixed faith about the affinity of Nummulites and Foraminifera with Nautili and Cuttle-fishes (the doctrine taught two hundred and sixty years before by Conrad Gesner), and directed their attention closely to the structure and minuter classification of these curious bodies. It was marked by the commencement of the extensive labours of Alcide d'Orbigny among the Foraminifera. The fifth and final epoch commenced with the notable discovery by F. Dujardin of the low and Amœboid nature of the animal of the Rhizopod, and is signalised by numerous and excellent researches into the features and forms of existing and extinct Foraminifera. At length these living problems may be said to be understood, and the monograph by M. d'Archiac himself fitly closes their history for the present.

The high geological value to which the Nummulites and their order, the Rhizopoda, have speedily attained during the last fifteen years, contrasts curiously with the degradation they have as rapidly undergone during the same period in zoological position. Before 1835 they were generally regarded as Cephalopoda, and naturalists of repute were not wanting who went so far as to describe even the parts of the minute cephalopod that constructed the foraminiferous shell. That they were not Mollusca was scarcely suspected, though half a century before their lower nature had been, on slender grounds however, often maintained. The assumption of their elevated zoological position led to many an argument against support of the theory of the prevalence of a warm climate during the ante-tertiary epochs, from the fact of the abundance of chambered cephalopods in the ancient sea-beds of now cold or temperate latitudes. The abundance of minute chambered Cephalopoda in the North Atlantic at the present time, and their almost universal distribution, were confidently appealed to as conclusive against the inference. Their number in the later formations, when the genera of Ammonitoida and Nautiloida had become scarce or disappeared for ever, was interpreted only as a continuance of the same class under new and minuter forms. Analogy was mistaken for affinity; and substitution of one group for one totally and organically different, although in the mere form of test not dissimilar, was mistaken for succession and representation within the sphere of one type. But the discovery of Dujardin led the way to an entirely new interpretation of the value of the Rhizopoda, and a new view of the part they play in time. Proving, from good evidence, to be among the lowest of animal forms, to be in fact Protozoa like *Amœba*, but differing from both Proteus and the animal element of the sponge by their investment with a hard and symmetrically arranged (generally in spiral symmetry) exo-skeleton, it is most interesting to note that their advent and maximum development have been, not during the apparent dawn of life, but amid the later epochs, and chiefly during those ages which many palæontologists regard as especially characterized by the highest forms of the animal kingdom. Indeed, so far as we know at present, the whole great group of *Protozoa*—the group that stands as it were at the very base and constitutes the rudiments of the animal series—is as characteristic of the tertiary section of time as the Vertebrata themselves are. A comparable phænomenon is becoming rapidly manifest in the molluscan subkingdom, now vastly increased by the accession of the Polyzoa to its ranks. These curious, lowly-organized, zoophytoid mollusca, instead of being the first of their type to appear, were preceded by members of all the higher orders of it, and do not become of much chronological value until the testaceous forms of the highest class of Mollusks occur, few and far between, and lose their strength and their importance.

The exquisite symmetry and regularity of conformation of the shells of most recent and fossil Rhizopoda were the chief sources of the errors that prevailed so long about their nature and zoological position. The true explanation of their structure appears to me to be that given in detail by our fellow-member Dr. Carpenter, to the effect that the entire mass, however symmetrical or regular, represents the products by successive gemmation originating from a single ovum. It matters little whether we regard each 'joint' or cell of a Nummulite as representing an individual or a zooid, provided we regard it as an element of the same essential nature with each polype of a polypidom, each cell-animal of a polyzoon, or individual of a Botryllus. The value of the regularity of the whole is not invalidated, because that whole is a compound and not a unity, and our faith in the specific value of the fossil, and its consequent geological importance, may be as strongly based on the constancy of characters whose diagnosis is drawn from the features presented by a congeries of individuals as from those presented by a single being. I make this remark, because the only serious objection that I can take to the views of M. d'Archiac touching the nature of the Nummulite concerns this fundamental point. When he states as an argument against its compound nature, that, if each of the cells were the proper envelope of a particular individual, we ought to find a greater irregularity in their development in the same shell, and asks why, if this theory were true, should the heights of different coils of the same spiral present constant relations, and why the first and last cells should be less large than those of the median whorls, we cannot accept the objections, for a crowd of comparable phænomena presented by the Sertularian zoophytes, animals having considerable affinity with the Polyzoa, although of higher organization, come to our recollection. The variations of the Hydroida, their morphology and reproduction, bear too close a relation to the phænomena exhibited by the rhizopodous organism, to permit us to regard the Nummulite and its allies as simple bodies, or to dispute the theory of their gemmigerous constitution; in other words, the regulation of their organization by the law of paramorphosis.

The stratigraphical distribution of the Nummulites is especially of interest to the geologist. As compared with the grand scale of epochs, their reign was short, but it was well-marked and compact, and offers but one more proof to the thousands now known towards the demonstration of the unity of time-areas of natural genera, facts that should make us strongly hesitate before admitting the value of apparent and daily-decreasing exceptions, and that should give us fresh hope of the future attainment of a knowledge of the grand laws regulating life in its relations to time, and fresh faith in the biological section of the foundations of geology. The Nummulites characterize a portion, not the whole, of the tertiary epoch. Though once, and not many years ago, Nummulites were regarded to be as probably indicative of the cretaceous date of a formation as of its tertiary place, it would now appear that, between the nummulitic tertiaries and true cretaceous strata, deposits intervene, whose fauna and flora are such that we must regard them as of tertiary age. A most interesting and important feature of these deposits, traceable in the north-west of Europe, the south of France, in Savoy, in Switzerland, along the southern slopes of the Alps, in Istria, and even in India, is, that in numerous localities they exhibit evidences of a terrestrial origin, marked by the presence of coal, often accompanied by lacustrine shells, and sometimes by freshwater limestones. In facts of this kind we may get at the true explanation of the break between the cretaceous and tertiary faunas, without having recourse to prodigious cataclysms or paroxysmal elevations of mountain chains, which, if they did occur, as might have been the case, could have made far less impression on the distribution of animal and vegetable life, except in the immediate vicinity of the convulsion, than slow and almost imperceptible changes affecting gradually the disposition of the geography of a wide-spread area.

"The dial moves, and yet it is not seen," paradoxically writes an old poet. Time cannot progress without change, however slow may seem his course. The true measure of the extent and importance of a convulsion (as well as of the importance of unconformity), should be the amount of organic change that we can trace to a connexion with the paroxysm. And yet what system of paroxysmal elevations has stood the trying test, when questioned on this principle?

It is of the Middle Eocene epoch—that section of the lower tertiaries of which the calcaire-grossier of the Paris basin may be cited as a central type and key-stone,—that the Nummulites are especially, and apparently exclusively, characteristic. The supposed carboniferous and oolitic Nummulites are of too doubtful a nature to be taken as exceptions. There is, it is true, a Nummulite (*N. intermedia*) found in the Miocene beds of Piedmont, and another (*N. garansensis*) in the Lower Miocenes of the Pyrenees. But I am not inclined to conclude with M. d'Archiac that these rare exceptions prove the existence of the last representatives of the genus after the Lower Tertiary fauna had disappeared, but rather to cite them in favour of the view that I have attempted to demonstrate, I trust successfully, when describing during the past year the Lower Tertiaries of the Hampshire basin,—to the effect that the so-called Lower Miocenes are essentially Lower Tertiaries and a portion of the true Eocene series, and that the passage from them into the Middle Eocenes is perfect and gradual, when we have for our examination an area presenting a full sequence of deposits.

Nevertheless it is not the less true that the nummulitic horizon is distinctly and definitely marked, and, from the frontiers of China and Thibet, even to the shores of the Atlantic, occupies a fixed position in the geological scale, a place above and succeeding the horizon of the lower tertiary lignites. The full demonstration of this great fact is a precious gain to our science; and when we consider what a vast area the nummulitic rocks occupy, what mighty mountains are made up of them, the prodigious accumulation of individuals of the fossils from which they receive their appellation, and the readiness with which their age can thereby be determined, we cannot but admit that the elucidation of their history has been a boon of no small value to comparative geology. This great tertiary formation extends across Europe, Asia, and Africa, forming a zone of 98° of longitude, comprised from south to north between the 16th and 55th degrees of latitude, and through much of its course exhibiting a breadth of 1800 miles. In the Himalaya, nummulitic rocks attain an elevation of more than 14,000 feet.

It will ever be a matter of just pride to our Society, that within our meeting-room and in our proceedings the main task was effected of clearing up the mist that clouded so long the geological history of the great nummulitic formation, and that here it was our indefatigable colleague, Sir Roderick Murchison, effected this great advance in tertiary geology. And now that the palæontology of the Nummulites has been made as clear as noon-day by the genius and labour of M. d'Archiac, it will ever be a matter of congratulation to us that the cabinets of our Society and the collections of its Members were freely and heartily placed at his disposal, and have proved of some value towards enabling him to perfect his researches.

The discovery, by Sir Charles Lyell and Mr. Dawson, of an amphibian related to new-world types, and of a probable land shell, of the family *Helicidæ*, in the interior of a fossil tree in the coal-measures of Nova Scotia, has excited general and deserved interest, and holds out a promise of future additions from unexpected sources to our roll of palæozoic animals. It is an event of no light significance. The number of palæozoic reptiles is steadily, though gradually, increasing at home and abroad. A new and highly curious form of Labyrinthodont from the Carluke Coal-shales, the *Parabatrachus Colei* of Owen, has appeared on this side of the Atlantic to support our hope of obtaining sooner or later a far larger list of palæozoic air-breathing animals than we at present possess.

Those who are interested in Permian palæontology will find a valuable contribution to this subject in the "Sitzungs-Berichte der Kaiserlichen Akademie der Wissenschaften" for June 1853. It is a memoir on the fauna of the German Zechstein formation by Baron Karl von Schauroth. A comparison is instituted between the German and English species (the latter as described by Professor King), and a concordance is given. From the lists in this paper it appears that there are 61 Permian species common to Germany and England; of these 21 are Lamellibranchiate and 17 Palliobranchiate bivalves. The total number of German species is 116, of which 21 are plants. In England we have 143, including 7 plants. The total number of known Permian species is stated as 237. In a contribution to the palæontology of the Triassic beds, an essay on the organic remains of the Muschelkalk near Jena, Dr. E. Smid enumerates 81 species. A striking feature of the assemblages of fossils in both Permian and Triassic series is the very small number of peculiar generic types. Of all the zones of life in time, these are the most unprolific in new and distinct generic types. Species they have in plenty of their own, but almost all belong to genera that are more important either above or below their horizon, than they are within them.

A long list might be given of recent papers on Oolitic, Cretaceous, and Tertiary palæontology, all more or less interesting, none without its value. For indications of most of these I would refer my hearers to the excellent 'Palæontographica' of Dunker and von Meyer, and the useful pages of the 'Jahrbuch' of Leonhard and Bronn. The memoirs by Reuss on cretaceous and other fossils are especially deserving of attention. In America, too, there is much doing in the study of organic remains. The vertebrata have found a most able investigator and describer in Dr. Joseph Leidy, who promises to be for the United States what Owen is to us. Much that I could wish to say on the progress of cretaceous and eocene palæontology I must for the present reserve; and of that of the newer tertiaries I will confine my remarks to an important work, yet uncompleted, the contents of which are equally worthy of notice at a time when the relations of the middle and lower tertiaries are subjects of discussion.

Most highly, indeed, to be commended is the admirably illustrated monograph of the miocene mollusca of the Vienna basin, published at the cost of the Austrian government and written by Dr. Hörnes, at whose disposal the fine collections of Partsch have been placed for this special labour. The figures are exquisite. The fifth part appeared in 1853, and contained monographs of the species of *Ranella* and *Murex* (6 of the former and 43 of the latter genus). When this work is completed we shall be in a better condition than ever for deciding upon the *vexata quæstio* concerning the limits of the middle tertiaries. From the materials already before us we may obtain foreshadowings of the conclusion, and it may not be undesirable to offer a few remarks suggested by the facts recorded by Dr. Hörnes; in other words, by the fossil species he has so well described and carefully elucidated.

As far as the work has progressed, the genera monographed are canaliculated Gasteropoda; well-marked types, that are not likely to mislead, belonging to as many as 24 genera. Now, in looking over the lists of species in each, several points strike our attention, viz. 1st, the great development of species in certain tropical genera, or genera in the main tropical, such as Conus (19 species), Cypræa (10 species), Mitra (13 species), Terebra (8 species), Murex (43 species), Ranella (6 species); 2nd, the fact that the species of the more extensive genera are mainly extinct; 3rd, the fact that a considerable number of existing mollusks, characteristically Mediterranean, are present in this fauna; 4th, the presence of very few, scarcely any, existing forms not Mediterranean; 5th, the fact that whatever Celtic forms are present, such as *Cypræa europea*, *Erato lævis*, *Nassa incrassata*, *Chenopus pes-pelecani*, and *Murex erinaceus*, they are shells common to the Mediterranean and Celtic faunas, and therefore most probably original members of the former; 6th, the very large proportion of species common to tertiaries in the north of Italy and south of France; 7th, the small number of references to the Touraine Faluns, though those that occur are of considerable significance; 8th, the small number and doubtful character of the identifications with eocene species. This fauna seems as it were to have been the cradle of the existing Mediterranean fauna, but in the main to have been characteristic of the arms of a great previous Mediterranean, *whose main centre* was tropical, though not a portion of the Indo-Pacific provinces of our times. It seems to have had no northern communications, at least in the direction of Austria. Its tropical character is not derived at all from either the presence of eocene species or from the stamp of an eocene *facies*. Some great intervention of different physical conditions over a vast area must have separated its epoch from the latest eocene æra. It is decidedly not the fauna of the so-called lower miocene. A well-worked list of more than 150 species warrants the suggestion of these provisional considerations.

The search after and description of fossil plants has been actively prosecuted on the continent, and not a few memoirs, several of them beautifully illustrated, have appeared during the year. As contributions of facts towards a future understanding of Fossil Botany, these papers and figures are welcome and valuable; but as palæontological data for the service of the geologist, the use and appreciation of them requires the greatest judgement and caution. The vegetable unit in lists of extinct beings is of far inferior value to the animal unit, and conclusions respecting the age and affinities of formations drawn from the fragments of an ancient flora should always be put forth as problematical and provisional. Yet in geological memoirs we too frequently find this caution lost sight of, or apparently unknown to their authors, who sum up the columns of animal and vegetable species alike, and add the numbers together, as if by diluting certainties with uncertainties we could come nearer a definite conclusion. Every botanist knows how difficult is the attempt to determine species of living plants from imperfect fragments, how slight is the clue in many cases afforded by a leaf, and how hopeless the task when he has before him only the fragment of a stem. Yet such are the materials from which in nine cases out of ten the describer of fossil plants constructs his species. Not content with indicating the possible or probable affinities of the morsel before him, he confers upon it the dignity of a generic and specific name, and enrols it in the catalogue of new types. When the specimen presents characters so positively different from any known form whatsoever, this proceeding may be excused; but such is not the excuse in the majority of instances. The nearer we approach our own epoch, the more difficult becomes the task, and the more are extreme care and forbearance demanded. With the greatest respect for the distinguished men who have of late contributed so much towards our acquaintance with the floras of the Tertiaries, I cannot but think that the positive nomenclature they have introduced into our lists is quite as likely to retard as to advance geology. Would that the warnings so often and admirably pronounced within our walls by my most able friends and fellow-members, Dr. Hooker and Mr. Charles Bunbury, were heard by some of the palæophytologists of Germany!

Among the most recent researches on this subject are the labours of Göppert on the flora preserved in amber. In this ancient resin portions of plants, even the flowers, are occasionally preserved as perfectly as the well-known insect remains that have so long excited the wonder of the curiosity-seeker, and yielded so rich a harvest to the entomologist. Of cellular plants 59 species were noticed thus embalmed by the eminent botanist just mentioned, and among them about two-fifths, and possibly more, as existing forms, Liverworts and Lichens being the prevailing identities. One Fern only is mentioned. The monocotyledons are restricted to the remains of an *Alisma*, a *Carex*, and portions of grasses. No fewer than 51 Gymnosperms are noted, and among them are identified *Thuya occidentalis*, an *Abies*, probably *canadensis*, and the *Librocedrus chilensis* of Chili! Of Angiospermous exogens 42 species were found. Among these are several regarded as identical with living types, as *Andromeda hypnoides* and *ericoides*, *Pyrola uniflora*, *Verbascum thapsiforme*, and *Sedum ternatum*. The whole list and the comments of the author are such as to excite the greatest curiosity, and to hold out hopes of fresh results from an investigation so likely to throw light on the climatal condition and geographical conformation of the northern hemisphere during the late tertiary epoch of the formation of the deposits in which the amber occurs. The same author has given an account of the tertiary flora of Java, with a list of 38 species all marked as new. Dr. Ettingshausen has published a finely illustrated memoir on the Fossil Flora of the Monte Promina in Dalmatia, mainly of an eocene character. Out of 45 species enumerated, one is considered identical with a Sheppey species. Leaves referred to Proteaceæ and to tropical Leguminosæ and Laurineæ are among the more curious forms. But the objections I have made to the definitely naming of fragments must be held good against all these papers, and to the extensive and in many respects highly valuable memoir of M. Heer upon the tertiary flora of Switzerland.

Dr. Ettingshausen has made the tertiary flora of Häring in the Tyrol the subject of a finely illustrated and elaborate monograph, one of the many beautifully got-up scientific publications that have of late been issued at the cost of the Austrian government. He describes no fewer than 180 so-called 'species,' or, more properly speaking, portions apparently of different plants. Of these 73 are common to the floras of other localities; out of this number 41 are eocene, 9 miocene, and 23 species common to eocene and miocene. Proteaceæ, Myrtaceæ, and Leguminosæ form as much as a third part of this flora. The Flabellariæ and Chamæcyparites remind us of certain eocene plants of the Hampshire basin. Compared with existing floras the general aspect is Australian. The author infers that the climate was tropical, and ventures to pronounce on the probable mean annual temperature of the region in which these plants lived, determining it to be 18° to 21° Reaumur. In this conclusion, as well as in the decisions about species and genera, there is a degree of over-precision assumed to which fossil botany can justly lay no claim. In a previously published memoir on the tertiary flora of the Vienna basin, the age of the latter is stated to be miocene and the climate subtropical. In these determinations scarcely sufficient allowance is made for difference of locality and varying conditions, such as time of year of deposit and local elevation. The botanical differences between the plant-bearing beds of our own eocenes might lead to conflicting conclusions were we not well acquainted with their geological affinities.

M. de Zigno has announced the discovery of a new locality in the Vicentin for fossil fishes of the Monte Bolca type, and a rich tertiary flora probably of somewhat later age. Of greater consequence and general geological interest are his investigations in a stratum of grey Jurassic limestone containing vegetable remains at Monte Spitz de Botzo in the Sette commune of the Vicentin, first indicated by Fortis towards the close of the last century. The bed lies upon oolitic strata containing *Terebratula spheroidalis*, and is covered by others containing *Ammonites athleta* and *viator*, *Terebratula diphya*, and other organic remains indicative of the horizon of our Oxford clay and Kelloway's rock. M. de Zigno regards the plant-bearing bed as the equivalent of the Great Oolite, or thereabouts. He has obtained more than 400 specimens from the localities where it appears. All the plants are of terrestrial origin, and bear the strongest analogy to the oolitic floras of Scarborough and Mamers. The number of species does not exceed 40, but the majority are new. They belong to the genera *Equisetites, Sagenopteris, Cycadites, Zamites, Otozamites, Araucarites,* and *Brachyphyllum.* The *Cycadeæ,* and especially the *Otozamites,* predominate. M. de Zigno is about to publish a monograph of his highly important discoveries, and it is to be hoped that British geologists will render him due assistance, the more so as all students of the English and Scottish oolites must feel greatly interested by this announcement.

But, on the risk of taking subjects out of the order of time, I must not omit to notice progress in the old and favourite direction of the vegetation of the carboniferous epoch and the origin and working of coal. The papers by Mr. Dawson and Mr. Poole on the phænomena of the coal-formation of Nova Scotia are contributions to this subject of very high interest, and are accessible in the pages of our own Journal. An excellent sketch, not without original matter, of the natural history of coal and the "Fossil Flora of the Mountain Limestone formation of the Eastern Borders," by Mr. George Tate, appended to Dr. Johnston's delightful work on the Natural History and Antiquities of the Eastern Borders, well deserves the notice of the geologist and student of fossil plants. Circumstances of commercial interest have directed the attention of many men of science during the past year to the investigation of the nature of coal, and attempts at a strict and unmistakeable definition of what coal is has, I fear, after carefully reading all that has been said upon it, taken up in vain much of the time and thought of both philosophers and lawyers. Coal has become a geological chameleon. Opinions on this vexed question must necessarily vary according to the point of view, whether chemical, or geological, or mineralogical, or microscopical, at which we regard it. By making an *à priori* rule as to what coal should be, any man may arrive at a strict specific character, and more than one view of the matter may be right.

Petrological Inquiries.

The often-discussed subject of cleavage, about which so many geologists are at variance, has been treated in a fresh and novel manner by Mr. Sorby, who has communicated an essay of singular interest, "On the Origin of Slaty Cleavage," to the Edinburgh New Philosophical Journal for last year. This diligent observer has called the microscope to the aid of the hammer and clinometer. By an examination of extremely thin sections of rocks under high powers (that which he recommends as most generally useful for the purpose in view is about 400 linear), he has been enabled to throw new light on some of the greater geological problems; among others that of the cause of slaty cleavage. For the examination of slate rocks he recommends the use of a polarizing microscope. The physical structure and the optical properties of the component minerals may be identified thus, even when in grains less than $\frac{1}{1000}$th of an inch in diameter. A comparison of sections of uncleaved with those of cleaved rocks, having similar mineral composition, shows that the minute particles are differently arranged in each. The alteration of the arrangement in the latter case is such as would result from the rocks having suffered a change of dimensions, been greatly compressed in a line perpendicular to cleavage, and elongated to a certain extent in the line of its dip. Of these changes there are evidences afforded also by the diminution in the distance between any two points lying in the line of pressure in contorted beds, the dimensions of the beds in different parts of contortions, the change in the dimensions of the organic remains, and the arrangement of the green spots so generally seen in Welsh slates, and resulting probably from original concretions. These spots, Mr. Sorby remarks, in rocks without cleavage are almost perfect spheres, or are elongated in the plane of bedding. In cleaved rocks they are like the minute particles compressed in a line perpendicular to the cleavage, and more or less elongated in the line of its dip. The result of Mr. Sorby's inquiries is the strong support of the mechanical theory of cleavage, and a confirmation of the observations of Professor Phillips and, partially, of the views maintained by Mr. Sharpe, from whom Mr. Sorby differs in maintaining that the *particles* in general have suffered a change of position without actual compressing or crystalline arrangement. Mr. Sorby maintains that it is not possible to reconcile the mechanical facts noticed in his essay with the supposition of an electrical action or other non-mechanical agent being the efficient cause of the phænomenon of cleavage. By ingenious experiments he has been able to produce similar arrangements of minute particles with those observed by him in nature, all favourable to the theory which he so ably upholds.

In the West Riding Geological Proceedings, Mr. Sorby has a paper on the oscillation of the currents that drifted the sandstone beds of the south-east of Northumberland, and on their general direction in the coal-field in the neighbourhood of Edinburgh. By careful study of the minuter characters of the drift-structure in sandstone,—more minutely and closely than has hitherto been done,—Mr. Sorby proposes to arrive at definite results concerning the precise directions, characters, and velocity of the currents. The instances given in this essay, which may be regarded as the prodromus of more extensive memoirs, are most interesting, and warrant the conclusions at which he has arrived so far. I am convinced that the path chosen by Mr. Sorby is one of very great consequence to the future progress of geology, and that by methods similar to those which I have advanced and put in practice in the observation in the field of the distribution of organic remains in strata, viz. the observation and careful noting of phænomena, inch by inch, is as sure to yield valuable results to the purely physical as to the natural-history observer. The smallest of facts is not only worthy of notice and record, but may often prove to be the key by which we are enabled to acquire a philosophical knowledge of the rock-masses we are studying. The geology of no region, however extensive or however limited, can be said to be done until its minute as well as its more conspicuous constitution has been fully and fairly made out. Hitherto this has rarely been attempted, and perhaps our science is not yet ripe for an extensive employment of the method.

The microscopic researches of Mr. Sorby on the structure of fresh-water marls and limestones open out a new field for inquiry as yet little more than indicated. The idea of ascertaining the origin of the structure through a determination of the forms of the minute particles into which shells resolve themselves by decay, and of estimating the relative proportions of the microscopic ingredients of a rock by delineating on paper the outlines of the particles present in a thin section of the stone with the aid of the camera lucida, then cutting them out and weighing the figures of each kind separately, is a process I believe wholly new in geological research and due to our ingenious associate. The value of the proceeding may be tested by the results, which, so far as they are published, are excellent. So long as the microscope thus employed is guided by a practical geologist, our science will be a gainer by this kind of investigation.

The distinction of all granites into two species or varieties, each characterized by mineralogical and geological peculiarities, has been forcibly insisted on by M. Delesse, and illustrated from his researches among the rocks of the Vosges mountains. He distinguishes,—1st, the 'granites des Ballons,' containing little quartz, orthose in large crystals, felspar (of the 6th system), dark mica affected by acids, and frequently hornblende, ordinarily accompanied by sphene; and, 2nd, the 'granite des Vosges,' mainly made up of quartz and orthose, with the addition of a little felspar (of the 6th system), dark mica affected by acids, and transparent mica in smaller quantities not affected by acids. This granite often takes a gneissoid structure. The former kind is eruptive, and constitutes the more elevated portions of the granitic chain; the latter has rather the characters of a metamorphic rock. The distinction between the two sorts is not merely local, and has been observed by M. Delesse in not a few granitic localities; among other regions, in Ireland.

In a memoir on the mineralogical and chemical constitution of the rocks of the Vosges, M. Delesse discusses those phænomena of metamorphism characterized by felspathization, that is, by the development of crystals of felspar (of the sixth system) in ancient stratified rocks. To these felspathised rocks of the Vosges he applied the name Grauwacke, a term by which he proposes to designate every sedimentary rock, whatever be its age or structure, in which crystals of felspar of the sixth system have become developed. I am inclined to object to the revival of the name Grauwacke in the present stage of geological research; it has been used so variously, loosely, and indefinitely that it had better be wholly dropped from our nomenclature. The sense in which it is used by M. Delesse is not that in which the majority of geological writers have employed it, and since the class of rocks to which he would restrict the name are highly important and well deserving of specific distinction, the invention of a new term would not only have been excusable, but also of good service. The question may arise whether the apparent felspathization, in the sense in which this word is used by M. Delesse, may not in some instances rather depend upon the original diffusion of felspar crystals through a sediment derived from showers of volcanic ash, constituting thus a rock of which numerous instances are familiar to the explorers of our palæozoic districts.

The line of research chosen by M. Delesse in the papers just noticed, and many others from his pen, is one sure to be productive of valuable results. The mineralogy of rock masses is of great consequence to the geologist, but to be satisfactorily treated must be dealt with by inquirers who are, like the author cited, practical geologists, and ready at the same time to avail themselves fully of the aid of chemistry. The treatment of the majority of simple minerals falls, in the main, within the sphere of the chemist; so much so, that we might almost be warranted in regarding mineralogy as the palæontology of chemistry.

Among the "general observations" prefixed to the new volume of M. D'Archiac's History are some brief but profound remarks on petrographical changes, and on the distinctions between the greater metamorphism of sedimentary formations and the lesser or metamorphism of contact, the latter being dependent on the action of igneous causes. The author calls attention to the fact of consolidation and tendency to metamorphism in the sedimentary strata of mountain masses, exhibited by the hardening of the limestones, their tendency to assume certain peculiarities of colour and frequently subcrystalline and even saccharoïd textures, the conversion of the marls and sandy clays into schistose beds, and the indurated and compact characters of the sandy elements. On the other hand, the continuations of the same beds, when forming horizontal table-lands or extended plains, composed of conformable and undisturbed strata, exhibit entirely distinct mineral characters, being comparatively unsolidified and putting on very different features of colour and texture. These differences between the same set of rocks—in the one case disturbed, crumpled up and contorted, in the other resting almost in their original repose—are exhibited by formations of all ages indifferently, and would lead to the inference that the greater metamorphism is mainly due to energy of dynamical causes.

Although properly the subject should be mentioned under a distinct head, I may here allude to Mr. Tylor's interesting essay on the changes of sea-level effected by existing physical causes during stated periods of time, a paper abounding in suggestions of general interest and in curious calculations. As the author continues to pursue the same line of inquiry, it would be premature to discuss his conclusions now.

Still more distinct and far less practical in its theme is Mr. Saull's pamphlet treating of the connexion of geological phænomena with astronomical causes.

Text-books.

The spread of a love for geology among the people and students of science has its surest indication in the appreciation of text-books and synoptical treatises. The year 1853 has not been behind in affording evidences of the popular appreciation of our science. That great standard of geological philosophy, the 'Principles of Geology,' by Sir Charles Lyell, has reached a ninth edition, one carefully and learnedly brought up to the ever-increasing knowledge of our day. A second edition has appeared of the 'Geological Observer,' a volume in which Sir Henry De la Beche embodies the fruit of years of fieldwork and reflection. A new elementary work of peculiar merit, entitled 'Popular Physical Geology,' has come from the pen of Mr. Jukes: this little book may be studied with advantage by the most experienced, and, keeping as it does, in a style highly commendable for perspicuity and nerve, the leading physical laws and facts of the science before the reader, unmixed with palæontological statements and conclusions, will serve as a wholesome corrective of a tendency to regard too exclusively its biological aspects, a bias on the part of geologists which a naturalist holds quite as much in dread as the sternest mineralogist or dynamical observer. A useful companion to elementary treatises in the form of an engraved table of the characteristic fossils of the several formations has been sent forth by Mr. Lowry. A new edition of Professor Pictet's 'Manual of Palæontology,' by far the best work of its kind, is a welcome contribution to our geological libraries; and the same may be said of Professor Phillips's 'Geology,' and of the lamented Dr. Mantell's 'Medals of Creation,' edited by Mr. Rupert Jones. Among elementary works that have appeared on the continent is one by the illustrious veteran Omalius D'Halloy, and in America Professor Hitchcock and Messrs. Adams and Gray have sent forth introductory treatises.

Conclusion.

In the course of this Address I have used some expressions that, as far as I am aware, are new to geological language, and involve an idea which, although hypothetical, I wish to put forth upon this occasion. I am strongly impressed with the belief, that, fanciful though it may seem, there is within it the germ of a great geological truth. I have spoken of genera concentrating towards the palæozoic pole, and *vice versâ*, of the substitution of groups, and the opposition of the more ancient to the mesozoic and modern faunas. The phrases have been incidental, and arose naturally out of the subjects under commentary, but the idea that lies at the base of them, whether true or fallacious, requires to be stated, and there cannot be a better opportunity than the present for venturing to start this fresh geological hare.

Every geologist whose studies have been equally or nearly equally directed to the organic phænomena of the three great sections of time usually received, Palæozoic, Mesozoic, and Tertiary or Cainozoic, cannot fail to have been struck with the greater value of the difference between the first or oldest section and the two newer divisions taken together, than between the first and middle terms and between the latter and the last. The degree of organic difference between the upper mesozoic and the lower tertiary epochs is rather more, but only slightly more, than the degree of difference between the lower and upper sections of the great mesozoic period. But the gap between palæozoic and mesozoic, although the link be not altogether broken, is vastly greater than any other of the many gaps in the known series of formations. I am one of those who hold, *à priori*, that all gaps are local, and that there is a probability at some future time of our discovering gradually somewhere on the earth's crust evidences of the missing links. All our experience and knowledge, theoretical and practical, warrant the affirmation that at every known stage of geological time there were sea and land. Even those who believe in a primæval azoic period will hardly sanction the supposition that there has been any repetition of azoic epochs since the first life-bearing æra commenced. And if so, and if there were always sea and land since the commencement of the first fossiliferous formation, we are warranted in assuming that both earth and water had their floras and their faunas. All geological experience goes to show, that wherever you have a perfect sequence of formations accumulating in the same medium, air or water as the case may be, there is, if not a continuance of the same specific types, a graduated succession and interlacement of types and of the facies of life-assemblages: even as on the present surface of the earth the faunas and floras of proximate provinces intermingle more or less specifically, or, if physical barriers prevent the diffusion of species, assume more or less one general facies. This passage, by aspect and type, of one stage in time into another is but scantily indicated at present in the uppermost manifestations of the palæozoic life and the lowermost of the mesozoic. The missing links will sooner or later reward the diligence of the geological explorer.

But in the general aspect of the palæozoic world, contrasted with the worlds of life that followed, although all are evidently portions of one mighty organic whole, there seems to me to be something more than the contrast that depends on the loss or non-discovery of connecting links. There is more than we can explain by this theory. Granting for its support all facts capable of being so applied, there are residual phænomena to be accounted for, and which as yet have not been referred to any law that I know of.

For some years I have lived in hope of the discovery of a palæozoic fauna and flora more in accordance with those of after-epochs than those we know, and fondly fancied that local differences of physical conditions alone might account for the discordance. But the fields opened by Murchison, Sedgwick, and Phillips have been so extended and have yielded such rich harvests at the hands of James Hall and his fellow-explorers in America, and of Barrande, de Koninck, de Verneuil, the Römers and Sandbergers, M'Coy, King, Salter, Roualt, and many other able palæontologists who have worked at palæozoic fossils in Europe, that it is becoming evident that we have before us a fair and true image of at least the marine aspect of the primæval group of faunas. The more they are investigated, the wider the ground is explored, the more striking is the difference in the main between the life palæozoic and the after-life.

Doubtless a principal element of this difference lies in *substitution* —in the replacement of one group by another, serving the same purpose in the world's œconomy. Paradoxical must be the mind of the man, a mind without eyes, who in the present state of research would deny the limitation of natural groups to greater or less, but in the main continuous, areas or sections of geological time. Now, that greater and lesser groups—genera, subgenera, families, and orders, as the case may be—or, in truer words, genera of different grades of extent—have replaced others of similar value and served the same purpose or played the same part, is so evident to every naturalist acquainted with the geological distribution of animals and plants, that to quote instances would be waste of words. This replacement is *substitution of group for group*—a phænomenon strikingly conspicuous on a grand scale when we contrast the palæozoic with the after-faunas and floras. A single instance of these greater substitutions may be cited to assist my argument, viz. the substitution of the Lamellibranchiata of later epochs by the Palliobranchiata during the earlier. In this, as in numerous other instances, it is not a total replacement of one group by another that occurred; both groups were represented at all times, but as the one group approached a minimum in the development of specific and generic types, the other approached a maximum, and *vice versâ*. I think few geologists and naturalists who have studied both the palæozoic and the after—I must coin a word —*neozoic* mollusca will doubt that a large portion of the earlier Brachiopoda—the Productidæ for example—performed the offices and occupied the places of the shallower-water ordinary bivalves of succeeding epochs.

Now in this substitution the replacement is not necessarily that of a lower group in the scale of organization by a higher. There is an appearance of such a law in many instances that has led over and over again to erroneous doctrines about progression and development. The contrary may be the case. Now that we have learned the true affinities that exist between the Bryozoa and the Brachiopoda, we can see in these instances the *zoological* replacement of a higher by a lower group, whilst in the former view, equally true, of the replacement of the Brachiopoda by the Lamellibranchiata, a higher group is substituted for a lower one. Numerous cases might be cited of both categories.

But can we not find something more in these replacements and interchanges than mere *substitution*, which is a phænomenon manifested among minor and major groups within every extended epoch? Is there no law to be discovered in the grand general grouping of the substitutions that characterize the palæozoic epoch when contrasted with all after-epochs considered as one, the Neozoic? It seems to me that there is, and that the relation between them is one of contrast and opposition—in natural-history language, is the relation of POLARITY.

The manifestation of this relation in organized nature is by contrasting developments in opposite directions. The well-known and often-cited instance of the opposition progress of the vegetable and animal series, each starting from the same point—the point at which the animal and vegetable organisms are scarcely if at all distinguishable,—may serve to illustrate the idea, and make it plain to those to whom the use of the term Polarity in geological science may not be familiar. In that case we speak of two groups being in the relation of polarity to each other when the rudimentary forms of each are proximate and their completer manifestations far apart. This relation is not to be confounded with divergence, nor with antagonism.

If we take the scale of geological formations, representing the succession of the leading divisions of time, and note for each of the epochs the known generic types present during its duration, we shall find there is not an equality of production, so to speak, at all times of fresh generic ideas. Genera have appeared, as it were, in batches. I am forced to use expressions that seem almost irreverent, and a phraseology of a loose and popular kind, in order to convey the more vividly my meaning. To talk of the appearance of a genus, that is, the appearance of an ideal type, is loose language I am aware, but its meaning or intention can scarcely be misunderstood. In the individuals of a species only can we have the embodiment of a generic idea; but in discussing a question of the kind I am considering it is convenient to use the word genus as if it were a realized unit and an entity. We speak, as it were, through a diagram. Now if commencing, upon our scale, at the dawn of the palæozoic epoch, and noting the beginning of genera or groups from the first known fauna up to the advent of man at the termination of the so-called tertiary epoch, we cannot fail to perceive the following general facts:—

1. During the earlier and middle stages of the palæozoic epoch there was a great development of generic ideas.

2. During the middle and later stages of the neozoic epoch there was a great development of generic ideas.

3. During the terminating stages of the palæozoic epoch the origination of generic ideas was very scantily manifested.

4. During the commencing stages of the neozoic epoch the origination of generic ideas was very scantily manifested.

5. The majority of generic ideas that originated during the palæozoic epoch belong to groups (of various degrees of generic intensity) which are characteristically palæozoic, *i. e.* have their maximum development and variety during the palæozoic epoch, or else are even exclusively palæozoic.

6. The majority of generic ideas that originated during the neozoic epoch belong to groups which are characteristically neozoic in the same manner.

7. The minimum development of generic ideas in time is at or about the passage or point of junction of the palæozoic and neozoic epochs.

8. Groups characteristically palæozoic swell out, as it were, in a direction *towards*, not from, the commencement of the palæozoic epoch.

9. Groups characteristically neozoic swell out in a direction *from* the commencement of the neozoic epoch.

That there are apparent exceptions to these general facts I do not pretend to deny, but the rules are so much more powerful than the exceptions that we may safely wait with confidence for the explanation of the seeming anomalies during the course of the progress of research.

Now there is but one conclusion that can be drawn from these facts, if after being tested with every evidence now known to us they remain intact as our science progresses. This conclusion is to the effect, that the relation between the palæozoic and neozoic life-assemblages is one of development in opposite directions, in other words, of *Polarity*. In the demonstration of this relation it seems to me that we shall, in all probability, discover the secret of the difference between the life anterior to the Trias and the life afterwards. The notion is in some degree a metaphysical one, but not the less capable of support through induction from the facts. I plead for its consideration, believing it to be worthy of earnest inquiry. I know that its novelty and seeming vagueness may repel many when it is thus briefly, and as if in outline, put forth. But before any geologist or naturalist rejects it, I would ask him to study carefully the admirable monographs, written without a bias, of whose merits I have been discoursing in this Address; to seek out the manifestation of the idea in the first instance in some important and characteristic group of beings about whose time-distribution we have now a sufficient knowledge, such an assemblage as the Trilobites described to us in the work of Barrande, or the Brachiopoda as exhibited in the monograph by Davidson; to take and analyse the ample lists of extinct beings marshalled in the pages of Morris, or in the more general muster-rolls of Bronn and Alcide d'Orbigny; and then, having done this, to consider earnestly and fairly the idea that I have ventured to suggest of *the manifestation of Polarity in Time.*

Gentlemen, since I have occupied this Chair I have heard two reproaches cast upon our Society, the one that we throw cold water upon theories, and the other that we are opposed to the practical applications of Geology. The fate of the concluding paragraphs of this Address will not, I hope, be confirmatory of this first accusation, one seldom urged against Geologists. As to the second, I believe I speak the sentiments of every working geologist in this Society, when I say that no papers, no discussions within these walls, are heard with more pleasure or received with more approbation than those which have a practical and economic bearing, always providing that sound science and original research constitute their foundation. Empiricism we eschew and abhor. Solid knowledge, careful observations, and sound scientific theory are as necessary for economic as for unremunerative geology. During the Session just concluded the various aspects of our science have each had an impartial share of attention. In the Session which is about to commence we have every prospect of holding our forward course in the sound and safe path that the Geological Society of London has chosen from its beginning.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 2, 1853.

George Shaw, Esq., was elected a Fellow.

The following communications were read:—

1. *On the* Coal-Measures *of the* South Joggins, Nova Scotia. By J. W. Dawson, Esq.

[Communicated by Sir C. Lyell, V.P.G.S.]

[This Memoir was accompanied by numerous MS. illustrations of sections, tree-stumps, roots, wood-structure, &c., some only of which are here engraved; and the references to figures having MS. attached, relate to Mr. Dawson's original drawings sent with this communication, and now in the Society's Library.]

The present paper on the Coal-measures of Nova Scotia is based on observations made by Sir Charles Lyell, with the assistance of the writer, in the summer of 1852, and on farther observations made by the writer in 1853, on whom the completion of the paper has devolved, owing to engagements which prevented Sir Charles from attending to it.

The coast-section of the South Joggins is already well known to geologists as one of the finest exposures of a continuous and conformable series of carboniferous rocks, and as being especially remarkable for the number of trees and other plants preserved *in situ* in an erect position*. In a coast-line of about seven miles in length, there is presented a vertical thickness of 14,000 feet of beds, extending from the marine limestones of the Lower Carboniferous series to the top of the Coal-formation; and, in the greater part of this distance, the beds are exposed in a vertical cliff, from 30 to 80 feet in height, and in the reefs which at low-tide are dry to the distance of 200 yards from its base. In the cliff, and on the beach, more than seventy seams of coal, with their underclays and roof-shales, can be *distinctly* seen, and erect plants occur at about as many distinct levels, while the action of the waves and of the tide, which rises to the height of 40 feet, prevents the collection of *débris* at the foot of the cliff, and continually exposes new and fresh surfaces of rock.

The section to be described in this paper refers to a vertical thickness of 2800 feet, in the central part of the Coal-formation, examined with especial reference to the conditions of accumulation of coal, the nature and mode of preservation of erect trees, evidences of contemporary land animals, and other points of present interest in geology. The most novel results of this examination have already been communicated to this Society, in a paper on the remains of a reptile and a land shell, found in one of the beds. All the new facts relating to the rocks themselves, and to the Flora of the Coal-period and its aquatic Fauna, are embraced in the present paper, and have been arranged as follows:

I. Sectional list of the beds.
II. Remarks on the mineral character and arrangement of the rocks occurring in the section.
III. Chronological sketch of the series of events which the section indicates.
IV. Notices of new facts relating to the fossils of the Coal-formation.

I. *Section of part of the Coal-measures of the South Joggins, Nova Scotia; in descending order.* Strike S. 65° E. Magnetic; Dip S. 25° W. 19°.

(The asterisks denote the ancient soil beds, with roots.)

[Appended to this paper is an abstract of Mr. Logan's general section of the Joggins measures, showing the relation of these beds to the other members of the Carboniferous system.]

Group XXIX.

On the western side of M'Cairn's Brook, which is about three-fourths of a mile S.W. from the Coal Pier, the coast-section shows a great thickness of grey sandstones, with grey and chocolate shales; in which were

* For reference to previous descriptions see note to paper on "Remains of a Reptile," &c., Quart. Journ. Geol. Soc. May 1853, vol. ix. p. 58. See also the list of papers, in the Society's Journal, relating to the Coal-fields of Nova Scotia and New Brunswick, appended to this memoir.

observed five small coal-seams with underclays, and erect trees at two levels, and also the instance of irregular bedding represented in fig. 1 A, MS.

East of M'Cairn's Brook is a thick bed of grey sandstone (grindstone) with prostrate Coniferous trees. Under this are grey and chocolate shales and grey sandstone with erect trees at two levels. Then follows a space of about 100 paces without section.

XXVIII.

	ft.	in.
Shale and sandstone, chocolate and grey	90	0
Shale and sandstone, chocolate and grey. In one of the beds an erect stump, converted into coaly matter	35	0
*Sandstone and grey shale. Stigmaria-rootlets	4	6
Shale, chocolate and grey	25	0
*Sandstone, grey. Stools of Stigmaria	3	0
Shale, grey. Upper part full of Stigmaria-rootlets	20	0
Shales and flags, grey, and in part calcareous. Vegetable fragments and fish-scales	15	0
Shale, hard grey	6	0

XXVII.

Shale, calcareo-bituminous. Shells of Modiola	1	0
Coal	1	0
*Underclay, resting on sandstone and shale. Rootlets	10	0
Sandstone, coarse grey. Irregularly bedded	6	0
*Underclay, arenaceous. Stools of Stigmaria and an erect stump	3	6
Shale, grey	6	0
*Sandstone and shale. Irregularly bedded. One bed has Stigmaria-rootlets	8	0
Shale, grey, with ironstone balls	2	8
*Sandstone, grey. Rootlets of Stigmaria	2	3
Shale, grey. An erect tree rooted in bed below	20	0
*Bituminous limestone. Rootlets of Stigmaria, Modiola, Cypris...	0	2
Shale, carbonaceous, with ironstone balls. Poacites, &c.	0	9
*Underclay. Rootlets of Stigmaria	0	10
Coal, shaly	1	0
*Underclay. Indistinct rootlets	1	2
*Sandstone, grey argillaceous, passing downward into shale and bituminous shale. An erect tree; Stigmaria-roots	3	0
Coal	0	1
*Underclay. Rootlets	0	10
Sandstone, grey. Erect Calamites and Stigmaria-rootlets descending from bed above	1	5
Shale, grey, pyritous. Numerous flattened plants	4	6
Coal, very pyritous	0	8
Shale, bituminous and pyritous. Coaly layers, Poacites, Ulodendron	4	0
Coal, with much mineral charcoal	0	8
*Underclay, hard and arenaceous. Stigmaria-rootlets	3	0

XXVI.

Shales, chocolate and grey, with sandstone bands, ripple-marks and coaly vegetable fragments on some of the sandstones. An erect tree. Reptilian foot-prints (fig. 18, MS.) and rain-marks.	66	0

XXV.

	ft.	in.
Shale, grey. Modiola in lower part, fewer towards the top	2	0
Limestone, black bituminous. Fish-scales, Coprolites, Modiola, Spirorbis, attached to carbonized trunks	2	0
Coal, impure. Sigillaria, &c., with Spirorbis attached; Modiola...	0	1
*Underclay. Stigmaria-rootlets	1	0
Shale, ironstone nodules, and coaly seams .... } Coal, impure, 2 inches .... } *Underclay. Many rootlets of Stigmaria .... } Shale. Ironstone nodules.. }	5	9
Coal	0	5
*Sandstone, grey. Many rootlets of Stigmaria	2	0
Shale, grey	5	0
*Sandstone, grey. Rootlets of Stigmaria	1	3

XXIV.

Sandstone, grey, alternating with chocolate and grey shales. Prostrate carbonized trunks, Fish-scales	45	0
Shales, chocolate and grey, alternating with even bands of grey sandstone. On some of the sandstones scratches of drift-wood.	75	0

XXIII.

Shale, grey, passing into black. Modiola in lower part............	0	6
Shale, calcareo-bituminous. Modiola, Cypris, Fish-scales	0	10
Coal and bituminous shale. Poacites, Sigillaria, Spirorbis, Fish-scales, Cypris	0	8
Underclay. Rootlets of Stigmaria..	3	9
Sandstone, grey. Rootlets	4	6
Shale and sandstone	8	0
*Underclay, hard and sandy below. Roots and rootlets of Stigmaria	1	6
Coal, impure. Full of Poacites..	0	1
Shale and argillaceous sandstone. Plants with Spirorbis, rain-marks?..	7	0
Sandstone and arenaceous shale. Erect Calamites in 5 feet of upper part; an erect coaly tree passes through these beds and the sandstone below (fig. 5. p. 26)	8	0
Sandstone, grey. Erect coaly tree as above	7	0
*Shale, grey. Roots of coaly tree spread in this bed	4	0
Sandstone, grey	4	0
Shale, grey. Prostrate and erect Sigillaria and Lepidodendron, Poacites, Asterophyllites, Ferns, Modiola, Spirorbis on surface of fossil plants, Stigmaria and rootlets	0	6
Coal, main seam, worked by the General Mining Association ...	3	6
Shale or underclay. Thins out in working to N.E..................	1	6
Coal, worked with main seam..	1	6
*Underclay and shale with bands of sandstone	20	0
*Sandstone and clay. Stigmaria-stools; on the surface of this bed a thin film of coaly matter. [*Coal Mine Pier here*]	2	6
Sandstone and shale. Irregular beds	5	0
Shale, grey, with bands of sandstone and ironstone	4	0
Sandstone, grey. Two erect stumps, one of them a Sigillaria with Stigmaria-roots (fig. 6, MS.), erect Calamites	2	0

	ft.	in.
*Shale, grey and ironstone. Roots and rootlets of erect stumps ...	6	6
Coal, impure. Much Poacites	0	0½
Shale, grey	0	11½
Coal and bituminous, shale. Prostrate trunks and mineral charcoal	0	0½
*Sandstone with clay parting. Stigmaria-rootlets and prostrate Sigillaria above the clay parting..................................	3	6
Sandstone and shales with ironstone..................................	12	0
Ironstone-band. Sigillaria, Favularia, Poacites, Ferns, &c.; Spirorbis attached to many of these plants........................	0	3
*Underclays. Rootlets of Stigmaria and carbonized plants.........	2	0
Coal, impure	0	1
*Sandstone, argillaceous. Stools and rootlets of Stigmaria.........	2	6
*Sandstone alternating with shales. In one bed Stigmaria-stools and an erect tree. In another Ulodendron and other trees, prostrate, with Spirorbis attached................................	10	0
*Shale, grey, passing downwards into underclay. Poacites, Lepidophylla, &c.; an erect tree, Stigmaria-rootlets in lower part	3	10
Coal	0	3
*Underclay. Rootlets	0	5
Coal and bituminous shale, in several alternations. Lepidodendron, Ulodendron, Poacites, Lepidophylla. (This is called the "Queen's Vein.")	1	9
*Shale, grey. Poacites in upper part. In lower part an underclay with remains of erect stumps	4	4
Coal	1	0
*Underclay, black, bituminous, slickensided, resting on hard arenaceous understone. Stools and rootlets of Stigmaria ...	3	0

XXII.

Shales, red and chocolate, with sandstone in uneven beds. Two erect stumps in one of the sandstones, ironstone in the shales	93	0
Sandstone and shales, chiefly grey. Erect Calamites, and an erect stump in one of the beds	11	6

XXI.

Shale, grey, passing into black. Poacites, Sigillaria, Calamites, coaly trunks, and an erect stump	14	6
Coal	0	8
*Underclay. Rootlets and coaly matter (fig. 3, MS.), 4½ inches to	0	2
Coal	0	2
*Underclay and shale, pyritous. Stigmaria, small erect stems or roots, coaly layers	14	0
Sandstone and shale. Very irregularly bedded	3	0
Shale and ironstone nodules. Two erect stems	3	0
Sandstone and shales. Carbonized wood and Poacites	8	0
Shales, chocolate and grey. Ironstone nodules. [*Brook here.*]	12	0

XX.

***Shales, chocolate and grey, and grey sandstones irregularly bedded. Stigmaria-rootlets in three of the sandstones.......	90	0

	ft.	in.
XIX.		
Sandstone, grey, laminated. Erect Calamites (fig. 5, MS.)	15	0
*Shale, grey and chocolate. Roots of Calamites	7	0
Coaly layer. Carbonized flattened trunks	0	2
*Underclay. Roots and rootlets of Stigmaria	2	0
Sandstone, grey, with chocolate and grey shale (fig. 1, p. 12). Very irregularly bedded, carbonized trunks, Artisia, rain-marks?...	30	0
*Shale, grey. Erect stump, Stigmaria-roots, one root traced 6 feet	3	6
Coal and bituminous shale. Poacites with Spirorbis, erect and inclined Calamites stand on surface of this coal	1	0
*Underclay	2	4
Bituminous shale and coal. Poacites and coaly trunks	0	10
*Understone, hard, arenaceous. Many rootlets of Stigmaria	1	6
Sandstone	7	0
**Shale, including two underclays with thin coaly seams. Sigillaria, Poacites, Stigmaria-rootlets	15	0
XVIII.		
*Shales and sandstones. One sandstone has Stigmaria-rootlets ...	25	0
Sandstone, and red and grey shales. Irregularly bedded, sun-cracks, erect Calamites in one bed.................................	60	0
Sandstone, and chocolate and grey shale	15	0
XVII.		
*Shale, grey and chocolate. Sun-cracked surface, and a stool of Stigmaria...	14	0
Coal. In roof, Poacites with Spirorbis................................	0	8
*Underclay passing into arenaceous shales	15	0
XVI.		
Sandstone, grey. Prostrate carbonized trunks and vegetable fragments. Forms a high reef at end of Coal Mine Point; has been quarried for grindstone	25	0
XV.		
*Shales and bluish sandstone. Two erect fluted stumps. One has Stigmaria-roots...	18	0
Coal and bituminous shale. Stigmaria, Sigillaria, Calamites, Lepidodendron, Poacites	1	2
*Underclay. Rootlets.. } **Shale, including two thin coals and underclays.................. }	8	10
*Sandstone, grey argillaceous. Erect trees and Calamites, Stigmaria and rootlets. Reptilian remains and land shell in one of the erect trees (fig. 2, p. 21)	9	0
Coal. Erect coaly tree (Conifer?) at its surface	0	6
*Underclay. Rootlets	2	0
Sandstone and shales. Prostrate Sigillaria, erect Calamites	21	0
Coal	0	4
*Underclay. Rootlets.	2	0
XIV.		
**Sandstones in thick beds, alternating with shales. In one bed an erect stump springing from shale with Poacites; lower, a		

	ft.	in.
coaly bed with Stigmaria underclay; still lower, a sandstone with erect Calamites rooted in shale, and immediately below this another erect stump	110	0
Sandstones, grey. Sigillaria, Lepidodendron, Ulodendron, Artisia, &c.	20	0

XIII.

*Shale, including a 4-inch coal with underclay. In the shale above the coal is a fine ribbed erect tree, 2 feet diameter, 4 feet of height seen. Its roots are well-marked (*Stigmaria ficoides*). The coal contains Spirorbis, Modiola, and Cypris; and its underclay has rootlets of Stigmaria	10	0
Sandstones. Fine ripple-marks	6	0
Shales and sandstones. Irregularly bedding (fig. 1, MS.)	12	0
Sandstone. Ripples, coaly fragments, Calamites	10	0
Shale and sandstone	10	0
Shale, calcareo-bituminous, resting on bituminous limestone. Modiola, Coprolites, Fish-scales, Cypris	5	0
Coal. Prostrate Sigillaria	0	1
*Underclay. Rootlets of Stigmaria	2	0
Sandstone. Ripples, and coaly fragments	6	0
Shaly clay	13	0
Bituminous limestone. Cypris, Modiola, Coprolites	3	0
Coal, with three clay partings	2	9
*Underclay. Rootlets of Stigmaria	1	6
Sandstone, grey. Two erect trees, one a Sigillaria	5	0
Clay	6	0
Sandstone. An erect fluted tree; erect Calamites rooted one foot above roots of tree. Also an erect coaly tree penetrating this, and clay above	8	0
Shale, grey and black, passing into bituminous limestone, with coaly bands. Modiola	10	0
Coal	0	10
*Underclay. Stigmaria-rootlets	1	0
**Sandstones and shales. Stigmaria-rootlets at two or three levels	30	0
Shales, coarse and fine. An erect tree; also Poacites with Spirorbis	8	0
Coal	0	5
*Bituminous limestone. Stigmaria-roots and rootlets, Modiola, Coprolites, Cypris	0	4
Coal	0	7
*Underclay	1	6

XII.

*Sandstones and shales, including a 6-inch coal and several underclays. Erect trees at five levels. One of the trees 4 feet in diameter, and irregularly ribbed; rooted in shale, with rootlets	80	0

XI.

Shale, passing into bituminous limestone, with coaly layers. Cypris, Coprolites, Spirorbis, Modiola	8	0
*Clay, pyritous, with coaly bands. Stigmaria-rootlets	20	0
Sandstone	5	0
Shale, with ironstone, passing into bituminous shale	20	0

	ft.	in.
Coal and bituminous shale. Poacites, Lepidophylla	5	0
*Underclay, resting on shale, with ironstone. Stigmaria-rootlets	6	0
Shale, arenaceous. Stems, Calamites, Poacites, Lycopodium?, Modiola	0	3
Coal	0	5
Shale and coaly layers	4	0
Coal and shale	0	4
Shale	0	9
Coal	0	2
Shale	0	10
Ironstone and bituminous limestone. Poacites, Spirorbis, Cypris	0	3
*Underclay and shale. Rootlets of Stigmaria	4	0
Coal	4	0
*Underclay, pyritous, passing into sandstone. Rootlets of Stigmaria	1	6
Sandstone and shale. Six large erect trees, one of them 15 feet in height, erect Calamites	30	0
Coal and bituminous shale	5	0
*Underclay. Stigmaria-rootlets	2	0

X.

Sandstone. Large erect tree	8	0
**Shale, with bands of grey sandstone, a few thin layers of coal, with underclays. Poacites, Ferns, &c. abound in the shales	60	0
***Shale, cholocate, with grey sandstone. Contain three thin coaly bands, with underclays and roof-shales, about	500	0
*Shale, grey, and sandstone. In upper part, an understone, with Stigmaria-rootlets, and an erect tree, Ferns, Poacites	82	0

IX.

Sandstone, grey, and shale. In lower part an erect tree extending 22 feet into these beds, and 3 feet into bed below	10	0
Shale	12	0
*Bituminous limestone. Stigmaria-stools and rootlets; at bottom a thin coaly layer, with prostrate trunks and attached Spirorbis	1	2
*Underclay. Rootlets and remains of erect stumps	2	6
Coal	0	3
*Underclay	3	0
Grey sandstone and shale. Stigmaria-rootlets	6	0
Shale, with coaly layers	8	0
Sandstone, argillaceous, and shale	6	0
Bituminous limestone. Rootlets, Fish-scales, Cypris ?	2	0
Coal and bituminous shale	0	9
*Underclay	2	0
Coal and bituminous shale	0	8
*Underclay. Stigmaria-rootlets	1	3
Bituminous limestone. Rootlets; Cypris	0	4
Shale	0	3
Coal	0	1
*Underclay. Stigmaria-rootlets	8	0

VIII.

Sandstone	5	0
Sandstone and chocolate shales	70	0

VII.

	ft.	in.
Shale, calcareo-bituminous, and bituminous limestone. Modiola, Cypris, &c.	5	0
Coal, full of minute spines	0	4
*Underclay, passing into chocolate shale. Rootlets	3	0

VI.

	ft.	in.
*Shales, chocolate and sandstone. Near bottom an erect tree rooted in hard arenaceous underclay. Stigmaria-rootlets	38	0
Shales, chocolate and grey, and sandstones	63	0
Sandstone, grey, with false stratification. Trunks of trees	15	0

V.

	ft.	in.
Shale, chocolate above, grey below. Thin coaly layers in bottom, Poacites	15	0
*Bituminous limestone. Rootlets, Cypris	0	5
Underclay. Rootlets	2	0

IV.

	ft.	in.
Sandstones and shales	30	0
Sandstone, grey Erect Calamites, flattened trunks	8	0
Shales, chocolate and grey. An erect tree	40	0

III.

	ft.	in.
Bituminous limestone. Cypris, Modiola, Coprolites, Fish-scales	0	5
Bituminous shale	0	4
Bituminous limestone. Cypris, Modiola, &c.	0	3
Bituminous shale	0	11
Coal	0	3
Bituminous shale	0	11
Coal	0	3
Bituminous shale	0	7
Bituminous limestone, earthy. Coprolites, Modiola, Fish-scales, Cypris	0	10
Bituminous limestone, with coaly layers	0	7
Shale and ironstone balls	7	0
Bituminous limestone, calcareo-bituminous shale, and coaly layer. Fish-scales, Cypris, &c.	3	0
Shale, grey	3	6
Coal and bituminous shale. Modiola	0	3
*Underclay. Rootlets of Stigmaria	1	6
Shale, arenaceous, and ironstone balls. Rootlets	5	0
Sandstone, grey	4	0
Shale, grey	4	0
Shale, black	0	6
Bituminous limestone. Modiola, Cypris, Coprolites	0	7
Coal	0	5
*Underclay, passing into chocolate shale. Rootlets of Stigmaria.	8	0

II.

	ft.	in.
Shales, chocolate and grey, and sandstones	45	0

I.

	ft.	in.
Sandstone, grey. An erect tree (Lepidodendron?) 8 inches diameter, 4 feet high; erect Calamites	12	0

	ft.	in.
Shale, grey	16	0
Bituminous limestone. Modiola, Cypris, Fish-scales, Spirorbis	0	4
Shale, grey	9	0
Bituminous limestone. Modiola, Fish-scales, Cypris	0	6
Shale, grey	2	6
Bituminous limestone and calcareo-bituminous shale. Modiola, Fish-scales, Cypris	3	0
Shale, grey	1	6
Calcareo-bituminous shale. Modiola, Fish-scales, Cypris, Poacites	0	6
Shale, grey	6	0
Bituminous limestone. Cypris, &c.	0	3
Shale, black	0	7
Coal	0	6
Bituminous limestone. Cypris, Stigmaria-rootlets	0	2
Coal	0	0½
*Underclay. Stigmaria-rootlets	4	0
Shales and sandstones, red and chocolate (not measured).		
Total thickness...	2819	2

II. *Remarks on the Mineral Character and Arrangement of the Beds.*

The rocks included in the foregoing section are, in the order of their respective aggregate thicknesses, shales and clays, sandstones, coals, and bituminous limestones.

1. *Shales* and *Clays* constitute the greater part of the total thickness, and consist of indurated mud, more or less laminated, and variously modified by contact with organic matters. Its original colour may be assumed to have been the dull red or chocolate*, due to the presence of peroxide of iron, and which still prevails in many parts of the section; but, where it has been long in contact with decomposing vegetable matter, it has assumed various greyish tints. This discoloration has been effected in two ways:—(1.) In many of the beds the peroxide of iron has been deoxidized and dissolved by the agency of carbonic acid disengaged in the decay of the vegetable matter; and it now appears in the form of nodules and bands of the argillaceous carbonate of iron included in the shales. Modern analogies, in the case of swamps and bogs, would lead us to conclude that this change occurred in fresh water. (2.) Where sea-water has had access to the beds, the deoxidation of its sulphates and the production of sulphuretted hydrogen have caused the ferruginous colouring matter to be converted into the bisulphuret of iron, which appears in large quantity in some parts of the section. This change now occurs in the lower parts and subsoils of salt-marshes, and may everywhere be observed in those of Nova Scotia; and it is deserving of notice that in modern marshes this chemical change, which in a short time converts red mud into a dull grey colour, is not incompatible with the contemporary growth of *Carices* and other marsh-plants. The frequent alternation and mixture of

* Dull shades of chocolate-red and purplish red.

the results of these changes in the Joggins section may be accounted for by the fact, sufficiently proved by other evidence, that the same beds of clay have been subjected to the action of vegetable matter, decomposing first in fresh water and then in the sea, or at least in brackish water*. In connection with these changes of colour, it occurs here as elsewhere that fossils are rare in the reddish beds; the *absence* of vegetable matter being in fact the cause of the retention of the red colour.

Black bituminous or carbonaceous shales are more rare at the Joggins than at Sydney, and much more so than at Pictou; and this, as well as the great number and small aggregate thickness of the coal-seams, probably indicates greater rapidity of change, and more frequent invasions of sedimentary matter, than at those localities. Several beds of shale, by the presence of great quantities of shells of *Modiola* and *Cypris*, with much organic matter, pass into a tough calcareo-bituminous rock, and finally into hard bituminous limestone. It is observable that the passage from common argillaceous shales to these *Modiola*-shales is often very gradual, the *Modiolæ* becoming more and more rare in ascending through several feet of shale. In these cases these shell-fish probably died out as their abode became invaded by muddy sediment.

Beds of clay containing roots of plants *in situ*, and destitute or nearly destitute of lamination, are designated in the Section "Underclays." As these are fossil soils, they will be more properly considered in connection with the vegetable matter which accumulated upon them.

2. *Sandstone*.—The line of distinction between these and shales is of course somewhat arbitrary, and I observe that many fine-grained beds, named sandstones in our notes, appear in Mr. Logan's section as argillaceous shales. None of the sandstones observed by us were very coarse, and most of them are argillaceous, though a few, especially the thicker grindstone reefs, are very purely siliceous and made up of sharp and uniform fine grains of sand. A few beds are hard, with a calcareous cement. The colour varies from the bluish-grey of the celebrated Joggins blue grindstones, to fawn and buff, the latter being usually a superficial discoloration occasioned by iron pyrites. We observed no beds of distinctly red colours, although these abound both above and below the part of the section examined by us. Mr. Logan notes a few beds as of reddish colours. These we have probably not separated from the chocolate shales, which are in some places highly arenaceous.

Regularly laminated and ripple-marked sandstones are comparatively rare, especially in the central part of the section; and most of the beds present various irregularities, such as rapid changes of thickness, false stratification, and large undulations of the surfaces. This is probably a consequence of the littoral origin of these beds, which is further indicated by the occurrence of unworn trunks of trees, fragments of vegetable matter scattered over the strata-sur-

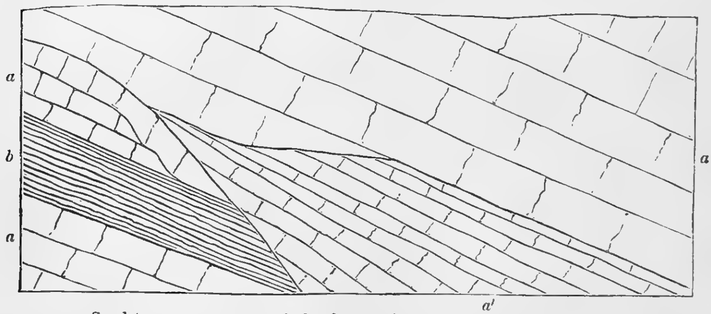
* Dawson on the colouring matter of Red and Grey Sandstones, Quart. Journ. Geol. Soc. vol. v. p. 25.

faces, sun-cracked surfaces, appearances resembling rain-marks, reptilian footprints, and the frequent conversion of these sandstones and of the clays resting immediately upon them into ancient swamp-soils. Few of the beds attain any considerable thickness without alternating with shales. The thickest continuous bed in the section is that at Coal Mine Point (Group XVI.). There are, however, much thicker beds in the upper and lower parts of the measures, beyond the limits of our section.

Evidences of contemporaneous currents and denudation are very frequent. On the lower surfaces of some beds resting on clay there are casts of scratches and furrows, as if produced by drift-wood with branches swept over the surface. In the case of beds which contain great numbers of trees retaining their bark and markings, and confusedly disposed, we may fairly infer that these have been swept away from forests invaded by the sand-bearing currents. The bare coniferous trunks found in other beds may have been long drifted in the sea. In other instances, the occurrence of numerous trunks and fragments of trees, covered with shells of *Spirorbis*, testifies at once to drift and to intermissions of deposition. We may account for the imbedding of so many plants in the erect position by allowing for their strength and toughness when recent, and for the resistance presented by the matted soils in which their roots were imbedded. It is worthy of remark, however, that in the two best-preserved beds of *Calamites*, as well as in several cases of the occurrence of erect trunks, the lower parts of the stems were imbedded in mud or very fine sand, and were thus strengthened and protected before coarser sand was swept over them*.

Well-marked instances of irregular denuding action are afforded

Fig. 1.—*Section of Sandstones and Shales in* Group XIX., *showing denudation and filling up.*



a, a. Sandstones. *a'.* Sandstone with drift-wood. *b.* Shales.

by the clays and sand-beds cut off by coarse sandstone represented in figs. 1 ms., 2 ms. (fig. 1), and 1 A, ms., which are the best in-

* This is also the case in the bed with erect Calamites near Pictou, Quart. Journ. Geol. Soc. vol. vii. p. 195, fig. 1.

stances of phænomena seen also, but less distinctly, in other parts of the section. Fig. 1 exhibits apparently the edge of a channel, cut in clay, and filled with sand and drift-trees, just as tidal and river channels in estuaries are now often filled with the debris borne down by an inundation or thrown in by a storm.

On the whole we may conclude that the sandstones mark temporary, and often very local, interruptions of the quiet deposition of clay and organic matters, which occupied the greater part of the time in which the beds of this section were formed; but that these interruptions were not of such a character as to transport coarse detritus, or such as occurred in a locality very distant from rocky promontories or gravel beaches.

3. Of fifty-four beds of *Coal* noted in the section, only three or four are sufficiently large to be worked with profit. That at present mined is 3½ feet in thickness, and the underlying bed 18 inches thick is worked with it, making in all 5 feet of coal. The coal of all the beds is of a free-burning bituminous quality, somewhat resembling that of Sydney, Cape Breton, though generally inferior in point of purity. The beds of coal are much more uniform in their thickness than those of sandstone and shale. Fig. 3 MS. shows an instance in which the clay-parting between two thin beds varies in thickness; and the clay between the two seams of the main-coal is said to thin out in working to the eastward.

In a section so perfect as that of the Joggins, excellent opportunities are afforded for inquiring into the circumstances under which beds of coal were accumulated, and some of the smaller and more shaly beds are more instructive in this respect than those of greater magnitude and purity. As has already been pointed out by Mr. Logan, the most constant condition required for the growth of coal is the occurrence of a bed of clay or argillaceous sand with *Stigmaria*; in other words, a soil with roots of trees of the tribe most abundant in the swamps and alluvial flats of the period. In most of these "underclays" only the straight cylindrical "rootlets," peculiar to *Stigmaria*, were observed; but in several instances the roots with the rootlets attached, and even stools with roots radiating from them, were observed. Only three instances are noted in the section of coals *without* perceptible *Stigmaria*-rootlets in their underclays. In one of these cases there were thin fibrous roots, and in two the coaly layers supported by the clays were almost entirely composed of leaves of *Poacites*. Some of the underclays are fine and argillaceous, and where recent must have constituted soft mud, or stiff retentive clay. The greater number are, however, argillo-arenaceous, and some decidedly sandy; and it is observable that many of the more argillaceous underclays are thin, and rest on beds of sand, into which the roots and rootlets often descend. In the section there are sixteen underclays more or less argillaceous and having a thickness exceeding 2 feet, without the intervention of sandstone. There are, however, eighteen of 2 feet or less in thickness, and resting on sandstone, coal, or bituminous limestone. Two only are decidedly sandy, although there are a number of arenaceous underclays abounding in *Stigmaria*, but having no beds of coal resting on them. In two instances, beds of bituminous limestone constituted *Stigmaria understones*, and the rootlets of *Stigmaria* are seen intermixed with well-preserved shells of *Cypris* and *Modiola*. These beds in their recent state must have been extremely rich marly soils. Nearly one half of the underclays have no coal resting on them, or have mere films of coaly matter intermixed with bituminous shale. Most of these beds, however, support either erect plants, or shales and sandstones filled with prostrate trunks of *Sigillaria* and other trees, remains of which are also found plentifully in some of the thinner coals. From this we may infer with certainty that the growth of a bed of coal usually occupied a much longer time than that required for the growth of a forest of *Sigillaria*, and that the growth of such a forest was the almost invariable preparation for the formation of coal; but that in many instances, especially in the more light and sandy soils, no accumulation of coaly vegetable matter occurred, such accumulations occurring most frequently at the surface of beds of clay, and more especially of those which were of no great thickness and rested on sandy subsoils. The conditions, therefore, which favoured the accumulation of coal were very similar to those which in modern times occasion the formation of peaty matter in swamps and bogs.

All the underclays have the bleached appearance seen in the subsoils of modern swamps, and no doubt from the same cause*,—the removal or change of the ferruginous colouring matters by the deoxidizing and solvent agency of decomposing organic matter and organic acids. A few of them are traversed by numerous slickenside fissures, probably in consequence of the movement of their mass under pressure, as the roots which they contained became softened or disappeared through decay. To this cause also, as well as to the penetration of roots, and to atmospheric influences, may be due the removal of the lamination which many of them, especially those resting on laminated shales, in all probability originally possessed. Few of the underclays contain much vegetable matter, except in the form of *Stigmaria*-roots and irregular coaly veins, which may have been the roots of other trees. It is, however, observable that the *Stigmariæ* and their rootlets often penetrate to considerable depths to reach coals, or other beds rich in organic matter. With the exception of the bituminous limestones already mentioned, the lowest underclay in the "Queen's Vein" is richer in organic matter than any other in the section.

There is no distinct evidence in this section of the formation of coal from drifted materials. Two of the three coals not observed to rest on *Stigmaria*-underclays consisted almost entirely of leaves of *Poacites*, which may have grown on the spot, and could scarcely have drifted far. There are two instances of coals based on *Stigmaria*-underclays which became submerged in such circumstances as to permit *Spirorbis* and *scales of Fishes* to be intermixed with the vegetable matter. This does not, however, necessarily imply driftage.

* [See also Report Brit. Assoc. 1853, Trans. Sect.]

True drift phænomena are confined to the presence of trunks of trees, sometimes carbonized, in the sandstones, and of fragments of mineral charcoal, the scattered debris of decayed trees, on the planes of lamination of the coal.

4. The *Bituminous Limestones* are beds of animal origin, being composed of the remains of shells of *Modiola* and *Cypris*, with *coprolites* and other remains of Fishes, the whole blackened by coaly matter. They are now hard and sonorous, though the penetration of some of them by *Stigmaria*-roots and rootlets shows that they were once soft and marly. They generally pass upwards into *Modiola*-shales, which are, in truth, their upper portions less decomposed at the time of their burial, and somewhat more mixed with argillaceous matter. These beds mark the slow and long-continued accumulation of animal matter in clear water, probably brackish.

It is remarkable that in almost every instance the conditions requisite for the formation of these limestones and their allied *Modiola*-shales have followed immediately on the formation of layers of coal based on underclays. This association with coal also occurs in several instances in the Sydney Coal-field*, and the two principal seams at Pictou have beds with remains of Fishes and *Cypris* in their roofs. At Sydney and Pictou, however, this appears to be the exception instead of the rule.

III. *Historical Sketch of the sequence of events indicated by the Section.*

The section at the Joggins is so perfect, and speaks so plainly of the mode of formation of its beds, that it does not seem to me presumptuous to attempt to read it as a connected history. In doing so, I of course follow the ascending order, and have therefore, in the sectional list (pp. 2 *et seq.*), numbered the groups of beds from the bottom toward the top. The subdivision into groups is merely to facilitate reference; and in so far as it is natural, is based on the fact that the section presents, in some places, a succession of beds crowded with interesting evidences of vegetable and animal life, and in others thick groups of strata comparatively barren in these respects.

At the base of Group I. we find an underclay, or fossil soil of argillaceous character, and 4 feet in depth, penetrated by rootlets of *Stigmaria*. Below this soil there are sandstones and shales having a few drifted trunks of trees imbedded in them; above it is a series of beds marking very tranquil and slow accumulation of organic and fine sedimentary matter. The published observations of Mr. Binney, Mr. Brown, and the writer†, as well as facts to be subsequently noticed in this paper, amply prove that the *Stigmariæ* were *roots* of the *Sigillaria* and its allies. We therefore take it for granted that a forest of *Sigillariæ* grew on this soil, the remains of which and of the vegetable soil which accumulated around them have produced half an inch of coal. The cause of the disappearance of the forest is revealed by the next succeeding bed, a bituminous limestone with

* Mr. Brown's Section, Quart. Journ. Geol. Soc. vol. vi. p. 116.

† Quart. Journ. Geol. Soc. vol. ii. pp. 134, 390, 393, &c.

shells of *Cypris* and fragments of *Modiolæ*. This last bed accumulated, no doubt, very slowly, in quiet waters which must have inundated, for a long period, the tract formerly occupied by a forest. This inundation was not accompanied by the deposition of mechanical debris,—an evidence either that it was very gradual, or that the spot was in the interior of a thick and wide swampy jungle, into which no currents sufficiently powerful to carry sediment could find their way. After a time the locality again became a soil, on which *Sigillariæ* again flourished, and accumulated the material of 6 inches of coaly matter before, by a farther subsidence, the water and its tenants were restored, and continued, with various interruptions occasioned by the influx of muddy sediment, to occupy the ground until 24 feet of thickness were accumulated, showing either that the original subsidence was of more than that extent, or that the surface was continually going down as rapidly as it was elevated by deposition. At length, however, the accumulation of 16 feet of mud, perhaps accompanied by elevatory movement, restored a terrestrial surface, which became clothed with trees and *Calamites*. A cast in sandstone of one of these trees, 8 inches in diameter, showed large rhomboidal markings, like the leaf-scars of *Lepidodendron*. A number of erect *Calamites* in this deposit were also seen standing in the cliff.

The next group shows the submergence, and burial under mud and sand, of this soil, with its forest and calamite brake. I observed no fossils in this group, but Mr. Logan has noted *Stigmaria* in its upper part *in situ*.

In Group III. we have a recurrence of the same circumstances observed in Group I. A soil supporting *Sigillaria*, and covered with vegetable mould, was submerged in waters inhabited by *Modiola*, *Cypris*, and fish; and then, for a long time, the locality was alternately a swamp and an estuary or lagoon. Only one underclay remains in these beds; and there are no erect trees, nor can these be expected. Coal and bituminous limestone are of too slow growth to admit of the preservation of trees *in situ;* and no instance occurs in the Section of erect plants passing through beds of these kinds.

Group IV. is a thick accumulation of sand and clay, which at one level has entombed an erect ribbed tree, and at another a thicket of *Calamites*. There were two terrestrial surfaces, sufficiently permanent for the growth of these plants, but probably not for that of coal. This period, as contrasted with the last, well shows the different results of rapid and slow accumulation of detritus. In the one we see little organic matter, but the rapid burial of growing plants has preserved their forms in the natural position. In the other we have considerable animal and vegetable accumulations; but decay has had time almost entirely to destroy the external forms. These differences are characteristic of many other parts of the Section.

Group V. is a return, but on a smaller scale, to the circumstances of Group III. It is chiefly remarkable for a bituminous limestone immediately overlying an underclay, without any coal between. Either no peaty matter grew on this soil, or it had time to decay before the accumulation of the calcareous deposit. The limestone itself, however, eventually became an undersoil, and a thin coaly layer accumulated upon it, to be buried under a thick bed of clay. These changes appear to require movements of elevation as well as of subsidence. It is possible, however, that the appearances in this particular group may be due to the heaping up and subsequent rupture of a beach or bar at the margin of a morass.

In the next group we have another thick series of sands and clays, with only one terrestrial surface, now an arenaceous underclay, with Stigmaria-rootlets, and an erect ribbed stump, 2 feet high by 1 foot in diameter. In the lowest sandstone are many drifted trees, indicating that there was neighbouring forest-land undergoing denudation.

Group VII. presents the usual succession of underclay, coal, and Modiola-limestone and shale. The latter is remarkable for its great thickness, indicating the lapse of a very considerable time without any inroads of mechanical detritus. The succeeding group, however, filled up these quiet waters with a great mass of sand and clay.

Group IX. is a fine series of underclays and coals, alternating with Modiola-beds. It contains nine distinct soil-surfaces, the highest supporting an erect tree, which appears as a ribbed sandstone cast, 5 feet 6 inches high, 9 inches in diameter at the top, and 15 at the base, where the roots began to separate. This tree being harder than the enclosing beds, at the time of my visit, stood out boldly at the base of the cliff, nearly three-fourths of its diameter, and the bases of three of its four main roots, being exposed. Five of the underclays support coals, and in three instances bituminous limestones have been converted into soils, none of which, however, support coals. The last of these bituminous limestones is a very remarkable bed. First we have an underclay; this was submerged, and a *Spirorbis*, or creature allied to this genus, which we shall find to be very common in the succeeding parts of the section, attached its little shell to the decaying trunks, which finally fell prostrate, and formed a carbonaceous bottom, over which multitudes of little crustaceans (*Cypris*) swam and crept, and on which 14 inches of calcareous and carbonaceous matter were gradually collected. Then this bed of organic matter was elevated into a soil, and large trees, with Stigmaria-roots, grew on its surface. These were buried under thick beds of clay and sand, and it is in the latter that the erect tree already mentioned occurs; its roots, however, are about 9 feet above the surface of the limestone, and belong to a later and higher terrestrial surface, which cannot, however, be distinguished from the clay of similar character above and below.

The Xth Group contains a vast thickness of sandstones and shales, the latter chiefly of chocolate colours, which, as they afforded few facts of interest, were not measured in detail. This group points to a long-continued interruption of the swamp-deposits previously in progress. During the greater part of the time occupied in the formation of these beds, the locality must have been a sandy or muddy sea-bottom, receiving much mechanical detritus, or an expanse of flats of reddish mud and brown or grey sand, covered by the tides. There are, however, some evidences of terrestrial conditions. In the lowest beds is a large erect stump, filled with laminated clay after the complete decay of its wood. In the clay filling it were abundance of Fern-leaves, *Poacites*, *Lepidophylla*, a few plants with attached *Spirorbis*, and a shell of *Modiola*. This tree was rooted in a thick underclay full of rootlets of *Stigmaria*. Higher up there are several thin coaly bands, with underclays; many of the shales abound in leaves of Ferns and *Poacites*, probably drifted, and the highest sandstone showed a large erect tree.

Group XI. commences with a soil resting immediately on the truncated top of the tree last mentioned. On this soil was formed a deep swamp, now represented by 5 feet of coal and bituminous shale in alternate bands. Large quantities of clay and sand buried this swamp, but not in such a manner as to preclude the growth of trees, many of which were entombed in the erect position. In these sandstones and shales, no less than six erect trees were observed at different levels, the lowest being rooted in the shale forming the coal-roof: 15 feet of the trunk of one of these trees still remain; two others were respectively 5 and 6 feet high. Erect *Calamites* were also observed. The soil which was formed on the surface of these beds supports one of the thickest coal-beds in the section, marking a long and undisturbed accumulation of vegetable matter. It was covered by clay, which became a Stigmaria-soil, and was then submerged for a sufficient time to allow the formation of a small bed containing *Cypris* and *Spirorbis*. Above this we find a series of beds indicating swamp conditions, alternating with aqueous drift and deposition, and finally again giving place, for a long period, to the quiet estuary or lagoon, inhabited by *Modiola* and ganoid fish, and receiving little mechanical sediment. We have here, as in some previous groups, three distinct conditions of the surface :—first, terrestrial surfaces more or less permanent; secondly, undisturbed marine or brackish water conditions; thirdly, intervening between these the deposition, probably with considerable rapidity, of sandy and muddy sediment. We may also observe that, admitting the *Stigmariæ* to be roots of trees, there are five distinct forest-soils without any remains of the trees except their roots; and we shall find throughout the section that the forest-soils are much more frequently preserved than the forests themselves.

The XIIth Group, 80 feet in thickness, consists of sandstones and shales, with few vegetable remains. There are, however, several underclays, and one thin coal, and erect stumps appear at five distinct levels. One of them is the largest tree observed in the section: it measured 4 feet in diameter, and was 5 feet in height. Its surface was irregularly ribbed, and it was rooted in clay containing Stigmaria-rootlets. Its roots, however, were too imperfectly preserved to show the markings of *Stigmaria*. In this group we have probably the margin of alluvial deposits, gradually spreading over the Modiola-inhabited waters of the last group, and occasionally presenting dry surfaces for a time sufficiently long to admit of the growth of trees of great size.

In the large series of beds included in Group XIII., there are no less than thirteen distinct forest-surfaces, marked by underclays or erect trees, and five periods of submergence indicated by beds with *Modiola*, &c., and three of them, at least, of very long duration. It will be observed that, in three instances, the order of succession is underclay—coal—bituminous limestone. This arrangement, so common in other parts of the section, seems to show a connection other than accidental between the long periods of terrestrial repose required for the growth of coal, and those of quiet submergence necessary for the growth of Modiola-beds. Perhaps the submerged coal-swamp was the most fitting habitat for *Modiola* and its associates; and these sunken swamp-areas may have been so protected by thick margins of jungle as to resist for a long time the influx of turbid waters.

In ascending through Group XIII., the first object of interest is a band of bituminous limestone with *Modiola*, *Coprolites*, and *Cypris*, which forms the roof of one coal and the underclay of another, evincing important changes of level with scarcely any sedimentary deposition. Above the upper coal, however, we have an erect plant, only 4 inches in diameter, surrounded by arenaceous shale, and, in the finer clay surrounding its base, *Poacites* with attached *Spirorbis*, which probably, like some of its modern congeners, could grow rapidly, and with equal facility, either on drifting or stationary plants. Still higher in this group, and immediately above a thick bed of bituminous limestone and Modiola-shale, is a very curious association of erect plants. An erect tree, converted into coal, springs from the surface of the shale, and passes through 14 feet of sandstone and shale. Apparently from the same level there rises an erect ribbed tree, probably a *Sigillaria*, in the state of a stony cast, which, however, extends only to the top of the sandstone. In the sandstone, and rooted about a foot above the base of the erect trees, are a number of erect *Calamites*. In this case the forest-soil has been covered by about a foot of argillaceous sand, on which a brake of *Calamites* sprung up. Further accumulations of sand buried them, and covered the trunks of the trees to the depth of 8 feet. By this time the *Sigillaria* was quite decayed, and its bark became a hollow cylinder, reaching only to the surface of the sand, and ultimately filled with it. The other tree still stood above the surface, until 6 feet of mud were deposited, when, its top being broken off, it also completely disappeared beneath the accumulating sediment; and being softened and crushed by the lateral pressure of the surrounding mass, it was finally converted into an irregular coaly pillar, retaining no distinct traces either of the external form or internal structure of the original plant. The structure of similar trees, to be noticed further on, renders it likely that this coaly tree is the remains of one of the *Araucarian Conifers*, which, it appears, flourished in the coal-swamps in company with the *Sigillaria*. The surface of the clay which buried this remarkable tree became itself an underclay or soil; and in the sandstone resting upon it were found casts of two erect trees, one of them 5 feet in height, and a *Sigillaria* with distinctly marked leaf-scars. The tops of these trees have been entirely removed, and their hollow stems filled with sand, before the deposition of a bed of mud resting upon them, and which is now the underclay of a bed of coal. This coal was next submerged under the conditions required for bituminous limestone and Modiola-shale. The Modiola-waters were then filled up with clay and sand, the latter ripple-marked, and with drifted vegetable fragments. Another soil was formed above these beds, and on it we find an inch of coal, with flattened *Sigillariæ*, which probably once grew on the underclay. This terrestrial surface was succeeded, as usual, by waters swarming with *Modiolæ* and fish, and on these were spread out beds of sand and mud, with ripple-marks, drift-trees, and evidences of partial denudation by currents. A terrestrial surface was again restored, and 4 inches of coal were accumulated; but the waters again prevailed, and in the coal itself we find *Modiolæ*, *Cypris*, and plants covered with *Spirorbis*, indicating that these creatures took possession while the vegetable matter was still recent, and probably much of it in an erect position. A terrestrial surface was, however, soon restored; for in the shale which covers the coal there is a fine ribbed stump, 2 feet in diameter, and displaying on its roots the markings of the true *Stigmaria ficoides*, as well as the rootlets *in situ* in the shale. This is the first instance we have here yet met with of the distinct connection of an erect ribbed stem with its Stigmaria-roots. The causes of the difficulty of observing the roots and stem in connection will be stated in the sequel.

The next group is probably the result of somewhat rapid mechanical deposition. Its lowest bed is a thick sandstone, deposited by currents which have undermined wooded banks, or passed through recently submerged forests, for it contains numbers of trunks of different trees, retaining their bark and surface-markings. In the succeeding 110 feet of sandstone and shale, I have noted but one underclay, supporting only a thin carbonaceous layer, which may, however, have been a soil for a long time. There are, however, erect trees and *Calamites* at three levels; and one of the trees springs from a shale loaded with *Poacites* which may have grown around its base.

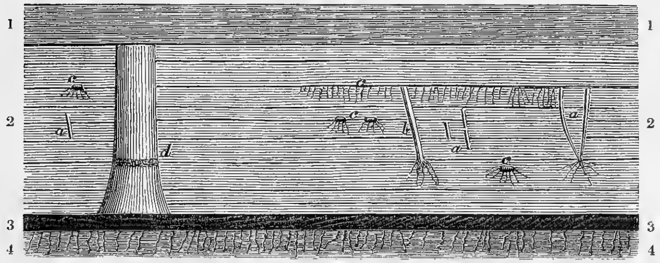
The next Group (XV.) is one of the most interesting in the section. We have, first, the usual succession of underclay, coal, and shale, capped by a thick deposit of sandstone and shale, with erect *Calamites* in the lower part, and above these prostrate trunks of *Sigillaria* and other trees. On this rests an underclay, with a coal 6 inches thick. In a bed of argillaceous sandstone, 9 feet in thickness, which covers this coal, were observed four erect trees, erect *Calamites*, and *Stigmaria*, at three levels; and in one of the erect trees (fig. 2) occurred the remains of two reptilian animals, and a land-shell described in a former communication*. Only three erect trees were observed in this bed in 1852†. The fourth, which I found in the summer of 1853, stands on the surface of the coal, and consists merely of the coaly bark enclosing a mass of fragments of decayed wood in the state of mineral charcoal, as represented in figs. 14*a*, MS. and 14*b*, MS. (fig. 18).

* Quart. Journ. Geol. Soc. May 1853, vol. ix. p. 58.

† One of these trees has Stigmaria-roots: fig. 8 MS.

The wood of this tree shows, in the longitudinal section, a cellular tissue, precisely similar to that of the Coniferæ; the cross section shows only elongated cells, but is very badly preserved. A tree of this description is not likely to have been more perishable than the *Sigillariæ*, which, in the same situation, remained until 9 feet of sandy mud had accumulated. I suspect, therefore, that this stump may be the remains of a coniferous forest, which preceded the *Sigillariæ* in this locality, and of which only decaying stumps remained at the time when the latter were buried by sediment. This is the more likely, as the appearances indicate that this tree was in a complete state of decay at the very commencement of the sandy deposit. The reptilian remains found in these beds give them more than ordinary interest, and may excuse a reference to the probable history of their formation more detailed than in the case of other parts of the section.

Fig. 2.—*Section of middle part of* Group XV. (p. 6), *in which the Dendrerpeton and Land-shells have been found.* See Quart. Journ. Geol. Soc. vol. ix. p. 61.



1. Underclay, with rootlets of *Stigmaria*, resting on grey shale, with two thin coaly seams.
2. Grey sandstone, with erect trees, Calamites, and other stems : 9 feet.
3. Coal, with erect tree on its surface : 6 inches.
4. Underclay, with *Stigmaria* rootlets.

a. Calamites. *c*. Stigmaria roots.
b. Stem of plant, undetermined. *d*. Erect trunk, 9 feet high.

(1.) The Stigmaria-underclay, 4, shows the existence of a Sigillaria forest, on the soil of which was collected sufficient vegetable matter to form 6 inches of coal, which probably represents a peaty bog several feet in thickness. (2.) On this peaty soil grew the trees represented by the stump of mineral charcoal mentioned above, and which were probably coniferous. This tree, being about 1 foot in diameter, must have required about fifty years for its growth to that size. It was then killed, perhaps by the inundation of the bog. (3.) During the decay of the tree last mentioned, *Sigillariæ*, *d*, grew around it to the diameter of 2 feet, when they were overwhelmed by sediment, which buried their roots to the depth of about 18 inches. At this level *Calamites*, *a*, and another *Sigillaria* began to grow, the former attaining a diameter of 4 inches, the latter a diameter of about 1 foot. (4.) These plants were in their turn imbedded in somewhat coarser sediment, but so gradually that trees with Stigmarian roots, *c*, grew at two higher levels before the accumulation of mud and sand attained the depth of 9 feet, at which depth the original large *Sigillariæ*, that had grown immediately over the coal, were broken off, and their hollow trunks filled with sand. Before being filled with sand, these trees, while hollow, must for some time have projected from a swamp or terrestrial surface, such as that which immediately succeeds them in ascending order; and it is no doubt to this circumstance that we owe the occurrence, in one of them, of reptilian remains and land-shells, as well as a mass of vegetable fragments, such as *Calamites*, *Poacites*, and a *Lepidostrobus* *, evidently introduced before the sedimentary matter, and forming just such a mass as might be supposed likely to fall into an open hole in a forest or swamp. (5.) The remaining beds of this group evidence the continuation of swamp-conditions for a long time after the trees last noticed were completely buried. They include, in a thickness of 28 feet, three underclays supporting coaly beds, and one with erect stumps; one of them with Stigmarian roots and ribbed. One of the coaly beds, which alternates with laminæ of shale, is filled with flattened trunks of *Sigillaria* and *Lepidodendron*, which probably grew on the surfaces on which they now lie, and indicate how small a thickness of coaly matter may mark the time required for the growth and decay of many successive forests.

On the whole, we can scarcely err in affirming that the habitat of the *Dendrerpeton Acadianum* and its associates was a peaty and muddy swamp, occasionally or periodically inundated, and in which growing trees and Calamite brakes were being gradually buried in sediment, while others were taking root at higher levels, just as now happens in the alluvial flats of large rivers.

I may add that in 1853 I found, in some additional fragments of the reptiliferous tree collected by Mr. Boggs, superintendent of the Joggins mine, a second, though imperfect specimen of the land-shell figured in the paper already referred to (vol. ix. pl. 4), and a few fragments of bone, apparently vertebræ.

Group XVI. consists of one thick bed of grey sandstone, with prostrate carbonized trunks. The sandstone is highly siliceous, and of the kind used for grindstones. It is the result of the complete submergence of the swamps of the last group, and their invasion by sand-bearing currents.

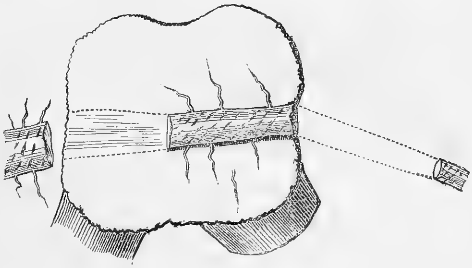
The next Group commences with the growth of *Calamites* on the surface of the great sand bed last noticed, after which there was the formation of an underclay and coal, the latter being afterwards inundated, and the plants at its surface overgrown with *Spirorbis*. In the shale covering this coal, about 14 feet above its surface, is a bed with shrinkage cracks, and containing a stool of *Stigmaria*, one of the roots of which was traced $9\frac{1}{2}$ feet. Its rootlets were attached, so that it can scarcely have been a drift-stump; and if now *in situ*, it must have grown on a mud-bank alternately inundated and dry, like the present salt-marshes of the Bay of Fundy. The *Stigmaria* in this bed is not of the most common variety or species. It has round marks regularly arranged, but flat, and without depressed areolæ, as represented in fig. 13, MS. That growth on occasionally

* Found in 1853.

inundated mud and sand was quite natural to the trees with Stigmarian roots, is shown not only by instances in this section, but by a very remarkable bed at Port Hood, Cape Breton, which I may refer to here as belonging to precisely the same class of facts with that now under consideration.

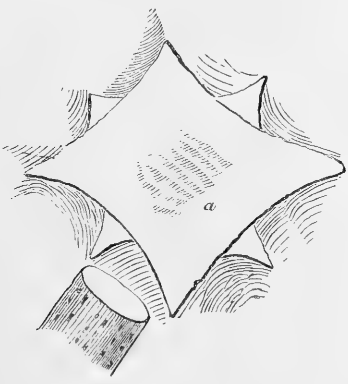
A bed of sandstone, in the coal formation at Port Hood, is filled with the stumps of large erect ribbed trees, with very distinct Stigmarian roots of two species; and more than one generation of trees must have grown on the spot, since one large stump was observed to be penetrated by the root of another tree, which must have grown through it after it became filled with sand, fig. 3. Yet several of

Fig. 3.—*Stump of a tree penetrated by Stigmaria; from the coal-measures at Port Hood, Cape Breton Island.*



the layers of this sandstone are ripple-marked; and the sandstone immediately underlying one of the large stumps, which had been removed, was found to be distinctly rippled, fig. 4. At Port Hood the beds dip gently toward the sea, and at low tide a large surface of the rock is exposed, with stony casts of stumps projecting from it, and Stigmaria-roots spreading in all directions.

Fig. 4.—*Impression of tree-stump in sandstone, with ripple-marks; from Port Hood.*



a. Ripple-marks.

Group XVIII. is a series of sandstones and shales less perfectly exposed than most other parts of the section. Chocolate colours prevail among the shales, and on the whole this group presents few indications of terrestrial conditions. One of the beds, however, has a surface with shrinkage cracks, and we observed a bed of erect *Calamites* and a Stigmaria-soil.

Group XIX.—The next group is of greater interest, showing seven soil-surfaces, intermixed with sedimentary deposits. The lower part presents the usual succession of underclays, coals, and shales; and two of the coals contain well-preserved remains of the plants (*Sigillaria*, *Poacites*, &c.) which grew on their underclays. The highest coal of this group has undergone a temporary submergence, as its upper part contains *Poacites* covered with *Spirorbis*. That this submergence was not without mechanical deposition, is shown by the preservation in an erect position of several *Calamites* which grew on the surface of the coal. On the clay next deposited grew a furrowed tree, with Stigmaria-roots (like that of fig. 13, MS.). This surface was buried under the irregularly-bedded mass represented in fig. 1, and the probable origin of which has been already referred to (p. 13). The surface, having been levelled by these deposits, was again occupied by forests of the Stigmaria-rooted trees, the only remains of which are an underclay, somewhat arenaceous, and a thin layer of impure coal with flattened carbonized trunks. On this prostrate forest a thick bed of clay was deposited, on the surface of which grew the finest Calamite brake now remaining in the section. These *Calamites* are, as usual, stony casts, and they are buried in a thick bed of sandstone passing downward into arenaceous shale. The largest stems are 5 inches in diameter, and attain a height of 8 feet, when they are broken off without any diminution of their diameter. They grew in groups or clusters, and were so numerous, that, in one place, twelve stems were counted in 8 feet measured along the face of the cliff. From the base of the cliff to the level of low water, 120 paces distant, they were observed to occur abuudantly. Part of this bed is shown in fig. 5, MS., where three groups are seen, the individual stems converging toward the base, and terminating in blunt points, as in the case of the bed of erect *Calamites* at Pictou, described by the writer *. Fibrous roots, probably those of the Calamites, occur in the underlying shale.

The beds last noticed curiously indicate the different ways in which the lapse of geological time may be marked. The sandstone, 8 feet in thickness, enveloping the *Calamites*, must have been deposited in a year or two. A layer of coal, 2 inches thick, is all that marks the growth and decay of a forest.

The XXth Group is a series of sandstones and shales, with three underclays. The shales are mostly chocolate-coloured, and the sandstones grey and irregularly bedded.

The XXIst is a succession of swamp-deposits, with a few barren intervals, but presents nothing sufficiently novel to detain us.

The XXIInd is a rather barren group, containing however erect plants at two levels. The lowest of these has both ribbed stumps and *Calamites*. The latter present evidences of extreme decay. The bark has not retained its cylindrical form, but has fallen inward in strips, leaving a rude cylindrical cavity now filled with clay-ironstone and shale.

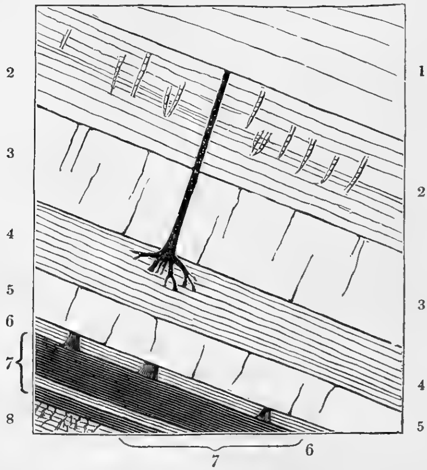
Group XXIII. is the most important continuous series of swamp and estuary deposits in the section, and includes the coal-seam at

* Quart. Journ. Geol. Soc. vol. vii. p. 195. fig. 1.

present mined. It commences with a black bituminous underclay, probably a soil of long continuance; it is filled with *Stigmariæ*. It supports a bed of coal on which grew a forest of large trees, of which a few very imperfectly preserved stumps alone remain. Above this we have a succession of shales and coals with underclays; the shales having at one level an erect tree, and in several places an abundance of prostrate plants. The surface was then covered with water, depositing mud and fragments of plants to which the *Spirorbis* attached its shells. On these sandstones *Stigmariæ* again took root, and two beds are filled with well-preserved stools of these singular roots, each with four main divisions branching dichotomously and with rootlets attached. They must have grown on beds of argillaceous and somewhat calcareous sand. The only result of the growth of these dense forests was an inch of impure coal, over the highest Stigmaria-bed. A lower and less important one supports an erect ribbed stump. Above the coal last mentioned is a muddy underclay with much vegetable matter, on which a varied and beautiful vegetation has flourished, and now lies prostrate in a thin band of shale and ironstone. In this instance we found three species of *Sigillaria*, a *Favularia*, and multitudes of *Poacites* and other leaves, as well as *Carpolites*. Many of these fossils have *Spirorbis* attached. They no doubt mark the site of a submerged and fallen forest, which instead of appearing, like so many others, as a thin layer of coal, has first served as a habitation for *Spirorbis*, and then been buried in abundant deposits of clay and carbonate of iron. A little higher in this group we find a thin coaly band, almost wholly composed of *Poacites*. No roots appeared in the underclay, and it is consequently possible that these leaves may have been drifted by water. On this coal is a thick bed of shale, supporting two interesting erect stumps, represented in figs. 6 & 6 *a*, MS. From the clay in which they are rooted they pass upward through a sandstone 2 feet in thickness into a shale with ironstone bands above. The smaller of the two is ribbed, but without leaf-scars—its roots are concealed under the beach. Opposite the sandstone the cast of the hollow trunk is of the same material, but the sandstone within the bark rises 7 inches above the surface of that without, showing that the sand bed was once thicker than at present, and that a part of it had been removed from around the stump before the deposition of the next bed. It is probable that the level of the sand within the trunk was originally lower than that without, and, if so, this sandstone may have lost much more than 7 inches. The larger stump, though rooted at the same level as the smaller tree, is brought by the rise of the beds to a sufficient height to allow its roots to be seen. It shows that while the sandstone within these stumps rises higher than that without, it also descends lower, though not quite to the roots, which with the base of the stump are filled with clay. We thus learn that after the trunk became hollow, and while its top continued to stand at least 3 feet above the surface, it was partly filled with a deposit from muddy water. The mud within was, however, much lower than that without, when sand began to be deposited and filled the greater part of the stump. The overlying shales bend downward into the tops of these stumps, showing that the material within was more compressible than that without, perhaps in consequence of some vegetable matter remaining at the base of the trunk. The roots of the larger tree have Stigmaria-markings, and the rootlets were distinctly preserved in the shale. Portions of the surface of the trunk showed the markings of a broad-ribbed *Sigillaria*, with oval leaf-scars on the ligneous surface. The bark, which is in a coaly state, is about an eighth of an inch in thickness, and its original strength and durability are well illustrated by the circumstances in which these trunks have been preserved. The detailed Section, p. 4, sufficiently illustrate the beds immediately succeeding, including the main coal. The shale roof of the latter, however, merits special remark. It abounds in large prostrate trunks of *Sigillaria* and *Lepidodendron*. One of the former has been traced for 30 feet in the roof of the mine. *Poacites*, *Asterophyllites*, Ferns, and other leaves also abound in it, and many of these, as well as the trunks of the prostrate trees, have attached *Spirorbis*. Shells of *Modiola* also occur, though rarely. In addition to all this, there are erect stumps, the Stigmaria-rootlets of which insinuate themselves like worms within the bark of the fallen trunks buried in the same shale. A collection from this bed gives a fine picture of the flora of these swamps of the Coal period.

On the surface of a bed of clay, 8 feet above the main coal, stands

Fig. 5.—*Section from the upper part of* Group XXIII. (p. 4).



1. Shale and sandstone. Plants with Spirorbis attached; Rain-marks?
2. Sandstone and shale: 8 feet. Erect Calamites.
3. Grey sandstone: 7 feet.
4. Grey shale: 4 feet.

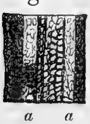
{ An erect coniferous? tree, rooted on the shale, passes up through 15 feet of the sandstones and shale.

5. Grey sandstone: 4 feet.
6. Grey shale: 6 inches. Prostrate and erect trees, with rootlets; leaves; Modiola; and Spirorbis on the plants.
7. Main coal seam: 3 feet 6 inches.
8. Underclay with rootlets.

another erect tree converted into hard shining coal, and reaching to the height of 15 feet, through beds of sandstone and arenaceous shale (fig. 5). Its roots, which are in the state of coal, spread in an irregular manner through the clay or soft shale, and its top appears to be broken off abruptly. After sand and mud had collected around this tree to the depth of 10 feet, and while its top projected above the surface, a dense brake of *Calamites* grew around, some of them attaining a diameter of nearly 2 inches and a height exceeding 5 feet. Farther accumulations buried these *Calamites* in the erect position to the depth of 5 feet, when their tops were broken off and the imbedded stems decayed and were replaced by sand. Still the erect tree remained undecayed, and though its top was broken off at this level, only the cracks which had formed in its wood were filled with sand, when the whole was buried by farther accumulations of sandy sediment, which contains drift-plants with attached *Spirorbis*. As this remarkable tree was evidently more durable than the ordinary *Sigillariæ,* and had irregular roots distinct from *Stigmaria,* and as it had quite lost its surface-markings, I was very anxious to ascertain its internal structure. After many trials, however, I could find only very indistinct traces of cellular tissue, the mass of the fossil consisting of compact coal divided by transverse joints, and by an immense number of minute vertical cracks with a few larger fissures which seemed to have a concentric arrangement. After abandoning the attempt in despair, I found, in a box of specimens with which I was favoured by Mr. Logan, a piece of fossil wood in precisely the same condition with this tree, but retaining in one part distinct evidence of its coniferous nature. Believing at the time that this specimen was from the beds in question, (though I have since learned that it belongs to another part of the section,) I was encouraged to make farther attempts, and had the whole of the tree taken down by a miner. After carefully selecting the most promising portions, I made new slices, and was rewarded by finding cellular tissue of distinct coniferous character, and in one small portion the hexagonal disks or reticulations characteristic of the Araucarian type of pines (see figs. 6 *a*, *a*, & 7). If, as I have no doubt, this tree grew where it now stands, we have thus evidence that coniferous trees grew in the same swamps which produced *Sigillaria* and *Calamites,* though they had hitherto been found only as drifted trunks in the sandstones. Their comparative rarity, however, in connexion with their durable nature, seems to prove that they formed only a small part of the vegetation of these swamps.

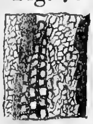
Figs. 6 & 7.—*Microscopical structure of the erect coniferous tree in* Group XXIII. (fig. 5).

Fig. 6.



Longitudinal section of the wood.

Fig. 7.



Transverse section of the wood.

Passing over a few beds containing evidences both of growth in place and driftage, we find, near the top of this group, a thin bed of impure coal containing trees with attached *Spirorbis*, and intermixed with these fish-scales and *Cypris*, the whole being capped by Modiola-shale. To account for the fossils in this coal, which rests on a true underclay, we must suppose the submergence of a forest, in such circumstances that fish and *Cypris* lived among its sunken trunks, and were buried along with them as they decayed and fell to the bottom.

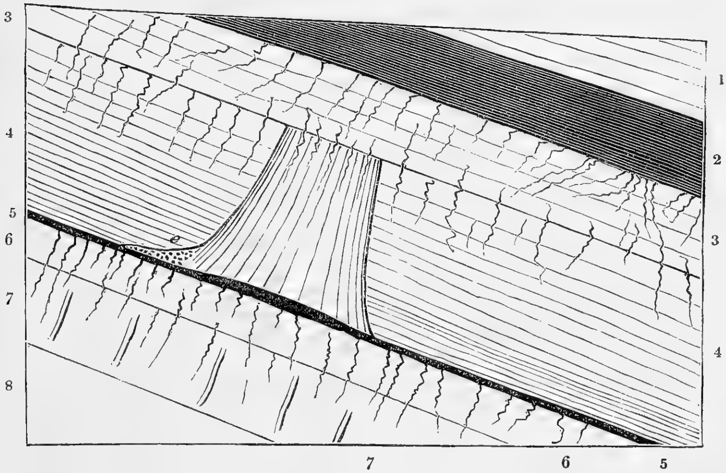
In Group XXIV. the waters retain their dominion, though gradually filling up with sediment. The sandstones of this group are very uniform and evenly bedded as compared with those of the last, and present no indications of vicinity to shores or water-courses, except in the presence of drift-wood and some singular scratches and furrows on the surfaces of the shales, casts of which have been taken by the overlying sandstones. Marks of this kind are very frequent in the Coal formation. They occur on a grand scale in the sandstone quarries of Pictou, and also on the French River of Tatmagouche. Many of them might easily be included in the convenient tribe of *Fucoides*, but their want of uniformity, the absence of organic matter, and their occurrence in beds containing drift-trees render it probable that they are scratches produced by roots or branches borne over the surface by currents. Such marks in modern inundated flats are usually straight, like glacial striæ, but when stumps or tree-tops are grounded and afterwards borne off, the most fantastic markings are produced. Very singular appearances also result from the eddying of the water around such obstacles, and much resemble many of these markings on the carboniferous rocks.

The XXVth Group is another series of fossil soils and their accompaniments, terminating upward in a thick bituminous limestone and Modiola-shale, with their usual fossils.

Group XXVI.—In the succeeding group we have the filling up of the waters inhabited by *Modiola*, with mechanical detritus. One erect tree occurs in this group, and many of the beds of sandstone are ripple-marked. On one of these rippled sandstones I found, on revisiting the section in 1853, a *series of footprints*, probably of some reptilian quadruped allied to those found in the fossil tree in another part of the section. These footprints are three-toed, each about 9 lines in length. The length of stride is 3½ inches, and the two rows of footprints 3 inches apart. Just where the rows of steps bend to the left, a slight mark nearer the left side appears to indicate a tail (fig. 18, MS.).

Group XXVII. is a dense series of underclays and their accompaniments, including eleven terrestrial or soil surfaces, five thin coals, erect plants at four levels, and two bituminous limestones. It much resembles some of the groups at the commencement of the section, and like some of these is very pyritous, marking the action of sea-water to a greater degree than in those central parts of the measures where *Modiolæ* and their accompaniments are less plentiful. The most remarkable part of this group is that represented in fig. 8. It includes a bed of erect *Calamites* and an erect tree with distinct Stigmaria-roots (fig. 12, MS.). The underclays are here so crowded above the erect plants, that the rootlets of one underclay pass downward among the erect Calamites, and the rootlets of another pass beside

Fig. 8.—*Section from the lower part of* Group XXVII. (p. 3).



1. Shale. 2. Shaly coal: 1 foot. 3. Underclay with rootlets: 1 ft. 2 in.
4. Grey sandstone passing downwards into shale: 3 ft. Erect tree with Stigmaria roots (*e*), on the coal.
5. Coal: 1 inch. 6. Underclay with roots: 10 inches.
7. Grey sandstone: 1 ft. 5 in. Stigmaria rootlets continued from the bed above; erect Calamites. 8. Grey shale, with pyrites. Flattened plants.

and within the cast of the erect tree, and have helped to obliterate its surface-markings, by passing downward immediately within the bark. The roots of this tree are casts in sandstone, probably from the surface of the sand surrounding its upper part, but the stump itself is filled with shaly clay from the underclay above. It will be observed that one of the bituminous limestones in this group has been converted into a Stigmaria-underclay and supports an erect tree.

In Group XXVIII. and the remainder of the section, we find gradually decreasing evidences of group conditions; and in other beds higher than those in our section, there are conglomerates and other evidence of very different conditions from those we have been considering—in short, of a return to the open sea of the Lower Carboniferous period. In Groups XXVIII. and XXIX., however, we have still a number of underclays with thin coal seams and erect plants; among the latter some large ribbed trees and two stumps converted into coaly matter, and with irregular coaly roots.

In conclusion, it appears evident that the series of events indicated by this remarkable section, and which I have endeavoured to state in the above historical sketch, consists of a long succession of oscillations between terrestrial and aquatic circumstances, and unaccompanied by any material permanent change in the nature of the surface or in its organized inhabitants. These oscillations depended on gradual and long-continued subsidence, alternating with elevatory movements, in an extensive alluvial tract teeming with vegetable and animal life, and receiving large supplies of fine detrital matter. On the one hand, subsidence tended to restore the original dominion of the waters; on the other hand, elevatory movements, silting up, and vegetable and animal accumulation built up successive surfaces of dry land, or of partially or occasionally inundated swamp. The results of these opposing forces no doubt always existed contemporaneously, so that by mere change of place one could have passed from a coal-swamp to a Modiola-lagoon or a tidal sand-flat; but in each separate locality they alternated with each other, with greater or less frequency; and it is probable that during a great part of the period the locality of our section was near the margin of the alluvial tract in question, where the various fortunes of the conflict would be more sensibly felt and more easily recorded than nearer the open sea or farther inland.

IV. *Notices of New Facts relating to the Fossils of the Coal Formation.*

1. *Sigillaria and Stigmaria.*—The identity of these plants, as the trunks and roots of trees of the same genus, has been established by Messrs. Binney and Brown, and is farther confirmed by facts already noticed in this paper. I shall give, under this head, explanations of some apparent difficulties, and facts bearing on the habits and structure of these singular plants.

It has been asked, in reference to the Joggins section*, how it happens that so many erect trunks show no roots, especially since the great number of fossil soils would lead us to anticipate that the former were less likely to be preserved than the latter. In answer I remark: (1.) The underclays are usually more perishable than the sandstones and arenaceous shales which contain the erect trunks, hence the former are often cut away before the trunks are disclosed. (2.) The roots, approaching to a horizontal position, have often been compressed or converted into coal, when the erect trunks and vertical rootlets have been preserved. There are cases, however, in which the Stigmaria-roots are preserved in a horizontal position, and with scarcely any flattening. Such roots were probably hollowed by decay and filled with mineral matter before the beds were compressed by the weight of newer strata.

The greater number of the erect fossil trees in the section do not show the markings of *Sigillaria*, but only furrows or ribs more or less distinct. Were they all *Sigillaria*? I think it probable that most of them were, and account for the disappearance of their external characters in the following ways:—(1.) These trees being stony casts of the interior of the bark, it is evident that if, when the sand or mud forming the cast was introduced, thin films of wood remained adhering to the inner surface, or if, on the other hand, a part of the bark itself was removed by decay, in either of these opposite cases, an indistinct

* Quart. Journ. Geol. Soc. vol. ii., President's Address.

cast must result. (2.) The interior of the cylinder of bark has often been smeared with clay before a cast was taken, and this clay either comes away with the bark, or falls off when weathered, taking with it the finer parts of the cast. (3.) The portion preserved in an erect position is generally only a few feet of the base of the trunk, where the markings were probably nearly obliterated by growth. (4.) In one instance rootlets of *Stigmaria* were observed to pass downward between the bark and the matter filling the interior, and leaving vermicular impressions of their own form over the whole surface. When all these causes are allowed for, it will not appear remarkable that few erect trees retain their surface-markings, and that these should generally be of the broad-ribbed and strongly marked species.

The dome-shaped fossil in the centre of *Stigmaria*, as described by Lindley and Hutton, and a similar body found at Sydney by Mr. Brown have occasioned doubt as to the true nature of *Stigmaria*. Such appearances may have been produced in the following manner. The trunks of *Sigillaria* usually expand rapidly toward the base, and if broken off near the soil, there would be a tendency in the bark, during decay of the wood, to fall in toward the centre. This would be much facilitated by the circumstance that the bark of *Sigillaria* was weak along the furrows, and hence tended to split into strips. Such strips, each with a row of leaf-scars, are found among the detached fossils on the Joggins shore. In the falling in of the bark, they would readily overlap each other and form a continuous coaly surface, leaving on the internal cast impressions of some of the leaf-scars, if any existed so near the root. Farther, the abrupt breaking off of a cylinder of bark projecting above the surface would crush together the sides of the imbedded portion, leaving only an open slit at top. This is well seen in the broken tops of erect Calamites*, and a curious instance of a similar deceptive appearance is presented by erect Calamites in this section, which, when imperfectly filled with sediment, assume either the appearance of a vertical row of lenticular bodies strung on a thin irregular string, or that represented in fig. 15.

The tendency of *Sigillariæ* to have four main roots dividing regularly at equal distances has been noticed by Messrs. Binney and Brown. It is illustrated by several erect trunks in this section (figs. 6*a* & 8, MS.), and still better by the remains of the erect trees found at Port Hood. Fig. 1, Port Hood, MS., represents a large erect stump with its four main roots. Fig. 4, Port Hood, MS., represents the markings on this root. Fig. 4, p. 23, represents the impression of another large stump in the sandstone. Fig. 5, Port Hood, MS., represents the markings of another species of *Stigmaria* found in the same bed. Accidental deviations from this singularly regular division of the roots are sometimes met with. In a collection at the Joggins, there is a small stump from the roof of the coal seam, with two large and two small roots, as if it had grown on the slope of a bank or edge of a channel. It is also common to find, especially in large trunks, instead of four roots, four great lobes giving origin to eight roots. The whole of this arrangement, as well as the peculiar structure of

* Quart. Journ. Geol. Soc. vol. vii. p. 196.

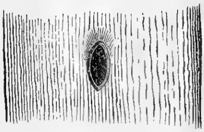
the rootlets, is no doubt a special provision for growth in soft and homogeneous alluvial soils and peaty muck. The curious resemblance of these roots to the cable-like rhizomata of the pond-lily *, would lead us to infer that their form and structure were intended rather to obviate the effects of excessive moisture, than to collect large supplies of liquid nutriment.

A nodule of ironstone from one of the underclays shows, though somewhat imperfectly, the structure of the rootlets or great hollow spongioles of *Stigmaria*. Fig. 11 *a*, MS. is a slice of the natural size. The outer circle is the original form of the rootlet, now filled with clear calc-spar. Within this is the shrunken rootlet, in a carbonized state. Fig. 11 *b*, MS. represents the remains of the rootlet magnified, and showing an outer and inner cuticle with intervening cellular tissue having open spaces. Fig. 11 *c*, MS. is a portion still more highly magnified.

Different opinions have been entertained respecting the mode of growth of *Sigillariæ*, owing to the supposed uniformity of the ribs and leaf-scars along the whole length of the trunk. Mr. Binney, however, remarks, that a specimen in the Manchester Museum shows four kinds of leaf-scars. The most distinctly marked erect trunk found by us in the Joggins Section affords an interesting illustration of this variety of marking. At the height of 5 feet above the base,

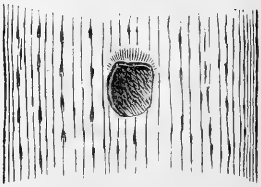
Figs. 9, 10, & 11.—*Ribs and Leaf-scars of erect Sigillaria stump, from the South Joggins.*

Fig. 9.



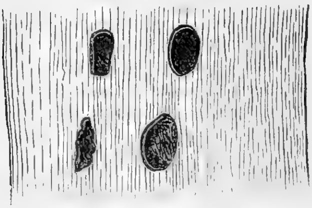
At 5 feet from the root.

Fig. 10.



At from 2 to 3 feet from the root.

Fig. 11.



Near the root.

the ligneous surface has deeply marked ribs and oval leaf-scars. A little lower it has broader and flatter ribs, with broad scars somewhat

* Nymphæa odorata.

heart-shaped, like those of *S. reniformis.* At the base of the trunk the ribs are obliterated, and there are distant rows of double scars, like those of *S. alternans* (figs. 9, 10, 11). These differences must have been produced by expansion of the trunk; and it would thus seem that ribbed trees of this genus were adapted to a remarkably regular kind of exogenous growth, the arrangement of these surface-markings being, in one modification or another, preserved even in the lower part of large trunks.

From the great abundance of *Stigmariæ* in some beds, it may be inferred that the trees to which they belonged formed thick groves. In other cases, however, they grew singly or sparsely on mud-flats. They could flourish on a variety of soils, from poor sand to the richest vegetable mould, but in all cases they seem to have required a swampy or water-soaked locality. In no instance did we find leaves attached to the trunks of *Sigillaria.* In some of the beds, however, the trunks are associated with great numbers of leaves of *Poacites,* and slender grass-like or needle-like leaves like those of *Lepidodendron* and *Cyperites.*

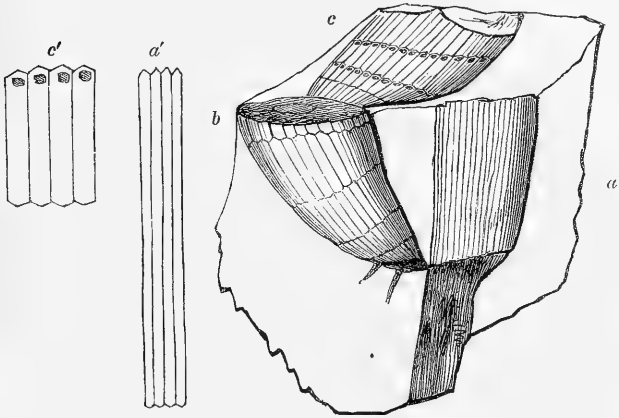
The preservation of so many trunks of *Sigillaria* in an erect position is in part due to the very durable nature of their bark as compared with their woody portion. This is well illustrated by the occurrence of an inclined trunk in one of the sandstones, and a prostrate one in the roof of the main coal, with shells of *Spirorbis* attached to the *inner side* of the bark, showing that the bark remained for some time under water and perfectly hollow, without losing its form. In both these instances the species is a narrow-ribbed one, resembling *S. Organum.* This difference in the durability of the bark and wood may be observed in many modern trees; for example the canoe birch, *Betula papyracea,* the tough bark of which often remains as a hollow cylinder long after the disappearance of the wood, and may sometimes be seen in swamps, filled with mud, while still apparently sound and fresh. When the casts of erect trees are of hard sandstone, they sometimes project from the cliff like columns or pilasters; but where they are filled with soft material, they waste with the surface of the cliff, and but for some slight difference of colour, and the coaly bark passing up at each side, across the beds, might easily escape observation. I may remark here that the section includes the erect trees observed both in 1852 (by Sir C. Lyell and myself) and 1853 (by myself alone). Many of them were not seen in 1852, and others seen in 1852 had quite disappeared before the summer of 1853. I have no doubt that a series of observations continued through several years would greatly increase the number of beds with erect plants.

Among the most common species of *Sigillaria* at the South Joggins are *S. Organum, catenulata, reniformis, scutellata,* and *alternans,* or species closely resembling these. Prostrate trunks of three species of *Favularia,* of two species of *Ulodendron,* apparently the *U. majus* and *minus,* and of three or four species of *Lepidodendron* are found along with the *Sigillaria,* and probably grew in the same swamps. We had no means of ascertaining whether the trees of these last-named genera had Stigmaria-roots. I may remark, however, that some of the underclays contain irregular coaly root-like bodies, which, if not the roots of coniferous trees, may possibly belong to some of the genera above mentioned.

2. *Coniferous Trees.*—Trunks of this description occur in the sandstones, both in a carbonized state and petrified by carbonate of lime. It is observable that they are most abundant in those parts of the section where the swamp-conditions of the productive coal-measures begin to disappear, and where drifted plants predominate over those which have grown in *situ*; in other words, in the sandstones above and below our Section. Two specimens of these drift-trunks were found, on being sliced, to have the characters of the genus *Pinites*, with medullary rays having two rows of cells, and cellular tissue with two, or more frequently three, series of hexagonal areolæ. One of them much resembles *P. Brandlingii* of Witham. The prevalence of coniferous trees as drift-wood in the sandstones, above and below the Coal-measures, is probably to be attributed to their capability of floating for a long time without becoming water-soaked and sinking, though it may also indicate that their principal habitat was farther inland than the Sigillaria-swamps. The erect coaly trees, however, already noticed, show that they did grow in those swamps, though not abundantly. The structure of the coaly coniferous tree above the main coal and its present position in the beds are shown in figs. 5, 6, 7, pp. 26, 27.

3. *Calamites.*—These plants appear erect and *in situ* at eight or nine distinct levels, and in some of the beds their roots and verticillate leaves or branchlets may be seen attached to the stems. At least two species occur; one of them resembling *C. Suckowii* or *C. cannæformis*, the other a coarse and irregularly marked species. Figs. 19 & 24, MS., and figs. 12, 13, 16 refer to the former species, fig. 15 to the latter. The Calamite-stems, when they can be traced to their bases, always terminate in obtuse points, the joints becoming shorter toward their extremities. The roots when not compressed are cylindrical, irregularly branched (figs. 13, 14), and covered with a thin coaly bark, marked with waving longitudinal striæ. The roots are given off not only from the base of the stem, but also from its lower joints, in large irregular tufts; see fig. 14, where three of these tufts are seen, and also irregular marks showing the places from which others have been broken off. The coaly investment of the stem is much thickened at the points from which the tufts of roots proceed. It was the habit of the Calamite to grow on mud and sand flats rising by new depositions, and it appears that the joints which were buried during the growth of the plant gave off tufts of roots instead of branchlets. The lower or underground joints of the Calamite had also the power of sending out new stems, which speedily attained to a greater diameter than that of their parent. In this way groups of stems were produced, and the plant was enabled constantly to maintain its position at the surface of the rising mud flats. Fig. 12 represents a fine specimen which well illustrates this peculiarity. The stem *a* stands at right angles to the bedding of a thinly

Fig. 12.—*Erect Calamites, from* Group XVI. (see p. 6).



Natural size. Half natural size.

Fig. 13.

Root of Calamite, from Group XXIII. (*magnified*).

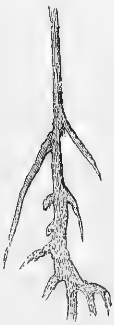


Fig. 14.

Erect Calamite, with roots; from Group XV.

One-sixth natural size.

Fig. 15.

Erect Calamite, constricted by pressure; South Joggins.

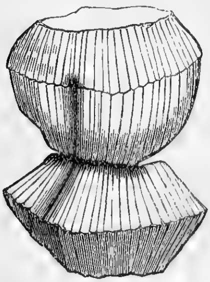


Fig. 16.

Leaves of Calamite; from Group XXIII. (p. 4).

laminated argillaceous sandstone. It is finely ribbed with distant joints, and its lower part is somewhat compressed, probably because imperfectly filled with sediment. The stem *a* gives off the stem *b*, the bark or coaly investment being thickened at the junction of the stems. The stem *b* rapidly increases in thickness, and at its fifth joint gives off the third stem *c*, which at first diverges from it nearly at right angles. Stem *a* is 1 inch in diameter. Stem *b* at the distance of 2 inches from the junction is $1\frac{2}{10}$ inch in diameter. Stem *c* at 2 inches from its origin is more than 2 inches in diameter. The ribs of *b* and *c* are wider and shorter than those of *a*, those of *c* being the widest. See fig. 12, *a'*, *c'*, by which it will be observed that the stems *a*, *a'*, and *c*, *c'*, though proceeding from the same root, are so different that they might be mistaken for distinct species.

All the erect Calamites exist as stony casts generally cylindrical, but when they have been imperfectly filled with sediment the spaces between the joints have given way to lateral pressure, as represented in fig. 15. I mention this here, because these compressed portions of the stem are liable to be mistaken for the base of the plant.

The leaves of the Calamite are but rarely attached to the stems. They are verticillate, linear, pointed, and delicately striated (fig. 16). They are either straight and horizontal, or slightly curved downward. In decay their extremities drooped into a vertical position, the basal portion still projecting horizontally.

Calamites formed dense and tall jungles or brakes, and sometimes flourished as an undergrowth in Sigillaria-woods. The greatest distance to which I have traced one of the Calamite brakes is in the case of that which occurs about 18 feet over the main coal. In a new shaft sunk about half a mile inland, this bed is found to abound in erect Calamites just as in the cliff, and the fresh unweathered specimens from this shaft displayed the attached leaves much better than those from the cliff.

4. *Poacites.*—These broad striated leaves are very abundant, not only in the Joggins section, but in all parts of the Coal formation of Nova Scotia, and even in the Lower Carboniferous rocks. They are occasionally seen to terminate in blunt points, but I have found no specimen with either petiole or stem. Straight or branching stems, with striation similar to that of these leaves, are, it is true, occasionally found in the same beds, but they may have belonged to Ferns. The largest specimen that I have seen is in the collection of Henry Poole, Esq., of the Albion Mines, Pictou. It is $18\frac{1}{2}$ inches in length, 5 inches wide at the larger end, and $1\frac{9}{10}$ inch at the smaller, where it is broken off. It has delicate longitudinal striæ, a sort of thickened midrib, and waves or sharp flexures of the striæ proceeding from the midrib to the edges, and probably marking undulations of the recent leaf, which must have given it a very graceful appearance. Smaller specimens, however, usually want the midrib and waving lines.

5. *Artisia.*—The casts of medullary cavities known by this name*

* [See also Professor Williamson's paper "On the Structure and Affinities of the Plants hitherto known as *Sternbergiæ*;" Manchester Lit. Phil. Soc. 1851, vol. ix.]

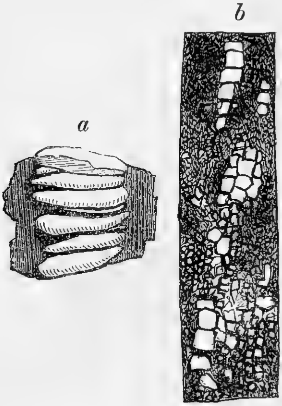
are occasionally found among drifted plants at the Joggins. As at Pictou and elsewhere, they appear to be of different species; some belonging to rush-like plants and having only a thin coaly investment, and others surrounded with a considerable thickness of carbonized or petrified wood. I shall here refer merely to a few examples of the latter kind, which is comparatively rare in the Nova Scotia coal-measures. Figs. 26 & 27, MS. represent cross sections of two specimens found in the irregularly-bedded sandstones of Group XIX. In both the internal sandstone cast is finely striated transversely, with less distinct longitudinal striæ, and both are enveloped by clear coal without structure. The coaly envelope of fig. 26, MS. is 1 inch in diameter, and is striated, or finely ribbed longitudinally. That of fig. 27, MS. is much flattened and somewhat smooth: its greatest diameter is 1 foot. Another specimen (17 *a*, *b*) has strong transverse wrinkles, nearly a line apart, but in places meeting and uniting: they occur at the edges of transverse internal coaly partitions. The coaly matter investing this specimen, which is about half an inch in thickness, shows the structure represented in fig. 17 *b*, MS. which resembles that of an erect tree (*Sigillaria*?) represented in fig. 21 *c*. This last species is very distinct in its external markings from the ordinary *Artisia approximata*; which, however, the specimens represented in figs. 26 & 27, MS. much resemble.

6. *Structure of Erect Trees.*—Beside the two erect trees (14 *a*, MS. and fig. 5, p. 26) whose structure, probably coniferous, is represented in figs. 6 & 7, p. 27, and fig. 18, I sliced specimens from nearly all the other coaly erect trees found in the section, and found structure in two of them (figs. 19 & 20). That in fig. 19 is probably coniferous, though the structure is too imperfectly preserved to allow any corroborative evidence to be obtained from longitudinal slices. Fig. 20 is from a coaly mass representing the base of a stump just at the surface of an underclay, and having the structure preserved only in one small portion, which may have been an internal core or ligneous axis. It consists of a very large and open structure of elongated cells, in irregular groups, separated by partitions of opake coal. Though the longitudinal structure is very well preserved, I could detect no traces of any markings on the walls of the cells.

Fig. 21, *a*, *b*, *c*, shows the structure of fragments of wood found in the tree containing reptilian remains. In the longitudinal section this wood shows, when highly magnified, cells or ducts with a sort of scalariform structure, fig. 21 *a*, like that of Ferns. The cross section shows an unequal cellular tissue, usually much compressed and imperfectly preserved, fig. 21 *c*. In large slices the tissue is seen to run in radiating lines, and there is an appearance resembling lines of growth, fig. 21 *b*.

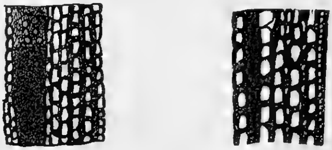
7. *Animal Remains.*—The remains of *Fish* found in the section consist of detached scales, teeth, jaws, spines, and coprolites. Most of them are small, and belong to the families of which *Palæoniscus* and *Holoptychius* are types. There are also a few rounded scales of Sauroid fish, approaching in form to those of *Megalichthys*. These fishes must have abounded in the creeks, lagoons, and channels of

Fig. 17.—*Structure of Artisia; South Joggins.*



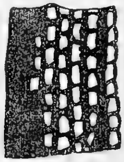
a. Cast of the pith-cavity: nat. size.
b. Transverse section of the wood: magnified.

Fig. 18.—*Structure of coniferous? wood, magnified; from the interior of an erect tree in* Group XV. (see p. 20).



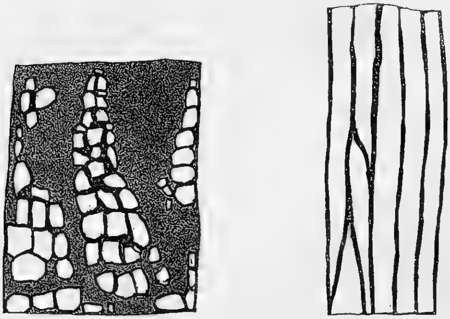
a. Longitudinal section. *b*. Transverse section.

Fig. 19.—*Structure of the wood of an erect coniferous? tree; South Joggins.*



Transverse section.

Fig. 20.—*Structure of the wood of a tree-stump, magnified; South Joggins.*



a. Transverse section. *b*. Longitudinal section.

Fig. 21.—*Structure of the wood of an erect tree* (*Sigillaria?*) *from* Group XV. (see p. 6).

Fig. 21 *a*.

Fig. 21 *b*.

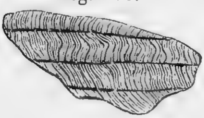
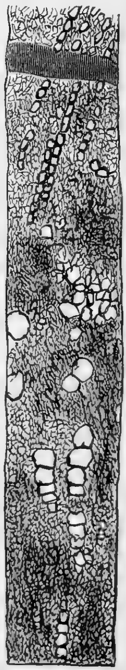


Fig. 21 *c*.



a. Longitudinal sections; magnified.——*b*. Transverse section, with supposed lines of growth; nat. size.——*c*. Transverse section; magnified.

the coal-swamps, as their remains occur in nearly all the bituminous limestones and Modiola-shales.

Two varieties of *Cypris* (figs. 29 & 30, MS.) occur. The more common variety is found in all the bituminous limestones and Modiola-shales.

The *Spirorbis* (figs. 31 *a* & *b*, MS.), so often found attached to vegetable fragments, and which so frequently serves to mark periods of submergence succeeding to those of vegetable growth, closely resembles the *Spirorbis carbonarius* of the British coal-fields.

Figs. 22 & 23 represent two species of the *Modiolæ*, which swarmed in incalculable numbers in the waters of the Joggins in the Coal æra. These creatures were so extremely numerous, that many beds of calcareo-bituminous shale and bituminous limestone are almost entirely made up of their shells; and it is often difficult to find a shell not crushed and distorted by the pressure of its neighbours.

Figs. 22 & 23.—*Modiolæ from the coal-measures of the South Joggins.*

Fig. 22.

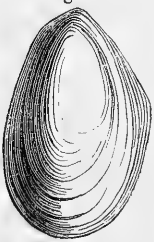


Fig. 23.

Figs. 24 & 25.—*Uniones from the lower Carboniferous rocks of the South Joggins.*

Fig. 24.

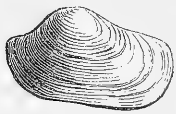


Fig. 25.

Figs. 24 & 25 represent a bivalve, perhaps a *Unio*, not found in that part of the section described in this paper. It was found by Mr. Logan in a bed of bituminous limestone 3000 feet below our lowest group, and associated with the lowest coal-seam but two in the entire section. It is therefore peculiar to the very bottom of the coal-measures, not being found, so far as I am aware, in any of the numerous calcareous bands occurring higher up. It is associated with Fish-scales and *Cypris*, and is separated by a great thickness of beds from the marine limestones of the Lower Carboniferous series.

Appendix.

Abstract of Mr. Logan's Section of the South Joggins Coal-measures.*

Mr. Logan's section extends from West Ragged Reef to Seaman's Bush, Mill Cove, a distance of about seven miles in a direct line. In this space he found a vertical thickness of 14,570 feet of conformable beds, which may be summed up as follows:—

* First Report Geol. Survey of Canada.

Nos. 1 and 2.—Grey, drab, and reddish yellow sandstones and conglomerates; and dark red, chocolate, and grey argillaceous and arenaceous shales. Large drift-plants, and in lower part erect Calamites .... 2267 feet.

(This corresponds with the "Newer, or Upper Coal-formation of Pictou," as described by Mr. Dawson.)

No. 3.—Grey and reddish sandstones, grey and reddish shales, with carbonaceous shales, underclays, and 22 seams of coal. Erect plants at two levels .... 2134 feet 1 inch.

No. 4.—Grey, drab, and reddish sandstones; grey, reddish, and chocolate shales, grey beds greatly preponderating; carbonaceous shales, bituminous limestones, underclays, and 45 seams of coal. Erect plants at eighteen levels; shells (*Modiola*) and fish-scales .... 2539 feet.

No. 5.—Reddish and grey sandstones and red and greenish shales, red beds greatly preponderating; some beds with calcareous concretions. Remains of carbonized plants ...... 2082 feet.

No. 6.—Grey, drab, and reddish sandstones, constituting nearly two-thirds of the whole; grey and reddish shales, carbonaceous shales, underclays, and bituminous limestones; 9 seams of coal. Upright plants at one level; great quantities of drift-plants, shells (*Modiola*), and fish-scales .... 3240 feet 9 inches.

(Nos. 3, 4, 5, and 6 contain the equivalents of the productive coal-measures of Pictou and Sydney, and in part of the sandstones which separate them from the Lower Carboniferous series.)

Nos. 7 and 8.—Reddish and grey sandstone, red conglomerate, red and chocolate shales, concretionary limestone, and two beds of gypsum. Remains of plants .... 2308 feet.

(Below these beds, and separated from them by a space equal to 300 feet of vertical thickness, is a thick bed of limestone, with shells of *Productus Lyelli*, and other fossils of the Lower Carboniferous series. This, with the overlying conglomerate, gypsum, red shale, and sandstone, is equivalent to the Lower Carboniferous or Gypsiferous series of Windsor, Shubenucadie, Pictou, Plaister Cove, &c., as established by Sir C. Lyell.)

The entire section contains 76 beds of coal, and 90 distinct Stigmaria-underclays. All the coals except one rest on Stigmaria-underclays; and there are 15 Stigmaria-underclays without coals. Erect plants were observed at 22 levels. There are 24 bituminous limestones, 17 of which are immediately connected with seams of coal.

The portion of section examined by Sir C. Lyell and Mr. Dawson in 1852, and by Mr. Dawson in 1853, includes *the lower part of No. 3 and the whole of No. 4.* In this portion of the section the number of coals and bituminous limestones seen by us corresponds with that of Mr. Logan's. We found, however, erect plants at a number of additional levels, though some of the beds in which erect plants were seen by Mr. Logan contained none at the time of our visit. The differences in detail between Mr. Logan's section and that in this paper, arise mainly from different estimates of the limits of beds, from the partial obscuration of portions of the section, and from the circumstance that many beds called by us sandstones, or argillaceous sandstones, appear in Mr. Logan's section as arenaceous shales. Mr. Logan has also measured in detail several thick masses of strata, which, in consequence of their poverty of organic remains, we merely estimated in the mass.

A list of the Papers having reference to the Coal-fields of New Brunswick and Nova Scotia, published in the "Proceedings" and "Quarterly Journal" of the Geological Society.

1842-43. 1. On the upright Fossil Trees found at different levels in the Coal-strata of Nova Scotia. Lyell, Geol. Proc. iv. p. 176–178.

[Previously described by R. Brown in Haliburton's 'Nova Scotia.']

2. On the Coal-formation of Nova Scotia, and on the Age of the Gypsum. Lyell, *ibid.* p. 184–186.

3. A Geological Map of Nova Scotia. By A. Gesner, *ibid.* p. 186–190. 4to. map.

1843-44. 4. On the Geology of Cape Breton. R. Brown, *ibid.* p. 269–272. 4 woodcuts.

5. On the Lower Carboniferous or Gypsiferous formation of Nova Scotia. Dawson, *ibid.* p. 272–281. 6 woodcuts.

6. On the Geology of Cape Breton. R. Brown, *ibid.* p.424–430. 3 woodcuts.

7. On the Newer Coal-formation of the East part of Nova Scotia. Dawson, *ibid.* p. 504-512. 4to map, 4 woodcuts.

1846. 8. Notice of some Fossils found in the Coal-formation of Nova Scotia. Dawson, Geol. Journ. ii. p. 132–136. 1 woodcut.

9. Notes on the Fossils communicated by Mr. Dawson. Bunbury, *ibid.* p. 136–139. 1 8vo plate.

[Mr. Horner's Address contains a summary of the foregoing, p. 170–181.]

10. On a group of erect Fossil Trees in the Sydney Coal-formation, Cape Breton. R. Brown, *ibid.* p. 393–396. 3 woodcuts.

1847. 11. On the Gypsiferous Strata of Cape Dauphin, Cape Breton. R. Brown, Geol. Journ. iii. p. 257-260. 2 woodcuts.

12. Description of an upright Lepidodendron, with Stigmaria-roots, Sydney, Cape Breton. R. Brown, Geol. Journ. iv. p. 46–50. 7 woodcuts.

13. On the New Red Sandstone of Nova Scotia. Dawson, *ibid.* p. 50–59. 4to map and section.

1848. 14. On the Colouring Matter of the Red Sandstones, and the White Beds associated with them. Dawson, Geol. Journ. v. p. 25–30.

15. On the Gypsum of Nova Scotia. Gesner, *ibid.* p. 129–130. 1 woodcut.

16. Notice of the Gypsum of Plaster Cove. Dawson, *ibid.* p. 335–339. 3 woodcuts.

17. Description of erect Sigillariæ, Sydney, Cape Breton. R. Brown, *ibid.* p. 354–360. 9 woodcuts.

1849. 18. On the Lower Coal-measures of the Sydney Coal-field, Cape Breton. R. Brown, Geol. Journ. vi. p. 115–133. 9 woodcuts.
19. On the Metamorphic and Metalliferous Rocks of the East of Nova Scotia. Dawson, *ibid.* p. 347–364. 4 woodcuts.
20. Notice of the occurrence of upright Calamites, near Pictou, Nova Scotia. Geol. Journ. vii. p. 194–196. 3 woodcuts.
21. On a Fossil Fern from Cape Breton. Bunbury, Geol. Journ. viii. p. 31–35. 1 plate.
1852. 22. Notes on the Red Sandstone of Nova Scotia. Dawson, *ibid.* p. 398–400. 2 woodcuts.
23. On the Remains of a Reptile and a Land-shell in an erect Fossil Tree in the Coal-measures of Nova Scotia. Lyell, Dawson, Wyman, and Owen, Geol. Journ. ix. p. 58–67. 3 plates, 1 woodcut.
24. On the Albert Mine, New Brunswick. Dawson, *ibid.* p. 107–115. 7 woodcuts.

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2. *On the* Structure *of the* Albion Coal-Measures, Nova Scotia; by J. W. Dawson, Esq. *With* Journals *of the* Exploratory Works *at the* Albion Mines, Pictou, Nova Scotia; by Henry Poole, Esq.

[Communicated by Sir C. Lyell, V.P.G.S.]

The Coal-measures of the Albion Mines present some features very different from those observed in other parts of the coal-formation in Nova Scotia. This must be very evident to any one who compares the published sections and descriptions of the coal-measures of the South Joggins and Sydney*, and those of the Pictou coal-field by Mr. Logan, Sir C. Lyell, and Mr. Dawson†. Unfortunately the natural sections at Pictou are so imperfect, that the order of succession of the beds is much less fully known than at the other places referred to. Recent exploratory works, conducted by Mr. Poole, Superintendent of the Albion Mines, have, however, brought out some important facts which are exhibited in the Plan‡ and sectional lists appended to this paper, to which these remarks relate, and with the aid of which I propose to state the more important points in which the Albion measures differ from the rocks of similar age in their vicinity, and, if possible, to indicate the causes of these differences.

1. The coal of the Albion Mines is somewhat peculiar in its structure and chemical composition. It is more highly laminated, abounds more in mineral charcoal, is more bituminous and much more free from sulphuret of iron, than the coals of other parts of

* Logan, First Report of the Geological Survey of Canada; Brown, Quart. Journ. Geol. Soc. vol. vi. p. 115.

† Quart. Journ. Geol. Soc. vol. vi. p. 347, note, and vol. ix. p. 58, note; and *supra*, p. 41.

[‡ A Plan of the Trial Pits on a scale of 5 chains to an inch has been presented to the Society by Mr. Poole.]

Nova Scotia. It has also white and very light ashes, and has a remarkable power of continuing in a state of combustion when covered with ashes, and of remaining alight until all the coaly matter is burned out, almost in the manner of peat. Its heating power is so much greater in proportion to its amount of fixed carbon than that of some other bituminous coals, that Prof. W. R. Johnston in his Report to the American Government on the Coals of America, suggests that it may have been produced from a different description of vegetable matter. A different mode of accumulation is, however, a more probable explanation. The following abstract of assays made by me for the General Mining Association, shows its composition and also the changes which occur in proceeding from the eastern to the western part of the mine, and in different parts of the thickness of the bed, or of that part of it (say 12 feet) at present worked.

		S.E. side: old workings. (About one mile eastward of Dalhousie Pits.)	N.W. side: old workings.	Dalhousie Pits.
Fall Coal.	Moisture	1·750	1·550	·800
	Volatile combustible matter	25·875	27·988	26·325
	Fixed carbon	61·950	60·837	66·925
	Ashes	10·425	9·625	5·950
		100·000	100·000	100·000
Top Bench.	Moisture	1·500	1·500	·900
	Volatile combustible matter	24·800	28·613	27·250
	Fixed carbon	51·428	61·087	61·350
	Ashes	22·272	8·800	10·500
		100·000	10·000	100·000
Bottom Bench.	Moisture	2·250	1·800	
	Volatile combustible matter	22·375	27·075	
	Fixed carbon	52·475	59·950	
	Ashes	22·900	11·175	
		100·000	100·000	

The excess of earthy matter in the coal of the eastern part of the mine is, probably, connected with the vicinity of this part of the workings to a spur or promontory of older (Upper Silurian) rocks, from which detritus may have been washed down at the time of the formation of the coal.

2. The thickness of the beds of coal in the Albion measures is very great, as compared with those of the Joggins and Sydney. At the Joggins, Mr. Logan's section shows an aggregate thickness of 44 feet, distributed among 76 seams. At Sydney there are, according to Mr. Brown's section, 31 seams, with an aggregate thickness of 37 feet. At Pictou, on the other hand, there is a thickness of 60 feet of coal in two great seams, beside several smaller seams.

3. There is also a very great thickness of black argillaceous beds associated with the coal, and an absence of the grey sandstones and reddish shales which are so abundantly intercalated in the coal-measures of Sydney and the Joggins. The following abstract of the

section at "Success Engine Pit," given in Mr. Poole's tables, well illustrates this and the preceding head.

	ft.	in.
Black carbonaceous shale, with bands of clay ironstone...	64	10
Main coal seam, including 23 inches of ironstone, in five bands	39	11
Black carbonaceous shale, with bands of ironstone	157	7
Deep coal seam, including one band of ironstone $14\frac{1}{2}$ inches in thickness	24	9
	287	1

In addition to this great thickness of argillaceous and carbonaceous beds, several hundreds of feet of black shales are seen to overlie them, in the sections afforded by the East River and road-cuttings. Erect trees are not known to occur in these beds; but flattened trunks of *Sigillaria, Favularia,* and *Stigmaria,* and *Flabellaria* and Fern leaves occur in the shales. There are also evidences of submergence during a part of the time occupied in the accumulation of these beds. Teeth and bones of fishes are found in the roof of the deep seam; remains of large holoptychioid fishes occur in one of the bands of ironstone in the main coal; and a considerable thickness of the black shale overlying the main seam is filled with the minute crustacean valves of a species of *Cypris* or *Cythere.*

4. There is an apparent unconformability of the coal and its associated beds with the members of the coal-formation immediately succeeding it in ascending order. The main coal dips to N. 45° E. at the Dalhousie Pits, and its outcrop is, as represented on the Plan, curved, the convex side being towards the dip. The first beds of sandstone that occur in ascending order appear to have a strike nearly E. and W., and dip to the north, at least in a part of their course. Thus at the quarry nearly north of the Dalhousie Pits, the sandstone dips nearly N.E., and is separated from the coal by a great thickness of shale; but westward of this point its outcrop approaches that of the coal, and at length, at the distance of about 1180 yards west of Dalhousie Pit, it approaches within a few yards of the outcrop of the main seam, and overlies its roof-shales with a higher and more northerly dip. See trial-holes, Nos. 15, 22, and 29; in the last of these the sandstone is stated to dip N. 30°, while the shale immediately below dips N. 20°, E. 22°. (See also Plan.)

At the "Colin Pits" this sandstone is worm-tracked, and presents other marks of littoral origin.

To account for the apparent want of uniformity in the dip of the sandstone and underlying coal-measures, and in the direction of their lines of outcrop, it seems necessary to suppose some degree of false stratification in the sandstone, and that a portion of the shale was removed by denudation before its deposition; or that during the deposition of the shale, a portion of the coal-field had subsided so as to allow a great thickness of shale to be accumulated over a portion of the coal, while another part was but thinly covered; or that the beds, which in the eastern part of the coal-field are wholly argillaceous, became very rapidly arenaceous in their continuation westward. In the present state of our knowledge, the former of these suppositions, that of denudation, appears best to comport with the relations of the shale and sandstone as observed in the trial-holes; though a larger number of facts bearing on the subject would certainly be desirable. In any case there is evidence of great local inequality in the conditions of deposit, and a high degree of probability that the previous tranquil condition of the area of coal-accumulation was broken up on the occurrence of strongly-marked physical changes.

5. The Albion coal-measures are succeeded in the direction of their dip by a thick and very coarse reddish conglomerate, no equivalent of which occurs in any other part of the coal-formation of Nova Scotia, at least in the vicinity of productive coal-measures. The outcrop of this conglomerate forms a prominent ridge, extending several miles in an east and west direction, and cut across by the valleys of the East, Middle, and West Rivers of Pictou: where it crosses the East River (about two miles north of the Albion mines), it dips at a high angle to the north, but much of this dip seems to be due to false stratification. Its outcrop runs obliquely to that of the Albion measures, but is broken off from them by a line of dislocation accompanied by vertical and disturbed beds, some of which are shown on Mr. Poole's Plan, at the place named Duff's Farm.

It is to be observed, that the sandstone already referred to coincides in part in its strike with this conglomerate, and for this and other reasons, the conglomerate has generally been believed to succeed the coal-measures in ascending order, and to form the base of the series described by the writer as the "Newer Coal Formation*."

The dislocation above referred to, and the circumstance that at the Middle River the conglomerate at its southern side dips to the south, forming a sort of small anticlinal, might afford reason to suspect that it belongs to the lower carboniferous series, were it not that it is succeeded in ascending order by a series of coal-formation rocks evidently not belonging to the older part of the system, nor equivalent to the Albion measures, and that it contains rounded fragments not only of the older metamorphic rocks, but of the lower carboniferous grits underlying the coal-measures. This conglomerate therefore either marks a change from the accumulation of vegetable matter and fine mud to that of the coarsest mechanical detritus, or it is the remains of a contemporaneous shingle-beach, separating the area of the Albion coal-measures from a larger outer space, in which deposits similar to those of the Joggins and Sydney coal-fields were accumulating.

I am inclined to prefer the last of these views for the following reasons:—1. The outcrop of the conglomerate extends from a point opposite the promontory of metamorphic rock east of the East River, to the high lands of Mount Dalhousie, in the eastern extremity of the Cobequid range of hills, crossing the mouth of an indentation in the metamorphic district, which in the older part of the carboniferous period must have been a bay or arm of the sea, exposed to an open expanse of water lying to the northward. 2. The conglomerate can-

* Quart. Journ. Geol. Soc. 1845, vol. i. p. 322.

not be traced to the margin of the metamorphic country, except at its extremities, so that in all probability it never extended over the low carboniferous district included within its line of outcrop. This is the more remarkable, inasmuch as the conglomerate has evidently resisted denudation better than any of the associated beds. 3. The conglomerate is full of false stratification and wedge-shaped beds of reddish sandstone, in the manner of ordinary gravel-ridges, and it even presents the appearance of passing into sandstone toward the dip, as if the coarse conglomerate were limited to the vicinity of the outcrop. 4. In the sandstone overlying the Albion measures, as well as in portions of the coal-formation manifestly overlying the great conglomerate, there are small seams of coal corresponding in their characters with those of the Joggins and Sydney, where no similar conglomerate occurs. 5. The supposition that the Albion coal was formed in a depressed space, separated by a shingle-bar from the more exposed flats without, accounts for the great thickness of the deposits of coal and carbonaceous shale, the absence of sandstones, and the peculiar texture and qualities of the coal, as well as the association with it of remains of fish and *Cypris*; since modern analogies show that such an enclosed space might be alternately a swamp and lagoon without any marked change in the nature of the mechanical deposits. 6. Movements of depression causing the rupture of the barrier, or enabling the sea to overflow it, and perhaps also admitting currents of oceanic water through the valleys of the metamorphic district to the southward, would sufficiently account for the overlying sandstones, as well as for the denudation of the coal-measures supposed to have preceded the accumulation of these sandstones. 7. The dislocation extending along the outcrop of the conglomerate is easily explained by the supposition that, in later elevatory movements, this hard and stony bed determined the direction of fracture of the deposits.

Large portions of the conglomerate have been removed in the formation of the valleys of the East, Middle, and West Rivers, and gravel-mounds derived from it are abundant along the course of these valleys, to the *northward* of the outcrop of the conglomerate, or in the direction of the present drainage.

The theoretical views in the above paper have not been hastily adopted, and they are now stated as affording at least a natural and probable solution of the peculiarities of the Albion measures.

For additional facts, localities, &c., I may refer to my paper on the Newer Coal Formation and the map attached to it*. The latter, however, owing to errors in the colouring, does not correctly show the limits of the metamorphic rocks. For this reason I send with this paper a corrected copy of a part of it, and a sketch and section illustrating the probable condition of the district in the coal-formation period and the present arrangement of the beds†.

* Quart. Journ. Geol. Soc. vol. i. p. 322. See also Paper on the Metamorphic Rocks of Eastern Nova Scotia, *ibid.* vol. vi. p. 347.

[† Mr. Dawson has presented a MS. map and section of the geological features of this district, and a sketch-map of the surface-conditions during the Carboniferous period, restored in accordance with the above description.]

Note.—A specimen of the main coal, showing its entire thickness, has lately been extracted by Mr. Poole for the New York Exhibition, and enables me to add the following detailed section of this great bed:—

	ft.	in.
1. Roof-shale: vegetable fragments and attached *Spirorbis* (in specimen)	0	3
2. *Coal*, with shaly bands	0	6½
3. *Coal*, laminated; layers of mineral charcoal and bright coal; band of ironstone balls in bottom	2	0
4. *Coal*, fine, cubical, and laminated; much mineral charcoal	3	2
5. Carbonaceous shale and ironstone, with layer of coarse coal ("holeing-stone"). Remains of large fishes and coprolites. This bed varies much in thickness	0	4½
6. *Coal*, laminated and cubical, coarser towards bottom	9	3
7. Ironstone and carbonaceous shale, with coaly layers and trunks of *Lepidodendron, Ulodendron, Sigillaria, Stigmaria*, &c., all prostrate	0	8
8. *Coal*, laminated as in No. 6, a line of ironstone balls in bottom	1	2
9. *Coal*, laminated and cubical, a few small ironstone balls. Many minute spines in this and underlying coal	6	7
10. Ironstone and pyrites	0	3
11. *Coal*, laminated and cubical, as above	10	3
12. *Coal*, coarse layers of bituminous shale and pyrites	1	0
13. *Coal*, laminated, with a fossil trunk in pyrites	2	1
14. *Coal*, laminated and cubical, with layers of shale, passing downward into black slicken-sided underclay with coaly bands	2	3
15. Underclay (to bottom of specimen)	0	10
Thickness perpendicular to horizon	40	8
Vertical thickness	38	6

JOURNALS *of* EXPLORATORY WORKS *at the* ALBION MINES, PICTOU, NOVA SCOTIA. By HENRY POOLE, Esq.

Journal of Metals passed through in sinking "Trial Pits" on the Crop of the "Main Seam" of Coal at the Albion Mines to explain the Numbers marked on the General Plan.*

[**This Plan of the Trial Pits, on a scale of* 5 *chains to* 1 *inch, presented by Mr. Poole, is in the Society's Library.*]

No. 2.

	feet	in.
Surface clay	4	0
Coal with clay, mixed	5	2
Good coal	6	4
Ironstone	0	6
Good coal	9	0
Bat and coal	4	6
Yields gas. Total...	29	6

No. 3.

	feet	in.
Surface clay	6	0
Good coal, with large fissures yielding water	7	0
Total...	13	0

No. 4.

Surface clay	7	5
Top of coal regular.		

No. 5.

	feet	in.
Surface clay	9	6
Black bat	3	6
Good coal	3	9
Total...	16	9

No. 6.

Surface clay	2	9
Coal	7	3
Total...	10	0

No. 7.

Surface clay to coal	10	6

No. 8.

Surface clay and shale	13	0

No. 9.

Surface clay	9	3
Coal	3	0
Total...	12	3

No. 10.

Surface clay	16	0
Black shale	3	6
Coal	0	6
Black shale	1	0
Coal, dip 27°	3	0
Ironstone	1	6
Coal	3	3
Total...	28	9

No. 11.

Surface clay	2	11
Soft blue shale	3	11
Hard blue shale	5	0
Black shale	11	5
Coal, dip 25½°	0	5
Strong black shale	2	7
Total...	26	3

No. 12.

Surface clay	10	0

No. 13.

Surface clay	4	0
Black shale	1	6
Coal	5	4
Total...	10	10

No. 14.

	feet	in.
Surface clay	4	0
Shale	6	7
Foul coal	5	2
Coal, dip 21° (sp. gr. 1·337)	0	9
Ironstone	1	5
Coal	4	10
Splintstone	0	9
Coal	3	6
Grey ironstone	2	0
Total...	29	0

No. 15.

Surface clay	13	6
Black sand	0	$0\frac{1}{8}$
Hard blue sandstone	9	$8\frac{7}{8}$
Shale to a fault	10	2
Shale below a fault	17	5
Black bat	4	4
Coal, dip 33°, N. 45 E.	6	9
Ironstone	1	4
Coal	5	6
Ironstone	0	6
Coal	3	7
Bat, with water	3	8
Total...	76	6

No. 16.

Surface clay	3	10
Shale	10	4
Bad coal	4	5
Good coal, dip 23°, N. 50 W. "strike"	1	5
Slaty ironstone	2	0
Total...	22	0

No. 17.

Surface clay: no coal	11	0

No. 18.

Surface clay	12	0
Yellow ochreous shale, dip 26°, N. 43 E.	7	3
Coal	5	1
Ironstone	1	3
Coal	11	5
Stone	1	2
Coal, dip 22°	13	2
Total...	51	4

No. 19.

	feet	in.
Surface clay	16	8
Sandstone, half across pit	1	8
Shale, dip 23°, N. 29 E.	8	0
Coal	1	9
Ironstone	1	6
Coal, inferior	10	0
Shale	3	0
Coal	0	2
Total...	42	11

No. 20.

Surface clay, "black"	10	0
Shale	3	0
Coal, dip 24°	1	4
Coal and bat, mixed	2	0
Total...	16	4

No. 21.

Surface clay	9	0
Soft shale	2	3
Hard shale (much water)	12	9
Total...	24	0

No. 22.

Surface clay	10	10
Sandstone, dip 31° due N.	5	6
Grey shale	3	2
Black shale	2	0
Grey shale	4	0
Hard grey shale	7	4
Black shale	2	4
Fireclay	2	0
Ironstone	0	9
Total...	37	11

No. 23.

Surface clay to coal, dip N. 10 E.	8	0

No. 24.

Surface clay to coal, 25°, N. 25 E.	7	6

No. 25.

Surface clay to coal, 19°, N. 65 E.	8	0

No. 26.

Surface clay	8	3
Coal at top dips 53°.		
Coal, dip 27°, N. 30 E.	10	3
Total...	18	6

No. 27.

	feet	in.
Surface clay	9	3
Coal, dips 24° and 32°, N. 22 E.	5	0
Total...	14	3

No. 28.

Surface clay	10	0
Coal, dips 27° and 31°, N. 22 E.	1	6
Coal, inferior	1	6
Total...	13	0

No. 29.

Surface clay	10	9
Sandstone, dip 30° due N.	5	2
Shale, dip 22°, N. 20 E.	13	1
Black shale	10	0
Coal	0	7
Fireclay	0	8
Coal and bat	6	0
Good coal	2	6
Ironstone	0	9
Coal	4	10
Stone	1	0
Coal	3	6
Fireclay and Ironstone balls, dip 29°, N. 30 E.	4	2
Total...	63	0

No. A.

Surface clay	3	6
Yellow shale (ochreous)	1	3
Blue shale, dip 22°	3	9
Total...	8	6

Colin Pits.

Engine Pit.

Surface clay	10	0
Sandstone, dip 28°, N. 45 E.	24	6
Blue shale, dip 25°	6	0
Total...	40	6

F. Pit.

Surface clay	11	0
Sandstone on deep side, dip 23°, N. 42 E. Shale on rise side.		

A drift was driven upon the "Holing stone" at 20 feet depth from No. 16 to No. 15, distance 150 feet.

The roof contains Sigillariæ and Lepidodendra.

A drift was driven at 34 feet down in No. 18, due north for 107 feet: no change in metals.

Journal of Metals passed through in sinking "Trial Pits" on the Crop of the "Deep Seam" of Coal at the Albion Mines; to explain the letters marked on the General Plan.

No. B.	feet	in.
Surface clay	8	6
Shaly coal	3	6
Ironstone balls	0	4
Total...	12	4

No. C.		
Surface clay	7	6
Coal, good	5	2
Black shale	7	4
Total...	20	0

No. D.		
Surface clay	11	0
Good coal	4	9
Ironstone	1	0
Coal	10	3
Ironstone	1	3
Coal and ironstone balls	13	6
Shale and coal	2	9
Total...	44	6

No. E.		
Surface clay, with boulders of stone and whin	26	6
Ditto, bored (no coal)	8	0
Total...	34	6

No. F.		
Surface clay and shale	24	8
Sand and gravel	1	3
(Stopped by water.)		
Total...	25	11

No. G.		
Surface clay and shale	17	5
Sandy black shale	1	1
Coal, dip 20°, N. 52 E.	0	8
(Yields water.)		
Total...	19	2

No. H.		
Surface clay	11	3
Sandstone	1	7
Fireclay	1	7
Sandstone	0	7
Shale	9	0
Coal	5	5
Ironstone, dip 24°	1	1
Coal	3	7
Stone	0	2
Coal (not through)	1	9
Total...	36	0

No. I.	feet	in.
Surface clay	8	1
Coal	3	3
Ironstone	1	2
Coal, dip 22°, N. 50 E.	9	6
Total...	22	0

No. K.		
Surface clay	4	4
Shale	14	9
Total...	19	1

No. L.		
Surface clay	6	6
Grey shale	25	0
Total...	31	6

No. M. 1.		
Surface clay	5	9
Black bat	2	6
Ditto and coal	6	9
Good coal, dip 24°, N. 42 E.	3	6
Ironstone	0	3
Coal	1	6
Stone	1	7
Coal	2	8
Total...	24	6

No. M. 2.

(47 links on dip N.E. from M. 1.)

Calculated for dip	5	6
Surface clay	12	4
Black bat	4	8
Ironstone	1	1
Black bat	4	2
Good coal	2	3
Bat and coal	3	0
Stone	0	4
Good coal	3	11
Total...	37	3

No. N.

Coal at the surface.

No. O.		
Surface clay	9	0
Coal, dip 31°, N. 32 E.		

No. X. Seen in the bank.

	feet	in.
Coal and bat, mixed	1	0
Good gas coal	2	7
Bat	1	0
Good coal	3	9
Pyrites-stone	0	2
Hard coal	5	7
Coal, worked by Adam Carr, Lessee, before the G. M. A.	3	0
Coal, not worked	0	7
Total...	17	8

"Success" Engine Pit, commenced July 18th, 1851, finished October 26th.

	feet	in.
Surface clay	8	2
Shale and bands of ironstone alternate	64	10
Main coal seam—		
Coarse coal	0	2
Good coal	5	0
Ironstone	0	6
Good coal	14	4
Ironstone	0	4
Coarse coal	7	7
Ironstone	0	4
Coarse coal	3	1
Ironstone	0	4
Coarse coal	2	11
Ironstone	0	5
Coarse coal	4	11
Shale and bands of ironstone alternate	157	7
Deep seam—		
Bad coal	0	2
Good coal	3	10
Ironstone	1	$2\frac{1}{2}$
Coal	3	$7\frac{3}{4}$
Slaty coal	0	$9\frac{1}{4}$
Good coal	4	2
Carried forward...	284	$8\frac{1}{2}$
Brought forward...	284	$8\frac{1}{2}$
Coarse coal	1	$0\frac{1}{2}$
Good coal, "worked by Carr"	3	8
Inferior coal	6	3
Total...	295	8

Third coal seam, underlying deep seam at $154\frac{1}{2}$ feet.

No. P.

Surface clay	10	0
Black bat	9	0
Coal, dip 21°	6	0
Total...	25	0

No. Q.

Surface clay and bat	8	8
Coal, dip 20°, N. 10 E.	12	3
Bat	0	6
Coal	1	8
Ironstone	0	2
Shaly clay	1	0
Total...	24	3

Fourth coal seam, underlying third seam at 112 feet. "Close to a fault."

Surface clay	8	8
Shale	10	9
Coal	1	0
Shale and coal, mixed	5	3
Total...	25	8

November 16, 1853.

E. B. Binney, Esq., was elected a Fellow.

The following communications were read:—

1. *On the* Superficial Deposits *of the* Isle of Wight. By Joshua Trimmer, Esq., F.G.S.

The following observations on the superficial deposits of the Isle of Wight were made in 1847, while studying the Eocene Tertiaries of that district, preparatory to the mapping of the same strata in Hampshire and Dorsetshire for the Government Geological Survey.

An examination of the coast-sections of the greater part of the island, namely from Ryde to Culver Cliff, from Shanklin to Freshwater Bay, and from the Needles to Yarmouth, showed that there are no traces there of the Lower Erratic Tertiaries or Boulder Clay. There is, however, abundance of flint-gravel, having much of the aspect of the Upper Erratics; and a deposit answering to the warp-drift, which has been described in former communications as spread in other districts over the denuded surface of that and of older formations, and mainly influencing the variations of soil.

Part of the undercliff at Ventnor consists of a mass of partially water-worn chalk and chalk-marl, enveloping and covered by flint-gravel, closely resembling some of that which occurs similarly associated in the Cromer Cliffs. It has evidently slipped from a considerable height in the cliffs which overhang the town.

Flint-gravel only slightly water-worn occurs, in its greatest development, on the summits of the lower range of hills throughout the island. A mass of it, at least 60 feet thick, caps Headon Hill; and a considerable thickness of it may be seen on the high ground in the neighbourhood of Osborne. The same kind of gravel, more water-worn, and evidently formed during the denudation of the original deposit, is found in lower situations associated with a loamy warp-drift, which frequently attains a depth of 5 and 6 feet; both deposits following the contours of the denuded surface on which they rest. Similar phænomena occur on the opposite coasts of Hampshire and Dorsetshire.

In the absence of organic remains from the gravel, and until the Upper Erratics of Norfolk, Suffolk, and Essex, whose age is defined by the presence of the Norwich Crag, shall have been traced further southward, so that their identity with the flint-gravel can be proved or disproved, its age may admit of a question*. This however is certain, that at whatever period the gravel may have been formed, and at whatever period denuded, the loamy deposit, called the warp-drift, is of very recent origin, and was not formed till after the denuded surface on which it rests had existed some time under subaërial conditions.

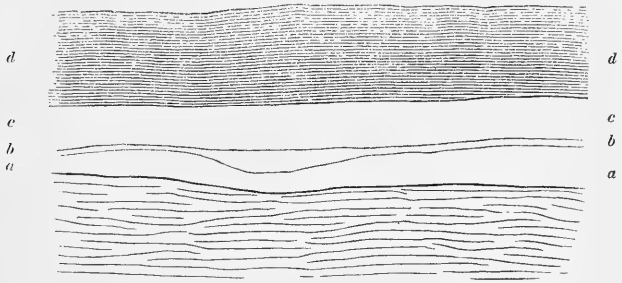
The evidence on which this conclusion is founded is similar to that presented by the pit at Gaytonthorpe in Norfolk, and is exhibited at the base of Headon Hill in Tolland's Bay. On the summit of the cliff, which is about 60 feet high, marl and calcareous tufa, abounding with land shells of existing species, are developed beneath the warp-drift. These calcareous deposits extend for about 300 yards from the base of Headon Hill. Near the N.E. termination there is the section which is given on the opposite page.

The warp-drift which covers these calcareous deposits consists of a brown sandy loam, more tenacious towards the lower part, with no traces of lamination, and containing fragments of flint and of the

* It must be borne in mind that this paper has been locked up since the beginning of 1848 in the archives of the Government Geological Survey. In recent communications to the Society, I have been able to speak more confidently of the age of this gravel: see Table, Quart. Journ. Geol. Soc. vol. ix. p. 295.

freshwater limestone, which must have required considerable force of water for their transportation.

Section of the Superficial Calcareous Deposits, Tolland's Bay.



Eocene Sands.

a, Calcareous tufa—land-shells: 10 inches to 2 feet.
b, Sand blackened by organic matter—calcareous concretions and land-shells: 4 to 12 inches.
c, Cream-coloured marl, with calcareous concretions, and a few thin black seams coloured by vegetable matter—land-shells: 2 feet 6 inches.
d, Warp-drift of brown loam: 5 feet.

Further to the N.E. the warp-drift appears under its usual character, often gravelly towards the base, and with no calcareous beds below it, but filling indentations and furrows in the bed on which it rests, whether that be flint-gravel or one of the eocene strata. On the S.W. it only appears at intervals, being partially concealed by the debris of the upper part of the cliff or by vegetation. At the base of Headon Hill it is well exposed, and accessible for examination for about thirty yards along the face of the cliff, while a gully has laid open a transverse section for about fifty yards in the interior. The warp-drift is there thinner, furrowing the surface, and varying in depth from 1 to 3 feet. The calcareous deposits are at least 12 feet thick, and consist of several alternations of cream-coloured marl, calcareous tufa, and bands of sand and clay blackened by organic matter. The thickness of these bands of sand and clay varies from 2 to 6 inches; that of the calcareous tufa from 6 inches to 2 feet. Land shells are distributed throughout the whole deposit. Some of the concretions in the calcareous tufa are cylindrical, some subglobular. The former have a cylindrical cavity in their centre, which is occasionally filled with decayed vegetable matter. These have evidently been formed around twigs and stems of plants. The subglobular concretions, after exposure to the weather, by which the outer calcareous coats have been removed, have so much of the form of the Helices and Cyclostomæ with which the deposit abounds, as to render it probable that they have had shells for their nucleus.

The species are—*Helix arbustorum* or *nemorum*; *Helix hispida*; *Cyclostoma elegans*.

A very careful search for freshwater shells only gave one large fragment of a *Succinea*, and three small entire specimens too fragile to be preserved *.

The following extract from the Proceedings of the Society, vol. ii. p. 449, describes a somewhat similar deposit, discovered by Mr. Bowerbank in another part of the island, at a much greater height:—

"During a recent examination of the greensand at Gore Cliff, Mr. Bowerbank discovered on the top of the cliff, and overlying the chalk-marl by which the cliff is capped, a bed consisting of detritus of chalk and chalk-marl, and enclosing in every part examined by him numerous specimens of existing species of land-shells. The deposit extends from near the edge of the cliff to the foot of St. Catherine's Down, a distance of about 660 yards. The range of the deposit he could not ascertain, as at a short distance from the spot examined by him the cliff assumes its usual vertical form."

The only particulars to be added to the above description are the following:—The accumulation varies in depth from 7 to 12 feet, as seen in the face of the cliff. It exhibits no traces of alternating deposit. A line of dark clay, in some places black, divides it from the chalk-marl. It is not covered by a warp-drift of brown loam, though such a deposit occurs at about the same height in the vicinity. It appears to be a portion of a deposit which had a greater extension seaward and has been removed by denuding action, as it forms a ridge which ranges along the edge of the cliff and slopes towards the land, so that there is a slight hollow between the edge of the cliff and the hill of St. Catherine's Down. The variations of soil in this district depend mainly upon the warp-drift, which at Tolland's Bay covers the calcareous deposit, and is spread over the surface of the Isle of Wight generally. There, as in Norfolk and Wales, the subjacent strata, whether of the chalk or the strata above or below it, only exert their full influence on the soil upon high and sharp summits and steep escarpments, where the warp-drift is either less than 6 inches thick or wholly wanting.

This dependence of the composition of the soil on the warp-drift rather than on the subjacent strata, is strikingly exemplified in the coast-sections extending from Black Gang Chine to Freshwater Bay. We have there sands and clays of various colours and composition cropping out and covered by a loamy warp-drift, which varies but little in colour and texture, and which is associated with flint-gravel, the two deposits following the irregularities of the denuded surface. The same appearances are exhibited on the outcrops of the several eocene strata, on the opposite coast, from Hordwell to Christchurch.

* At a subsequent visit, in company with Mr. Rose of Swaffham, flint-gravel was found exposed in part of this section, forming the base of the tufaceous deposits. In this gravel shells of the genus *Unio* have been discovered by the President, from whom we may expect a more detailed description of this and other similar deposits in the Isle of Wight.—[Jan. 10, 1854.]

2. *On the* Geology *of some parts of* Central India.

By Lieutenant R. H. Sankey, H.E.I.C.S.

[Communicated by Prof. Ansted, F.G.S.]

[Abstract.]

In this paper the author gave a very general sketch of the distribution of the different classes of rocks and soils of Central and Southern India. The "red-soil" and calc-tuff (Kunkur) of the granitic districts, the "black-soil" of the basaltic districts, the "laterite" of the Konkun coast and other districts, called also locally "iron-clay" and "lithomarge," and perhaps the diamond-breccia of Southern India, are superficial deposits.

The age of the immense basalt or trap formation of Central India is unknown. An extensive freshwater deposit (or series of deposits) occurs in this trap-formation; and Lieut. Sankey observes that it is invariably found between two layers of trap. The author considers it probable that these freshwater beds are the remains of a lacustrine or fluviatile formation extending from Bombay to Rajamundry, or entirely across the peninsula from sea to sea, in one direction; and from Medcondah (in the centre of Hydrabad) to Saugor (towards the north of Bundelcund in the other direction); an extent of nearly 700 miles in length and 500 in breadth.

These freshwater beds in the trap have been especially observed at Nagpoor*, Jubbulpoor†, and in the Sichel Hills‡.

In the same district sandstone and limestone occur to a great extent—the former known as the diamond-stone§; the latter characterized by fish-remains of Jurassic age‖. But the relations of these rocks with the basalt are not evident.

Lieut. Sankey makes especial reference to the late researches of the Rev. Messrs. Hislop and Hunter in the vicinity of Nagpoor¶, and concludes by detailing the observations made by himself and Dr. Jerdon in the Kamptee, Oomrait, and Pachmurra districts, on the coal, coal-shale, and sandstone there met with. The coal occurs about five miles north of the village of Oomrait (which is in Lat. 22° 8′. Long. 78° 46′, and fifteen miles to the west of Chindwarra), on the bank of a stream at the village of Chota Burkoi, where it outcrops as a layer about 1 foot thick. The shale and sandstone with which the coal is associated have afforded numerous remains of plants, as *Pecopteris, Glossopteris, Sphenopteris, Phyllothecæ*, and *Vertebrariæ*, such as occur in the Burdwan coal of N.E. India.

On the north and west of Kamptee this fossiliferous sandstone

* "Geology of the Nagpur State;" by the Rev. S. Hislop; Journ. Bombay Asiat. Soc. July 1853, pp. 58–76.

† Dr. Spilsbury, Asiat. Soc. Journ. 1833.

‡ Dr. Malcolmson, Trans. Geol. Soc. 2 ser. vol. v. pt. 3.

§ See Memoirs, by Captain Franklin, Geol. Trans. 2nd ser. vol. iii. pt. 1; and Dr. Malcolmson, vol. v. pt. 3.

‖ See Quart. Journ. Geol. Soc. vol. vii. p. 272; and vol. ix. p. 351.

¶ A fine collection of the freshwater fossils of this district have been presented to the Society by the Rev. Messrs. Hislop and Hunter.

forms a series of great thickness. Sandstone also makes its appearance ten miles south of Nagpoor.

In the Pachmurra Range the sandstone is calculated by the author to be at least 2700 feet thick, and he thinks it probable that it is continuous with the coal-fields of Jubbulpoor, &c. to the North, and to the N.W., with that beyond Baitool. Lieut. Sankey, together with Dr. Jerdon, traced the sandstone almost up to Hurdagur, twenty miles S.W. of Pachmurra; and he does not doubt that, by its continuation under the trap-range of Muttoor, it is connected with the coal-bed of Oomrait.

DONATIONS

TO THE

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I. TRANSACTIONS AND JOURNALS.

Presented by the respective Societies and Editors.

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——— Philosophical Society, Transactions. Vol. x. part 2.

———. Proceedings. Vol. v. no. 48.

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————. Anniversary Address for 1852.

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II. GEOLOGICAL AND MISCELLANEOUS BOOKS.

Names of Donors in Italics.

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Ball, Dr. R. Annual Address delivered before the Geological Society of Dublin, Feb. 16, 1853.

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Catalogue of the Birds in the Museum of the Royal Asiatic Society, by Edmund Blyth. *From the Royal Asiatic Society.*

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Dana, J. D. On the Classification and Geographical Distribution of Crustacea.

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D'Orbigny, C., and A. Gente. Géologie appliquée aux Arts et à l'Agriculture, comprenant l'Ensemble des Révolutions du Globe.

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Lynch, Lieut. W. F. Report of the Expedition to explore the Dead Sea.

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Pictet, F. J., and W. Roux. Description des Mollusques fossiles qui se trouvent dans les Grès verts des Environs de Génève. Livr. iv.

Ponzi, Prof. Giuseppe. Descrizione della Carta geologica della Provincia di Viterbo.

———. Sopra un nuovo Cono Volcanico rinvento nella Val di Cona.

———. Sulla Storia fisica del Bacino di Roma.

Ringgold, Commander. Memoir and Maps of California.

Salter, J. W. On the Lowest Fossiliferous Beds of North Wales, 1852.

Sedgwick, the Rev. Prof. A. Geology of the Lake District of Cumberland, Westmoreland, and Lancashire.

Sorby, H. C. On the Origin of Slaty Cleavage.

Tate, George. The Fossil Flora of the Mountain Limestone Formation of the Eastern Borders.

Vogel, Dr. A., Jun. Ueber den Chemismus der Vegetation. *From the Royal Academy of Munich.*

Westwood, J. O. Addresses at the Anniversaries of the Entomological Society, 1852, 1853.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

1. *On the* "Caradoc Sandstone" *of* Shropshire. By J. W. Salter, Esq., F.G.S., and W. T. Aveline, Esq., F.G.S.

[Read June 15, 1853.*]

The part of the country to which this paper particularly refers is the tract lying between the Wenlock Edge on the east, and the Longmynd, Caer Caradoc, and the Lawley Hills on the west, extending also northwards to the Wrekin, and the country about Buildwas on the left bank of the Severn. When first mapped by the Geological Survey, it was considered, in conformity with the views of the author of the 'Silurian System,' that the whole tract was superior in position to the Llandeilo flags, and that the 'Pentamerus (or 'Hollies') limestone,' so well developed around the base of the Longmynd, was the uppermost stratum of the formation called 'Caradoc sandstone.' It was shown, however, in a paper read before the Society (Quart. Journ. Geol. Soc. vol. iv. p. 298), that around the Longmynd these upper portions of the Caradoc, or the Pentamerus beds, were alone developed, the lower and typical portions being wanting†, and that these upper strata reposed unconformably on the strata of Llandeilo flags around the district of Shelve and Bishop's Castle. In a paper lately read by Professor Ramsay (vol. viii. p. 162), the connection of these 'Pentamerus limestones' and conglomerates with the *base of the Wenlock shale* was fully expressed. It became necessary, therefore, to re-examine the boundary-line between the Caradoc sandstone and Wenlock shale along the base of the Wenlock Edge, where the 'Pentamerus beds' had been described ('Sil. Syst.') as forming an intermediate or passage group from the Lower to the Upper Silurian, and to draw the line at the base of those beds, if they should prove distinct from the lower and more typical portion of the 'Caradoc.'

It was also necessary to ascertain whether these 'Pentamerus

* For the other papers read at this meeting, see vol. ix. p. 317.

† The fossil lists, too, appended to that paper indicated a large proportion of Upper Silurian fossils mingled with those more peculiar to the formation, such as the *Pentameri*, &c., and but very few Llandeilo flag species.

beds' could be identified with that 'upper portion of the Caradoc' developed at May Hill and the Malverns, and which has lately (vol. ix. p. 215) been described by Professors Sedgwick and M'Coy as exclusively charged with Upper Silurian fossils, or whether they formed a distinct series, intermediate between the Upper and Lower Silurian rocks, and containing an intermediate group of organic remains.

During the examination, the authors were able not only to confirm the previous view of the physical connection of the beds in question with the base of the Upper Silurian series, but to establish the fact of a great unconformity between them and the subjacent so-called 'Caradoc sandstone'; and the evidence of the fossils was found to be in accordance with the geology.

The fossils of the supposed typical Caradoc sandstone have been already stated by Prof. Sedgwick to be the same with those of the Bala group (*l.c.* p. 229). Not only are the forms identical, but in association and proportionate numbers of the prevailing species it would be difficult to mark any difference as compared with those of Bala or Meifod. And there is no admixture of other or new forms, or of those characteristic of higher parts of the system. This will be shown in briefly noticing the character and fossil contents of its subdivisions. And in this respect they are in striking contrast with the overlying grits and limestones of the 'Pentamerus beds,' which, along the whole extent of the country under review, are characterized by species nowhere to be detected in the adjacent Caradoc strata, but which for the most part are the same as are found in the Wenlock strata, mingled with others more characteristic of this particular horizon, and occasionally plentiful in the upper portion of the Llandeilo flags, such as the *Pentameri*.

The strata that will now be brought under notice in more detail are—1. the various subdivisions of the rocks hitherto called 'Caradoc sandstone' in Shropshire (the lowest beds of which are cut off from any inferior strata by great faults); 2. the Pentamerus sandstone and limestone; and 3. the lowest portion of the Wenlock shale. The beds in a descending section are as follows:—

		Localities where well exposed.
Wenlock shale.	9. Grey rubbly concretionary shales, 1500 feet thick, with occasional calcareous bands.	Wistanstow; Hughley Mill; Buildwas, &c. &c.
"Pentamerus beds." (Upper Caradoc, 'Sil. Syst.'	8. Purple shales, 200 to 400 feet thick.	Cheney-Longville foot-bridge; W. of Hughley; Belswardins brook; N. of Buildwas; S. end of Longmynds.
	7. Thin limestone bands, interstratified with ochreous sandstone, and argillaceous shales (Pentamerus beds).	Cheney-Longville; Acton Scott; near Soudley (the Hollies); Merrish-wood, Harley; Belswardins; Morrell's Wood, near the Wrekin, &c. &c.
	6. Conglomerates and sandstones.	Church Preen; Kinley; Harley; Morrell's Wood; E. of Wrekin; S. and E. of Longmynds.

The above lie unconformably on—

Llandeilo and Bala rocks. (Caradoc sandstone, 'Sil. Syst.')

	Localities where well exposed.
5. Thin-bedded sandy shales, full of *Trinucleus concentricus.*	Banks of the Onny at Cheney-Longville; near Acton Scott.
4. Thick and thin-bedded brownish and yellow sandstones, with calcareous courses, highly fossiliferous.	Onny River; Bushmoor; Whittingslow; Acton Scott; Cardington; Holly farm, Soudley.
3. Thick freestone beds of a brown colour, often largely streaked with green and purple (Horderley flags).	Longlane; E. of Horderley; Soudley; Enchmarsh; Chatwall.
2. Yellow coarse sandstones (in some places a conglomerate which is rarely fossiliferous), with a calcareous band at Horderley, Harnage Park, &c.	Corston Heath; Horderley; Hoar Edge; Acton-Burnell Park; Cound Moor; near Harnage.
1. Sandy and argillaceous shales, in parts fossiliferous, but generally barren.	Harnage; Cressage; Shineton; Mary Dingle, N. of Leighton.

1. *Shales of Cressage, Leighton, &c.*—These beds, which occupy the low ground north of Acton-Burnell Park and Cressage Park, are well seen at the villages of Harnage near Cound, and at Shineton. They are generally fine and thin-bedded argillaceous shales, without fossils, readily separating into layers, and as such may be seen at a mill one mile north of Leighton Church, and also on the brook east of Belswardins Hall, Cressage, where a trial for coal has been made, and where they dip at an angle of 60°, and are covered unconformably by the Pentamerus limestone. Occasionally they are more arenaceous, and contain Lingulæ, Trilobites, Encrinites, &c., as at Shineton, Harnage, and Cound. The following fossils have been observed *, but the specimens are not fully examined:—

Olenus —— sp. Shineton.
Trinucleus concentricus, *****.
Asaphus —— sp., *. Shineton.
Agnostus. Shineton.
Beyrichia complicata, and a minute Cythere.
Orthis alternata, ***. Harnage.
—— testudinaria.
Nucula, Orthonota, Theca, Lingula. Harnage.
Bellerophon nodosus (see Appendix). Harnage.
Graptolites, Fenestella, Ptilodictya. Harnage.

The occurrence of the *Trinucleus,* a true *Asaphus,* and *Agnostus* would be quite sufficient to mark these as Lower Silurian, if the characteristic Bala species of *Beyrichia, Orthis,* and *Bellerophon* were absent. These beds are distinctly succeeded at Harnage Park and near Cound by the—

2. *Hoar Edge grits.*—Thick sandstones, often coarse-grained, and containing rounded pebbles of quartz,—some of a very large size, and small pebbles of red jasper and green earth. They are well

* The relative abundance of the species is indicated by asterisks.

shown at Corston on the extreme southern point of the district, where they consist of pebbly grits interstratified with finer sandstones and occasional shales, full of fossils. They extend by Hopesay Common to Horderley, where they are less gritty, and become so calcareous as to form a good building-stone. They are then interrupted for awhile by faults and the trappean ridges of Hope Bowdler and Ragleth ; and they reappear as coarse grits in the Hoar Edge, where they are quarried, dipping east from the Lawley Hill at an angle of 50° to 70° ; from whence they are continued by Frodesly Park and Ruckley to Acton-Burnell Park and Harnage Grange, with a limestone band continuous along their lower portion. The strike turns here towards the east, and they are soon overlapped by the coarse grits (6.) at Kinley. Fossils are very numerous in some portions. The following are the species hitherto observed :—

Calymene Blumenbachii, *.
Trinucleus concentricus, **.
Phacops apiculatus, **. In the shaly beds.
Homalonotus rudis, *. A rare Bala species !
Beyrichia complicata, ***. In the shales.
Orbicula punctata.
Orthis elegantula.
—— Actoniæ.
—— flabellulum, ****.
—— vespertilio, ***.
—— testudinaria, *.
—— calligramma.
Strophomena expansa.
—— concentrica, *Portl.* **.
—— spiriferoides, *M'Coy.*
Rhynconella, two or three species.
Stenopora fibrosa, *****.
Retepora, n. sp.

3. *Thick-bedded flags or freestones of Sibdon, Longlane, and Horderley.*—These consist of fine-grained freestones, greenish olive and yellowish brown, much streaked with purple, and usually thick-bedded, with calcareous partings full of fossils. They dip at moderate angles, except along a line of disturbance which extends from Ragleth Hill southwards to Sibdon. On this line their lower beds are much disturbed, and in some places quite perpendicular. North of the trappean hills of Hope Bowdler, along the ridge of Enchmarsh and Chatwall, these flags, somewhat diminished in thickness, dip at angles from 50° to 60° ; at Broome and further north they lie at a lower angle, 30° to 40°, until they reach Church Preen, where they are covered unconformably by the grits No. 6. At Chatwall and Enchmarsh pebbles of quartz occur in the freestones, and there are beds of yellow sandstone rendered in parts highly calcareous by abundance of the *Orthis alternata*, Sow. (one of the characteristic fossils at Bala). The lower portion of these flags passes through thinner beds into arenaceous shales which overlie the Hoar Edge grits last described (No. 2). Their upper layers graduate into the thin-bedded flagstones of the next division.

The fossils are the same as those of the grits last mentioned, with the exception of some of the rarer species, and the addition of

Tentaculites annulatus.
Homalonotus bisulcatus.
Strophomena grandis.
—— bipartita (see Appendix), a species with a strong central rib; very common in the next division. Chatwall.
Modiolopsis; one or two small species.
—— modiolaris. Chatwall.
Nucula —— sp., same as a Bala species; Cheney-Longville. And one or two other bivalves.
Orthonota nasuta. Horderley.
Turbo crebristria. Chatwall.
Nebulipora favulosa, var. lens. (N. lens, *M'Coy.*)
Glyptocrinus basalis, *M'Coy.* The rings of this species occur in great numbers.
Murchisonia simplex, *M'Coy.* Chatwall.
Bellerophon bilobatus, ***.
Orthoceras; smooth, and with central siphon. Horderley; Chatwall.
Diplograpsus pristis. Occurs at Soudley quarries.

The prevailing species, however, are

Orthis elegantula, O. testudinaria, and O. alternata;
Leptæna sericea;
Nebulipora favulosa, var. lens; and
Glyptocrinus basalis; separate rings and stems, which occur in the greatest profusion on every slab.

4. *Thin-bedded flags, with much sandy shale and thin beds* (2 *to* 6 *inches thick*) *of greenish sandstone.*—They are more earthy about the upper parts, and at Acton Scott pass into a hard and thick-bedded siliceous flag, formerly quarried for building-stone. The best section of these is seen on the Onny River, above the Horderley flags last noticed; and they are also well seen along the lane leading west from Cheney-Longville to the common, where all the beds are visible, dipping at a low angle towards the village. Proceeding northwards they occur also at Woolston, Bushmoor, Wittingslow, Acton Scott plantations, and the Marshbrook station of the Shrewsbury and Hereford Railway. They are seen near Hope Bowdler at the Holly Farm-house, where calcareous courses come out immediately under the farmyard*. At Gretton quarry, near Cardington, they are better seen than anywhere else, the quarry being a perfect magazine of fossils in a soft yellowish sandstone. On the ridge-road from Broome to Church Preen, several openings in the lower part of these beds occur, rich in fossil shells. The beds are not nearly so much disturbed as those of the previous division, and generally dip at low angles.

* Fragments of these limestones were gathered from the lime-kiln (now deserted) further down the brook, where an attempt was formerly made to burn the overlying "Pentamerus limestone." It was the accidental mixture of some of those specimens in the original collection, that introduced so many characteristic Llandeilo species into this uppermost band or "Hollies Limestone." See Silurian System, vol. i. p. 217. and pl. 19.

The fossils are very much the same as those of the two preceding divisions—

Calymene Blumenbachii, *****,
Orthis testudinaria, *********,
—— alternata,
Orthis vespertilio,
Nebulipora favulosa, var. lens,

being still the common fossils. There is, however, a considerable difference in the proportionate numbers of certain species. The following, which are rather rare in the lower beds, are the commonest species here:—

Phacops conophthalmus.	Gretton, Hatton, &c.
—— truncato-caudatus.	Acton-Scott plantation, &c.
Homalonotus bisulcatus.	Do., Cheney-Longville.
Tentaculites annulatus.	Do., do.
Modiolopsis orbicularis.	Do., do.

while the following are but rare in most of the localities:—

Trinucleus concentricus.
Bellerophon bilobatus.
Orthis flabellulum.
Strophomena expansa.
Glyptocrinus basalis.

The last, indeed, so common in division No. 2, is seldom or never met with here. One rare and curious fossil was detected near Cheney-Longville, which may serve still more to identify these beds with those of the Bala rocks,—the *Pterotheca undulata*, Salter, a curious and rather large Pteropodous shell found in strata of this age in Caernarvonshire. At Acton Scott, in the quarry near the church, *Cybele verrucosa* and *Lichas laxatus* occur, together with *Strophomena depressa, Leptæna transversalis,* and *Orthis biforata*; and at Gretton quarry near Cardington, a trilobed *Illænus* and *Acidaspis Caractaci,* with fucoids, are found, in addition to almost all the common Bala fossils. This locality is well worth the attention of collectors.

The topmost bed of these flags is a dark grey shale, calcareous and rubbly, with bands of concretionary limestone frequently occurring in the micaceous shale. It is well seen in the river Onny at Cheney-Longville, where it forms a small ledge easily accessible when the water is low, and plainly dips under the shales next described. It also comes out in the Horderley-road, where it is full of fossils; and is still better seen by following up the little brook called Batch Gutter, where it has been quarried. The same bed is traceable in the road-side between Acton Scott and Henley, in the brook above Ticklerton Hall, and even ranges as far up as Plash, north of Cardington, where a well lately sunk has brought up abundance of this peculiar shale; and in the brook above Church Preen, yellow-brown shales occur with some of the same fossils. It is then overlapped by the coarse grits belonging to the overlying series, and disappears. The fossils are very plentiful. The following are characteristic:—

Lichas laxatus.
Phacops truncato-caudatus.
—— conophthalmus.
Ampyx —— sp.
Orthis Actoniæ.
—— vespertilio, **.
—— elegantula.
Strophomena bipartita, **. (Appendix.)
Clidophorus ——, oval sp., **.
Nucula varicosa, *Salter* (Appendix).
Orbicula elongata, *Portlock*, **.
Scalites (Pleurotomaria) lenticularis, ***.

Bellerophon bilobatus, ***.
—— acutus, *** (not carinatus).
—— sulcatinus, *Emmons*? (Appendix). This is also found in Tyrone.
Orthoceras ——.
No Trinucleus found; but fragments of loose grey shale in the Onny, most probably from this locality, have them in abundance.

5. *Trinucleus shales.*—Above the grey calcareous shales last-mentioned occur, both in the Onny River and further north, a series of thin-bedded sandy shales of a yellow or yellow-brown colour. In the Onny they are well seen in a low cliff on the left bank, about 300 yards above the foot-bridge to Cheney-Longville, dipping eastward at an angle of 20°, free from any admixture of calcareous beds, very uniform in character, and full of the *Trinucleus* to the very top. About halfway along the cliff they are at once overlaid unconformably by the calcareous and shaly beds of the 'Pentamerus limestone,' above which no *Trinuclei* are found. In the fields at Batch Gutter above mentioned, the same shales occur with *Trinuclei* and *Orthides.* In the lane that leads from Marsh Farm to Acton Scott, they also occur (with the same fossils) very near Henley, but they do not appear farther north, being overlapped by the Pentamerus beds. The fossils are—

Trinucleus concentricus, ****.
Clidophorus, same species as above.
Orthis elegantula.
Leptæna sericea, small, ****.

It is, we feel certain, fragments of this shale which have furnished the *Trinuclei* mentioned by Prof. Sedgwick as occurring *within* the limits of the Wenlock shale, and *above* the Pentamerus limestone*. The boundary of the Wenlock shale in the first editions of the Survey map was extended rather too far westward along this part of the country, and was made to include this shale, now more correctly referred to the uppermost part of the Llandeilo and Bala rocks.

6. *Coarse grits of Church Preen, Kinley, &c.*—The lowest strata of this overlying group are coarse grits and sandstones, hitherto classed with the so-called Caradoc sandstones. They occur only at the northern end of this district, and extend from the Wrekin nearly as far south as Cardington, reposing on the successive divisions of the beds before described, and are here overlapped by the limestones and shales of the Pentamerus beds. At Gibbon's Coppice and Morrell's Wood, they lie upon No. 1, the Cressage shales, and are a coarse sandstone, very gritty in its upper part, and containing a large species of *Lingula* very like *L. crumena* of the Malvern sandstones, but apparently distinct; and in the same slabs with it *Pentamerus oblongus* and *Atrypa hemisphærica,* thus uniting it with the overlying shales. This conglomerate is not continuous across the Severn, for at Shineton and Belswardins, on the opposite bank, the shales and limestones are the lowest beds. But it reappears in Cressage Park, where it is full of casts of *Rhynconella decemplicata* and another species, both identical with those from the same beds at Minton on the edge of the Longmynd. There are some very imperfect *Orthides,* which cannot be determined, in these grits at Kinley. Here the beds rest on the Lower or Hoar Edge grits (No. 2). No

* Quart. Geol. Journ. vol. viii. p. 228. Prof. Sedgwick agrees with us in this.

fossils have been found in the conglomerate at Church Preen, at which place it rests on the upper shales (No. 4) of the Llandeilo series. It extends two miles further south by Plash, Sheaves, and Oakwood, where the Pentamerus limestone again overlaps it, and continues as the base of the series.

It is evident that this underlying sandstone cannot be considered apart from the same beds which skirt the Longmynd, appearing at various points beneath the Wenlock shale, and described by Prof. Ramsay in his late paper (vol. ix. p. 175) as "the pebbly shore of the Wenlock sea." At Minton, All Stretton, Hope, Bogmine, &c., it is chiefly filled with species which are to be found in Upper Silurian rocks.

Calymene Blumenbachii, *****,
Illænus Barriensis, ****,
Encrinurus punctatus, ****,
Cheirurus bimucronatus,
Phacops Downingiæ, *,
—— Stokesii,
Prœtus Stokesii, *,
Strophomena pecten,
Atrypa reticularis, ***,
—— marginalis, ***,
Pterinea retroflexa,
Goniophora cymbæformis, *,
Holopella obsoleta,
Bellerophon trilobatus,
—— expansus,
—— carinatus,

are all Upper Silurian fossils. The following are chiefly Lower Silurian :—

Tentaculites annulatus, ****.
Orthis reversa, *Salter*, ***.
—— biforata, *Salter*, ***.
† —— Actoniæ.
† —— vespertilio.
Rhynconella decemplicata, *.
Scalites lenticularis.
Lituites cornu-arietis.
Holopella cancellata, ****.

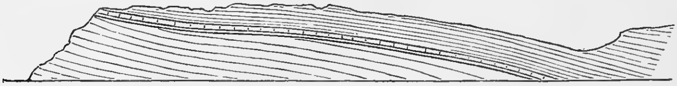
The aspect of the fossils is not Lower Silurian, and, except with some of the upper sandstones and conglomerates in Caermarthenshire, there is no part of the Llandeilo flags with which they have any near resemblance; while the presence of abundant *Pentameri* and of many other fossils indicate clearly the connexion of these beds with the next stratum, the Pentamerus limestone, which here and there slightly overlaps it in some of the localities where they have been observed together.

7. *Pentamerus limestone.*—The beds which may be classed under this name in the country under consideration are beds of sandstone, often so highly calcareous from the presence of fossils as to be limestone, but generally thin-bedded layers of yellow or yellow-brown micaceous sandstone, interstratified with brown and blue shale. Their lower boundary is traceable along the whole line at intervals from Cheney-Longville to the Wrekin, but the upper limit, consisting of soft purple shales (No. 8), is inseparable from the Wenlock strata. The Pentamerus limestone is first seen on the banks of the Onny in the low cliff above mentioned, where it consists of thin courses of bastard limestone with *Pentamerus undatus*, and is overlaid by shales with thin beds of sandstone, full of fossils. The accompanying woodcut will show the slightly unconformable position of these beds on

† These two species are, however, not in the Survey collections. Prof. E. Forbes observed them at Hope Quarry.

the Trinucleus shales below. It is difficult to examine, as, except in droughts, one must stand up to the knees in water. Further down

Section on the north bank of the River Onny, at Cheney Longville foot-bridge, Shropshire; showing the Pentamerus-beds lying unconformably on the older strata.



5. Trinucleus-shales (Llandeilo and Bala rocks).
7. Pentamerus-beds. 8. Purple shales, followed by Wenlock-shale.

the brook the banks show red shales (No. 8), not far from the foot-bridge, below which the ordinary Wenlock shale makes its appearance.

No *Pentamerus oblongus* occurs at this section, but by following the line northwards, it is found in abundance, with the *Atrypa hemisphærica*, &c., at the following places:—Banner-bank plantation near Acton Scott; and in the brook at Ticklerton, and the Holly Farm, Soudley, the limestone (locally called "Jacob's") is full of large specimens of this shell, which is the prevailing fossil from hence to Buildwas. The limestone and overlying shale is remarkably well seen at Ticklerton. It occurs again in well-developed beds in the brook that runs from Stone Acton towards Rushbury, and is then traceable by blocks in the ploughed lands and in the ditch-courses to Day's Coppice, and to the north of Church Preen along the Kinley ridge. Near Harley there is an excellent section in the brook at Merrish-wood, and another in the brook east of Belswardins. The following are characteristic fossils:—

Acidaspis crenatus. Morrell's Wood, Wrekin.
Encrinurus punctatus, ****.
Phacops Stokesii.
Illænus;—a trilobed species; at Cheney Longville.
Calymene Blumenbachii. Morrell's Wood.
Cyphaspis megalops. Do.
Phacops caudatus. Belswardin, Acton Scott, &c.
Trinucleus concentricus. Very rare; only at Acton Scott, in soft yellowish sandy shale with Atrypa hemisphærica.
Beyrichia tuberculata.
Tentaculites annulatus; var. with close rings, ***.
Annelide-markings, very common.
Atrypa hemisphærica, ******.
—— var. with two raised plaits. Morrell's Wood.
—— reticularis, ***.
Orthis elegantula.
—— reversa, **.
—— testudinaria.
—— vespertilio? One specimen. Acton Scott, sandy shales.
—— calligramma. Rare. Belswardin, near Cressage.
Strophomena pecten, *****.
—— compressa, ***.
——, one or two other species. Morrell's Wood &c.

Pentamerus oblongus. Abundant everywhere.
—— undatus, ****.
—— lens, ****.
Leptæna transversalis, *.
—— Grayii. In shales, Shineton Coppice.
Crania implicata? Morrell's Wood.
Modiolopsis, Clidophorus, Murchisonia, Turbo, Scalites, Euomphalus, and Orthoceras occur rarely, and are all more or less doubtful species.
Pterotheca (transversa? or an allied species). Morrell's Wood.
Petraia, wide and short species. Shineton Coppice; Kinley.
Petraia bina, ***.
Halysites catenulatus. Very rare, near Stone Acton.
Stenopora fibrosa, **.
Favosites alveolaris, *. Morrell's Wood.
Ptilodictya (dichotoma?).

8. *Purple shales.*—Wherever the section is well-exposed these shales are to be seen lying beneath the grey rubbly Wenlock shale, and above the Pentamerus beds. They occur on the north bank of the Onny just above the Longville foot-bridge; in the brook at Ticklerton; west of Hughley; the brook at Belswardins; and north of Buildwas. They are from 200 to 400 feet in thickness, and in some places contain bands of fine blue micaceous sandstone. Few fossils have been found. The following occur at one or other of the above localities:—

Beyrichia tuberculata, *.
Leptæna lævigata, ***.
—— transversalis.
Orthis biloba, **.
Strophomena pecten, **.
Atrypa reticularis, *.
Rhynconella furcata, *.
Petraia bina, **.

This peculiar red shale may also be seen near Choulton Bridge, at the southern end of the Longmynds, occupying the same position between the Pentamerus beds and the true Wenlock shale; and the section there is consequently in accordance with that under Wenlock Edge;—the fossils are the same in both cases.

9. *Wenlock shale.*—On the banks of the Onny, below the foot-bridge, as above stated, the Wenlock shales are exhibited; but not very conspicuously. They readily yielded the following fossils:—

Phacops caudatus, var. longicaudatus, **.
Calymene tuberculosa, **.
Beyrichia tuberculata, *.
Cardiola interrupta, **.
Theca anceps, *Salter*.
Loxonema elegans, *M'Coy*?
Orthoceras subundulatum.
Graptolithus priodon, **.

The Wenlock shale, characterized by the above and other common species, extends from hence to Buildwas, and along the whole line appears to dip conformably with the Pentamerus beds. If it overlaps them at all, it can only be at the south end of the Wenlock escarpment, where from Sibdon to Corston the shale lies against the lowest grits (No. 2), without the intervention of the Pentamerus beds. Around the Longmynd, however (see the Paper above referred to, vol. iv.), the Wenlock shale often rests on the conglomerate beds without the intervention of the limestone, and often on the bare Longmynd rocks without any intermediate beds at all. The Pentamerus limestone, too, in the same region, frequently overlaps the conglomerate beds, so that there may be a slight amount of unconformity between each of these strata in their turn. But the connexion between the organic remains of the conglomerates and those of the Pentamerus limestones is perfect, and the latter appear gradually to lose their peculiar species, and to graduate upwards into the Wenlock shale. This may be accounted for, however, by the land gradually sinking during the formation of these beds, without supposing any great disturbance or long interval of time, and hence, as above stated, there is very little change in the fossil contents, except what may be referred to a variation in the depth of the sea.

Between these strata, however, and the sandstone formerly called "*Caradoc sandstone*," there is *no true passage*, nor any similarity in fossil contents in the country under review; and it is evident that they can no longer be classed under the same name. The rocks east of Caer Caradoc, formerly considered as typical Caradoc, are the equivalent of the Meifod and Bala rocks, and of their upper and middle portions only. The overlying strata, on the contrary, are identical (at least in part) with the arenaceous beds described by Prof. Ramsay (vol. iv. p. 299) as lying at the base of the Wenlock shale at Builth, and with the sandstones of Presteign, May Hill, and Malvern, to which Prof. Sedgwick has applied the term "May Hill sandstone." Whether the Caradoc sandstone of the Welsh counties (*supra*, vol. iv. p. 294*) be identical with these overlying beds, as suggested from fossil evidence by Professors Sedgwick and M'Coy, is not yet certain, from the want of sufficient fossil data; but so far as the collections yet made in these barren tracts may serve, the fossils agree well with this view, scarcely any of the true Bala fossils being found in them; and, on the other hand, many common Upper Silurian fossils are plentiful there.

Should further examination prove this to be the case, the name "Caradoc sandstone" might still be retained for this large intermediate formation, several parts of which have been constantly so named in various works; and the "Pentamerus limestone," characterized by species which are plentifully found in beds† below and above this "Caradoc" formation, is thus linked on to the older strata, and at the same time forms the bed of passage from the Lower to the Upper Silurian rocks.

Summary.

The conclusions to be drawn from the foregoing data may be thus shortly stated. The rocks east of the Longmynd hitherto known as

* At p. 296, the conglomerates around the Longmynds are identified with the Welsh Caradoc sandstone, but they were not separated from the rocks east of Caer Caradoc.

† The sandstones referred to in the memoir by Prof. Ramsay, before quoted, as occurring 1000 to 1500 feet below the Caradoc sandstone of North Wales, are full of the characteristic *Pentameri*, *Atrypæ*, &c. of these uppermost beds. All the *Pentameri* abound there, and *Atrypa reticularis*, *Holopella cancellata*, &c. are frequent fossils. *Atrypa hemisphærica* is more rare.

Caradoc sandstone are now divided into two groups. The lowest and greatest portion is equivalent to the middle and upper portions of the Llandeilo and Bala rocks, and were accumulated in the following order:—

1. Fine shales, with small Trilobites (*Olenus, Asaphus, Agnostus*) and shells, deposited in deep water (most probably the equivalents of the Black Shales, Malvern).

Elevation of Land, or Shallowing of Sea.

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2. Coarse calcareous grits and conglomerate; a littoral or shallow water deposit.

3, 4. Sandstones, with occasional pebbles, laminated in the upper parts, and in some localities northwards with many beds of shale. A finer deposit than the last, and indicating a greater depth of water. Fossils exactly those of Bala.

5. Thin-bedded arenaceous shales, with fewer fossils, but of the same species; *Trinucleus concentricus* very abundant. A still greater depth of water is here indicated. (The higher part of the Llandeilo or Bala series.)

Evidence of upheaval and partial dislocation.

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6. A coarse deposit (unconformable on Nos. 1 to 5) in the immediate neighbourhood of the Longmynds, and derived from them (in part deep water around steep land, *Forbes*). A great change in the organic remains. The characteristic Llandeilo and Bala fossils have given place to a mixed series, including several species found in the Upper Llandeilo flags, but with many others more characteristic of the Wenlock limestone.

7. Finer sandstones, with much shale and great abundance of *Pentameri*, and other Brachiopoda. Land gradually sinking (*Ramsay*, Geol. Journ. vol. ix. p. 175). Fossils chiefly Upper Silurian.

8, 9. Grey and greenish shales, very fine sediment: deep water. Trilobites, Graptolites, and Cephalopods abundant. Fossils all Upper Silurian.

Appendix.

Description of some of the Fossils. By J. W. Salter, Esq. F.G.S.

Some of the most characteristic fossils mentioned in the above lists are yet unpublished; it seems desirable therefore to give their characters in brief.

1. Bellerophon nodosus, Salter.

B. ornatus, M'Coy, Syn. Woodw. Foss. 310.

B. vix uncialis, anfractibus 3, subangulatis, costatis. Apertura lata, subrhombica, facie umbilicali planatâ, quàm exteriori rotundatâ breviore.

Costæ rotundatæ, retrorsæ, ferè ad carinam obtusam ductæ, et faciem umbilicalem attingentes; striæ accretionis primum rectæ reticulatæ, deinde unâ cum costis retroflexæ, crenulatæ.

I should have thought, with Prof. M'Coy, that this was *Cyrtolites ornatus*, Conrad; but in Hall's figure, and in specimens from New York, the lines of growth are direct across. In that species, too, the umbilicus has a sharper edge, and the plaits do not go at all within it. *B. nodosus* is sometimes as large as the American species.

Localities. Llandeilo and Bala rocks;—S. of Llangollen; Beddgelert; Llanfyllin; Hope Bowdler, Shropshire; in beds "3" of section, p. 64.

2. Bellerophon (Bucania) sulcatinus, Emmons?
(Hall, Pal. New York, Part 1. t. 6. f. 10?)

B. uncialis et ultra, convolutus, anfractibus a dorso convexiusculo depressis, striatis. Carina lata, plana, (sublævis?) marginata, vix elevata. Striæ concentricæ fortes, circiter 10 (ad carinam sæpissime interstriatæ et in ætate plurimæ), a lineis crebris valde reflexis undique decussatæ. Apertura lata, expansa, sinu profundo.

This very beautiful shell differs from *B. sulcatinus*, as figured by Hall, in having regular ribs towards the angular edge, which become interlined and form a broad band of close striæ as the shell grows older. The umbilical face, too, is free from ribs, which I have some reason to think is not the case with *B. sulcatinus*. The striæ, too, on that shell, appear to meet at a very much more obtuse angle than in ours. It should be called *B. lingualis*, if the above characters are sufficient to separate it. It must have been a very thin shell.

Bellerophon acutus, Sow., appears to be quite a distinct species from the *B. carinatus*, Sow. It has a very acute keel, and flat, almost excavated, sides, strongly striated; the umbilicus is very large, and sharp-edged. Now that good specimens are obtained from Horderley (with the species above described), it is clear that the Ayrshire shell figured under this name in the Quart. Geol. Journ. vol. vii. Pl. 9. f. 18. is distinct. It has a small umbilicus with a rounded edge, and the sides are comparatively convex. It may, however, be a variety of *B. carinatus*.

In upper part of beds "4" of section, pp. 64, 67.

3. Strophomena bipartita, n. sp.

S. semiovalis, radiatim crebristriata, angulis haud extensis. Striæ æquales costis prominulis (nisi in areis cardinalibus) interruptæ, costâ medianâ maximâ elevatâ in duas partes testam dividente. Testa undique lineis concentricis ornata, margine cardinali sæpe corrugato. Valva ventralis lente convexa, intra lamellis brevibus ad angulum 90° divaricatis, areâ angustissimâ. Altera plana (costis minus conspicuis) dentibus externis distinctis ad angulum 80° divergentibus: dentes interni (fulcrum cardinale) duo, paralleli, angustissimi, externis breviores. Long. unc. 1, lat. unc. 1¼.

The striation of this flattened shell is a good deal like that of *S. grandis*, which, however, has the dorsal, not the ventral valve the more convex; the interior differs much. The remarkable central ridge, as well as the regular surface and distant ribs, distinguish it from the *S. concentrica* of Portlock, a fine species, which occurs also in the Horderley section, and which from good specimens I find to be truly distinct from *S. compressa* of the Caradoc sandstone.

Localities. Near Hope Bowdler and Cheney Longville, abundant in the thin flags (4) of the Horderley section.

4. NUCULA VARICOSA, n. sp.

N. deltoidea, subæquilateralis, utraque rotundata. Umbo subcentralis, elevatus, falcatus, lunulam excavatam imminens. Margo anticus cardinis arcuatus; margo ventralis convexus. Testa supra medium modicè convexa nec gibba, lævis, nisi sulcis 5–8 concentricis gradatis exarata. Sulci aut varices in juvene remoti, ad marginem gradatim approximati. Long. lin. 4, lat. 4.

This pretty species is unlike any other palæozoic *Nucula* with which I am acquainted, by the few sharp concentric lines, or rather steps, of growth, which are more approximate in the older parts of the shell. It is most abundant in the Bala rocks, and has been referred by Prof. M'Coy to the *N. levata*, Hall, which has only faint concentric lines of growth, a pointed anterior side, and a much less prominent beak. We have never seen it from the Upper Silurian.

Localities. Fine specimens occur in the uppermost calcareous beds of No. 4 of the above section;—Onny River; at Acton Scott; Ticklerton, &c. Also Bala; Conway Falls, &c., North Wales.

On the STRUCTURE *of the* STRATA *between the* LONDON CLAY *and the* CHALK *in the* LONDON *and* HAMPSHIRE TERTIARY SYSTEMS.

By JOSEPH PRESTWICH, Jun., Esq., F.R.S., F.G.S.

PART II.—THE WOOLWICH AND READING SERIES.

[PLATES I. II. III. IV.]

[Read May 18, 1853. For the other Communications read at this Evening Meeting see Quart. Journ. Geol. Soc. vol. ix. p. 274.]

ON two former occasions I have given some account of the deposit immediately underlying the London Clay, as well as of that which, to the eastward of London, lies upon the Chalk, and which I have respectively termed the "BASEMENT BED OF THE LONDON CLAY*" and the "THANET SANDS†." Between these divisions, which form the upper and lower portions of the *Lower London Tertiaries*, is a group of sands, pebble beds, and mottled clays, extending from Sandwich to Marlborough and from Newhaven to Dorchester. This group, with the two above-mentioned, completes the series of these Lower Tertiaries, and is the one which more particularly embraces the beds which have hitherto been described as the "*Plastic Clay Formation*," exhibiting in one part of its range the mottled clays of Reading and Newbury, and, in another, the clays and sands, with fluviatile and æstuarine shells, of New Cross,

* Quart. Journ. Geol. Soc. vol. vi. p. 252. † *Ibid.* vol. viii. p. 235.

Woolwich, and Bromley. Some of the principal sections in these localities have been described by Parkinson*, Webster†, Dr. Buckland‡, Phillips and Conybeare§, Morris‖, Mitchell**, Richardson††, Warburton‡‡, and more recently by the Rev. Mr. De la Condamine§§; whilst outlines of some underground sections have been planned by Mr. R. W. Mylne‖‖, and a short notice relating to the superposition of these and the other Tertiary strata has lately been given by M. Hébert***. But nevertheless the correlation of the beds at the different sections has not, I conceive, been correctly shown, and the position which the strata of the Reculvers and Herne Bay hold with respect to those of Woolwich and Reading yet remains unsettled. At the same time, the lists of fossils even at the several best-known and often-explored localities admit of many additions and corrections. From the very circumstance of the band of green sand with the *Ostrea Bellovacina*, which underlies the mottled clays at Reading, having been referred to the band of green sand at the base of the Thanet Sands at Woolwich, and which likewise reposes upon the Chalk, it has had a tendency to place the Mottled Clays too low with respect to the fluviatile beds of Woolwich, and rather to correlate these latter with the Basement Bed of the London Clay at Reading. There was however another reason for this arrangement, inasmuch as in the sections at Blackheath, and elsewhere near London where the mottled clays show themselves, these latter underlie the Woolwich shelly clays; but, as will be shown further on, this relative position is not permanent, for another and larger portion of the "mottled clays" set in upon these Woolwich beds as they trend westward from London.

It has been shown in my previous papers that both the "Basement Bed of the London Clay" and the "Thanet Sands" are respectively nearly uniform in their lithological and palæontological characters (when fossiliferous) throughout their entire range—the former being coextensive with the London Clay itself, whilst the latter extend only from the Isle of Thanet to a short distance westward of London—and that both are essentially of marine origin.

The middle division of the Lower Tertiaries, of which it now remains to treat, is, on the contrary, in different areas so very different in its lithological structure and in its organic remains, that it presents one of those cases where the evidence of superposition is indispensable. Were it not for the well-marked horizons afforded by the upper and lower divisions, which confine this group within distinct limits, it would in fact often be difficult or rather impossible to identify its synchronous beds, when viewed in detached sections, either by their

* Organic Remains, vol. iii. p. 171, and Trans. Geol. Soc. 2nd ser. vol. iii. p. 212.

† Trans. Geol. Soc. vol. ii. p. 196.

‡ *Ibid.* vol. iv. p. 277.

§ Geology of England, pp. 24–26 and 37–52.

‖ Mag. Nat. Hist. June 1835, p. 356, and Proc. Geol. Soc. vol. ii. p. 450, 1837.

** Proc. Geol. Soc. vol. i. p. 482; vol. ii. p. 551; vol. iii. p. 131.

†† *Ibid.* vol. ii. pp. 78, 222, 449; Trans. Geol. Soc. vol. vi. p. 211.

‡‡ Quart. Journ. Geol. Soc. vol. i. p. 172; Trans. Geol. Soc. 2nd ser. vol. i. p. 52.

§§ Quart. Journ. Geol. Soc. vol. vi. p. 440.

‖‖ Sections of the London Strata.

*** Bulletin, Soc. Géol. de France, 2nd ser. vol. ix. p. 350.

mineral or palæontological characters alone. It is this feature which forms one of the chief points of interest of the group, for if it is important to identify strata by their organic remains or by their lithological structure, it is not less so to trace the changes of composition which can occur in strata on the same plane, to note the modifications in the fauna by which such changes are accompanied, and to determine the limits to which the variations may extend. The case now before us is, so far as it regards the dimensions of the deposit itself, one comparatively of small importance, but it is valuable from the clear and unmistakeable testimony which it affords on these points. It was the extremely variable character of this group, which putting on occasionally the appearance of the group beneath, and at other times assuming the character of the one above it, that led to the impression of a want of order and of irregularly recurring strata throughout the whole of the Lower Tertiaries. So deceptive, indeed, are these common points of structure, that it is only lately that I have been able to satisfy myself that these changes are confined essentially to one portion of the series, and that one restricted to the limits of the middle division, and that strata so very dissimilar are really equivalent. This once determined, and having eliminated the two more uniform groups, it becomes apparent that there is in the "Lower London Tertiaries" a defined order of superposition formed of three distinct and independent groups of strata.

At the same time there cannot well be strata varying more in appearance and character than we find forming this series in the separate sections at Reading, Deptford, Blackheath, and Herne Bay; by tracing the group at short intervals it is seen that it is by actual alteration in some of its beds, effected as they range from west to east, as much as by the thinning out of others, that these changes are produced. The strata are, in fact, on the same horizon and clearly synchronous (see Pl. I. Diag. A & C.). Under these circumstances there are objections to giving this division a simple designation dependent either on mineral character or on place, for the former is constantly varying, and the type of the series in one district may be entirely different in another. Still a name taken from some well-known place is probably the least objectionable, or rather the more convenient, and I purpose therefore to term this division the "Woolwich and Reading series," as the two principal forms of structure are well exhibited in the sections at and around these localities*. I shall, however, in speaking of this group, sometimes use the name of that locality only, to the particular characters of which the observations may have reference.

The grouping of the "Lower London Tertiaries" will therefore stand thus:—

I. The Basement-bed of the London Clay.

II. The Woolwich and Reading Series.

III. The Thanet Sands.

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* The Woolwich section has the inconvenience of exposing the three divisions of the "Lower London Tertiaries" together. The term applies only to the middle part of the section (see Pl. I. Diag. A. Loc. sect. 25).

The series of local sections forming the diagrams A, B, & C, Pl. I. have been arranged with a view to show the original structure and sequence of the beds of the Woolwich and Reading series, and of the other two divisions of the Lower London Tertiaries at the commencement of the London Clay period, as also to prove the correlation of the strata, and to render apparent the remarkable changes of lithological character which the strata undergo in their range from Wiltshire to the coast of Kent. These sections are either described in the text, or in the explanation of plates; whilst a few others, which possess features which those sections do not embrace, are given in separate figures.

§ 1. *Range and General Physical Features of the "Woolwich and Reading series."*

Throughout the Isle of Wight and the western portion of the London Tertiary district, this middle group consists of unfossiliferous mottled clays passing into or alternating with non-persistent sands: as it approaches near to London, strata of laminated and carbonaceous clays, sands more calcareous, and thick shingle beds of flint pebbles, with fluviatile and æstuarine shells, set in and replace the mottled clays. Following the group still further eastward we find it gradually becoming less pebbly and argillaceous, and at last passing entirely into light-coloured pure quartzose sands mixed with more or less green sand, and containing in its extreme eastern range a distinctly marine fauna. Viewed horizontally this middle division may therefore be divided into three distinct areas of—

W.	C.	E.
Sands and Mottled Clays. (*Reading and the Isle of Wight.*)	Pebble beds, Sands, and laminated Clays. (*Woolwich, Blackheath, and Bromley.*)	Quartzose and Glauconiferous Sands. (*Herne Bay and Canterbury.*)

These lithological changes are effected in an east and west direction in both the London and the Hampshire districts. In the latter, the last (E.) form of structure is only partially developed. It exists a few miles east of Newhaven, and, with the second, is well exhibited in an outlier on the coast three-quarters of a mile south of that town. The latter shows again at the west of Brighton, but there merges into the first (W.) form, which is continued by Lancing and Arundel to Botley near Winchester, in a narrow belt marked by its generally well-wooded surface, and by a succession of villages. These beds then pass two miles south of Salisbury, thence a few miles north of Wareham to near Dorchester, becoming more sandy as they proceed westward. Returning along their southern outcrop they pass by Lulworth to Studland, and in the Isle of Wight range, as is well known, through the centre of the island from Alum Bay to White Cliff Bay.

Throughout its northern range this division only occasionally presents any marked surface-features, and the sections are small, indistinct, and far apart. On its interrupted southern outcrop the vertical position of the strata restricts them to within so narrow a band, that they can rarely be seen except in the coast sections.

Of the connection existing at this period between the Hampshire and London Tertiary districts there are few remaining traces: only here and there on the broad chalk tract a hill higher than usual may be found capped by some of the lower tertiary beds, which resume their range in the London Tertiary district at Marlborough Forest. The greater part of these fine woods are planted on a thin and irregular capping of the clays and pebble beds* on the Chalk. The tertiary strata here attain a height of 600 to 700 feet above the level of the sea and form a narrow zone, which gradually expands as it trends eastward and falls to a lower level. At a short distance E.S.E. of this Forest the chalk attains, on the downs above Inkpen to Highclere, its greatest height, reaching at the former place an altitude of 1011 feet. The view from the fine open ridges of downs over the well-wooded, broken, tertiary lowlands, which, commencing abruptly at their base, stretches in an apparent plain far to the eastward, is one of considerable beauty. In this part of the district the sands and mottled clays form a large portion of the surface, and appear peculiarly favourable to the growth of timber trees. At a short distance further eastward the London Clay commences and the Bagshot Sands almost immediately follow, the latter forming more open tracts of heath and common.

Along their northern boundary the "sands and mottled clays" rise at a very gentle angle, and cover a considerable extent of ground on the chalk hills to the north of Newbury, and thence by Pangbourne, Reading and Sonning to Twyford, Maidenhead, and Taplow, where a further expansion of them forms the picturesque district known as the Burnham Beeches. The chalk hills which bound the tertiary area on the north, unlike the chalk of Salisbury Plains, present but a small extent of open downs, and are well-wooded on their summits; this arises in part from a covering of clay drift and in part from thin cappings of the lower tertiary beds, the latter being especially frequent to the north and north-west of Reading, and again around Beaconsfield, Penn, and Amersham. They are also found to some extent near St. Albans, Welwyn, and to the north of Hertford, and between Ware and Bishop Stortford. Eastward of this latter place the mottled clays are less important, and at the same time the lower tertiaries become confined to a narrow belt, owing to which condition, and the spread of the Boulder-clay drift over so much of North Essex, these beds rarely present in this part of their course any marked features of surface.

The southern outcrop of these strata, in consequence of the steep angle at which they rise, is very narrow,—a feature persistently maintained from the neighbourhood of Inkpen, by Kingsclere, Old Basing, Farnham, and Guildford, to Croydon, along which line of country the "sands and mottled clays" form a belt generally from 50 to 200 yards broad, rarely exceeding a breadth of a quarter of a mile, and only occasionally showing any discernible independent character of surface. As this group, however, from its composite character of sands and clays, presents a more yielding surface than the homogeneous mass of

* Including also a clay and gravel drift.

London clay which succeeds and reposes upon it, or the chalk which rises from beneath it, its line of outcrop is not unfrequently marked by a narrow and shallow depression between the chalk and the London clay, as at Old Basing, Guildford, and Sutton; but in other places, the chalk, lower tertiaries, and London clay form one continuous slope or nearly continuous surface falling more or less rapidly from the former to the latter, as at Itchingwell, Ewell, and Carshalton.

Eastward of Croydon the middle division of the Lower Tertiaries changes its character, the mottled clays gradually thinning out, and great masses of pebbly sands setting in in their place, together with clays containing fluviatile and æstuarine shells. At the same time the Thanet Sands develope themselves, and the basement-bed of the London Clay becomes thicker. In consequence of this increased importance of the Lower Tertiaries, and of the decreasing dip of the strata, this series suddenly expands and forms that varied and most agreeable tract of country extending from the Addington Hills to Bromley, Chiselhurst, Blackheath, and Greenwich, and eastward to Bexley and Farningham: in the latter neighbourhood these beds merely cap the chalk hills between the valleys of the Cray and the Darent.

Eastward of this district the tertiary beds are more confined to the higher grounds, as to the Swanscombe Hills, Windmill Hill near Gravesend, and the hills of Cobham and Shorne, in all of which the beds of shelly clays form a constant feature. On the banks of the Medway, below Rochester, these beds dip northward beneath the London clay. Continuing however further eastward this series gradually passes, apparently entirely, into a light-coloured quartzose sand with more or less green sand, which crops out in the low ground at the foot of the chalk hills between Chatham and Faversham. It forms a broader belt by Boughton, Canterbury, and between that city and Sandwich, presenting sometimes a rather barren sandy surface; but it is in general too closely associated with the Thanet Sands, or covered by drift, to exhibit any independent surface-features.

§ 2. *Details of Structure and Local Sections.*

Hampshire District.—At the southern extremity of the vertical tertiary strata at White Cliff and Alum Bays in the Isle of Wight, and immediately adjacent to the chalk, is a fine massive deposit of bright-coloured tenacious mottled clays. Their prevailing colour is blood-red, especially at White Cliff Bay; but the rough indistinct beds into which this mass is divisible in Alum Bay, exhibit mixtures, some of light bluish grey and yellow, others of light and dark slate colour, of lavender, puce, and yellow, or brown and yellow. The tints are generally dark and the colours bright. These beds contain no animal remains, and mere traces of vegetable remains in the shape of small pieces and fragments of carbonized wood. They are almost free from any admixture of sand, and altogether their structure, for a deposit so variable as this shows itself elsewhere, is compact and homogeneous.

The entire space between the London clay and the Chalk in the Isle of Wight, varying from 90 to 140 feet, is occupied by this mass of clay, with the exception of an irregular bed of 2 to 4 feet of sand above and as much below it *; the Basement-bed of the London clay existing here in a mere rudimentary state, while the Thanet Sands are wanting. This locality presents, in fact, the peculiar mottled argillaceous structure of the Reading series in its greatest and most exclusive development, being in fact almost as compact and impermeable as the London clay itself †.

Proceeding from this centre either westward or eastward, considerable changes take place in these strata. In the former direction we pass from the Isle of Wight over to Studland Bay ‡, where mottled clays of a rather light colour appear to succeed to the chalk, but the section is too obscure to determine the exact dimensions and superposition of the beds: they seem to be thinner and more sandy. Between this point and Lulworth Castle I am not aware that any sections of these beds are exposed §. At Lulworth there is a small section in the Park of light mottled red clays and some pebble beds overlying the chalk.

Proceeding toward Dorchester, the mottled red clays almost disappear, and are replaced by coarse sands, irregular pebble and shingle beds, and whitish clays. Two miles from this town towards Wareham, the road cuttings on the hill show the chalk capped by a few feet of tertiary beds, consisting first of brown ferruginous clay, with light brown-coated unrolled flints, covered by a bed of small pebbles, succeeded by brown clay, coarse sand, another fine conglomerate, and then mottled clay. The whole is not above 10 to 12 feet thick, and fills up a very irregular and deeply indented surface of the chalk ‖. About a mile further, near Little Maine, the chalk is overlaid by sands, which in one place are concreted into large blocks of sandstone,—the ordinary Druid sandstone. In a field adjoining the road there is a complete nest of them, fifteen to twenty in number, and varying in size from 2 to 6 feet in diameter. Westward of this locality there are several outliers of these lowest tertiary beds, which continue to show an increasing conglomerate character, the sands becoming coarser and the clays whiter and mixed with pebbles and

* Quart. Journ. Geol. Soc. vol. ii. pp. 255 & 259, and Pl. IX. strat. "b."

† In sinking one Artesian well at Portsmouth, a water-bearing sand bed was met with in this series; whereas in another well sunk at a short distance from the first, the entire space between the London clay and the Chalk was occupied with a solid and compact mass of mottled clays without a seam of sand, and consequently without water.

‡ For particulars of this section, and various points connected with the tertiary geology of this district, see a paper by the Rev. W. B. Clarke in the Mag. Nat. Hist. new ser. vol. iii. p. 390.

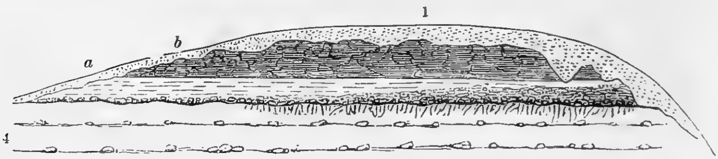
§ The clays near Corfe are, I believe, higher in the series, and belong to the Bagshot Sands. They are brought by the disturbances affecting that district into close proximity to the Chalk.

‖ This section is, however, rather problematical. The conglomerate contains pebbles apparently of the palæozoic rocks. The whole district requires a closer examination. For a description of some Tertiary outliers to the west of Dorchester see Dr. Buckland and Sir H. De la Beche, in Trans. Geol. Soc. 2nd Ser. vol. iv. p. 4.

flints, the latter large and often but little rolled. The whole mass becomes also more irregular and variable, which, with its more shingly and coarser character, indicates a nearer approach to the source from whence these portions of the materials of this division of the Lower Tertiaries were derived. The exhibition, however, of these Lower Tertiaries throughout this district is very imperfect and unsatisfactory *.

If now we proceed northward from the Isle of Wight, we find that beneath Southampton the beds between the London clay and the Chalk consist essentially of mottled clays about 80 feet thick †. At Fareham the railway cutting exposed a good section of bright red mottled clays and the London clay with its fossiliferous Basement-bed above them. At the outcrop of this group at Kembridge, between Romney and Salisbury, we find the only instance I am acquainted with in the Hampshire Tertiary district of a character common to these beds in the western part of the London district, viz. the occurrence of a band of the "*Ostrea Bellovacina*" in a bed of greenish sand immediately over the chalk and beneath the mottled clays ‡. The following is the section taken from my former paper (Journ. Geol. Soc. vol. iii. p. 360):—

Fig. 1.—*Railway-cutting, Kembridge.*



		Feet.
1.	Flint-gravel	2 to 8
b.	Mottled red, grey, and yellow clays	15
a.	Clayey yellow or greenish sand, with an underlie of the *Ostrea Bellovacina* and green-coated flints	4
4.	*Chalk*	6

At Clarendon Hill the strata are very similar to those at Alum Bay, but they are reduced in thickness to about 45 feet, and contain

* One of the best sections near Dorchester is at Yellowham hill, on the Blandford road.

† The section of these beds at the Artesian well of Southampton, as noted by Mr. R. Keele, is as follows:—"These mottled clays were remarkable from the almost entire absence of sand or water throughout the whole formation. No organic remains were found or indications of lignite. The clay was of extraordinary purity and hardness, and of almost every variety of colour. The last 6 or 8 feet of the lowest beds were of less degree of purity, the clay being mixed with a coarse flinty sand as they approached the main bed of chalk; the last 5 feet of the bed was of a dark green colour, and mixed with water, with black flint, pebbles, and very coarse sand, all strongly tinted with the dark green colour above-mentioned."

‡ There is probably some other locality near Salisbury where this shell occurs, as the *O. undulata* figured by Sowerby from the neighbourhood of that city is apparently the *O. Bellovacina* of the Tertiary beds.

several subordinate beds of sand. At Bishopstoke, near Winchester, on the contrary, the mottled clays have nearly disappeared, and appear to be replaced, in part or wholly, as at Addington near Croydon, by sands and thick beds of rounded flint-pebbles in yellow sand. In one pit at Stoke Common they are 12 to 15 feet thick, and exactly resemble the shingle beds to the S.S.E. and E.S.E. of London.

Taking an easterly course from this line, the mottled clays and some associated pebble beds * range past Chichester, Arundel, to Highdown hill near Worthing, to the north of which, at the village of Clapham, a thick stratum of small rounded flint-pebbles overlies the clays as at Croydon; but whether these pebbles belong to the Basement-bed of the London clay or to the mottled clay group, there is at present no evidence to show. Wick House hill on the west of Brighton is capped by a few beds of mottled and carbonaceous clay reposing on sand over chalk—the section is incomplete, and no fossils have been found. Passing thence to the detached outlier at Newhaven, we find a totally different group of strata; a thick bed of sand overlying the chalk, succeeded by a series of laminated grey clays containing numerous fluviatile and estuarine shells.

Particulars of this section have been given both by Dr. Mantell† and Dr. Buckland‡. Owing to the frequent fall of the cliffs, the section, however, is constantly varying. I have never been able to see it in perfectly clear sequence; but still, as there are some points which I have noticed in addition to those described by former observers, I herewith give a rough account of the section, premising at the same time that, owing to the impossibility of approaching some parts of the cliff, it must be considered only as approximative.

Section, upper part of Cliff, Castle Hill, Newhaven.

	Feet.
Gravel of subangular flints and tertiary flint-pebbles in ochreous and ferruginous sandy clay, averages about	6
i. Grey clay passing into dark yellow sand and then again into grey clay: no fossils. [Were it not that part of the upper portion of this bed presents a mottled red appearance, I should have been disposed to consider it as the lower part of the London Clay; even now I am not satisfied but that the small quantity of mottled clay observed may not belong to the overlying drift, the line of separation being at that spot perfectly indistinct and very irregular.]	12
h. Round flint-pebbles in grey clay and yellow sand (Bt.-bed L. C.?) ...	1
g. Laminated grey clay with seams of yellow and ferruginous sand	8
f. Mass of concreted oyster rock (*Ostrea Bellovacina*)	2
e. Layers of comminuted shells, yellow sands, grey clays with well-preserved shells, and with an intermediate bed of grey clayey sand	6
d. Yellow, light brown, and red sand in layers, with seams of laminated grey clay—traces of vegetable matter	5
Carry forward	40

* It is uncertain whether these beds are continuous or not between Botley and Clapham.

† "On the Geological Structure of Sussex," and Trans. Geol. Soc. 2nd Ser. vol. iii. p. 204.

‡ Trans. Geol. Soc. vol. iv. p. 296.

	Feet.
Brought forward...............	40
c. Dark grey laminated clays, sometimes fossiliferous, with thin layers of ironstone—vegetable impressions, and an underlie of ferruginous and carbonaceous clay—selenite common	20 ?
b. White sand 2 feet, to which succeeds ochreous sand 1 to 2 feet, passing down into light greenish sand* : no fossils..........................	25 ?
a. Green and ferruginous-coated flints in greenish sand†	2
Chalk to base of cliff.	87

The organic remains I have found in this section are as follows:—

Cyrena cuneiformis, *Fér.*
—— intermedia, *Mell.* ?
Cerithium variabile, *Desh.*
Dreissena serrata, *Mell.* ?
Hydrobia Parkinsoni, *Mor.* ?
Melania inquinata, *Desh.*
Melanopsis buccinoides, *Fér.*
Ostrea Bellovacina, *Desh.*
Psammobia Condamini, *Mor.*
Unio.
Cypris ?
Leaves of plants figured by Dr. Mantell (in Stratum *c*).

Dr. Mantell also mentions the occurrence of the *Avicula media*, Sow., *Helix lævis*, Flem., and *Cytherea convexa*, Brong. (probably the *Dreissena*, *Hydrobia*, and *Cyrena cuneiformis* of the above list), and Fish-teeth resembling those of the Mustelus.

In addition to these there are in the collection of the Geological Society some curious specimens, apparently of cones and seed-vessels, found by Mr. Warburton. These beds require further investigation.

In consequence of this being a distant outlier, and of the absence therefore of connecting links, the relation of these fossiliferous grey clays and thick beds of sand to the mottled red clays of the Isle of Wight is not readily apparent. That they are in reality synchronous will be further on shown to be probable, by analogous changes in the same division in the London district.

The few foregoing observations merely give a sketch of this group in Hampshire. The rarity of sections and want of time have prevented me from working it out so fully as I could have wished. It will serve, however, to show the relation of this portion of the series to that of the same age in the London district, and which I purpose treating in greater detail. The number of sections exposed to the westward of London along both the north and south lines of outcrop of the Lower Tertiaries renders this a work of comparative facility, until we arrive in the neighbourhood of London. The chalk tract separating the Hampshire Tertiaries from those of the London district at their nearest point of approach is about twenty miles broad.

London District.—In entering upon this area we find the middle division of the Lower London Tertiaries resuming its position with characters almost identical with those under which it outcrops in the neighbourhood of Salisbury, as the two following sections will show:—

* At Seaford this sand contains masses of rough ferruginous sandstone concretions: and the flints of stratum *a* beneath it are often cemented into considerable-sized blocks.

† It is at the base of this bed that the *Websterite* and hydrate of alumina occur.

*Clarendon Hill, Hampshire** (*several small pits in a brick-field*).

		Feet.
London Clay.		
I.	Basement-bed of the London clay (flint-pebbles in clay and sand) ...	1
II.†	Mottled clays with a few subordinate beds of sand, about..........	45
	a. Flints and pebbles in green sand and clay	1
Chalk.		47

Pebble Hill, Berkshire (*section from two pits in nearly adjoining brick-fields*). Pl. I. Diag. A, Loc. sect. 2.

		ft.	in.
London Clay.			
I.	Basement-bed of the London clay (flint-pebbles in clay and sand)	0	9
II.	Light mottled greenish clay	10	0
	Irregular bed of sand	5	0
	Sandy grey and brown clay passing into slightly mottled clay ...	25	0
	Red tile clay	5	0
	Fine sand	3	0
	Band of *Ostrea Bellovacina*	0	3
	a. Flints and pebbles in green sand and clay........................	1	0
Chalk.		49	0

In Marlborough Forest the tertiary beds are so thin and so disturbed by, or mixed with, drift, that no good sections can be obtained; enough, however, is exposed to see that they consist of mottled clays with sands and pebble beds reposing upon chalk. At Bagshot Hill, two miles west of Hungerford, the series is more complete, but is badly shown, and consists of the following beds:—

Bagshot Hill (*section from a few small pits and road-side cuttings*). Pl. I. Diag. A, Loc. sect. 1.

		Feet.
I.	Flint-pebbles in clay and sand, some blocks of puddingstone on surface...	3
e.	Laminated yellow clays and sands ....about	12
d.	Dark mottled clays, light green with bright red.......................about	35
c.	Imperfect iron-sandstone and sand	2
b.	Yellow sand and green clayey sand, with a thin seam of oysters at base...	8 ?
a.	Ferruginous clay with small flint-pebbles	0½
		60½

Chalk, with a very uneven surface.

The *Ostrea Bellovacina* is the only fossil found in this section, which is merely exposed in part and is given approximately. At Prosperous Wood these beds are more sandy, and contain subordinate layers of iron-sandstone 2 to 3 feet thick. At Inkpen mottled clays again preponderate and are worked to some extent: they are not fossiliferous. At Pebble Hill the irregular and undulating bedding of the Reading series is apparent, both in the section taken by itself, or viewed in relation to the Wickham and Newbury pits.

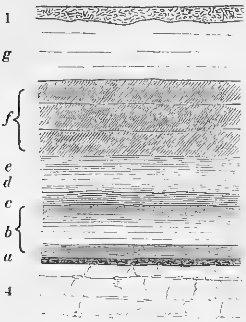
* See Quart. Journ. Geol. Soc. vol. vi. pp. 257 & 258 for fig. of this and the following Section.

† Group II. probably would admit of as many divisions as the mottled clays at Pebble Hill, but the section is too imperfect (the lower beds not being exposed when I was there) to give the exact sequence and thickness of each bed: on the whole also it is more argillaceous.

At a pit on Liquid Farm, three and a quarter miles E.S.E. of Aldbourne, and at Hopgrass Pit, one and a half mile W.N.W. of Hungerford, isolated masses of the mottled clays are worked, apparently in depressions or hollows on the summit of the chalk hills. In both places the clays are interstratified with thick beds of sand, are extremely irregular in their stratification, and none of the beds contain any fossils. At Wickham, five and a half miles north-west of Newbury, the section of these beds, showing a considerable change from the series at Pebble Hill, which is three and a half miles further south, is tolerably complete.

[*The vertical scale of this and all the following sections, except when mentioned to the contrary, is* 50 *feet to the inch.*]

Fig. 2.—*Wickham* (*section from three or four pits in the brick-field*).



		Feet.
1.	Gravel of pebbles and subangular flints in clay and sand	5
g.	Yellow sands more or less argillaceous	15 ?
f.	Mottled black, red and greenish clays	20 ?
e.	Brown and yellow clay and ochreous sand	5
d.	Light yellow sand striped ochreous and grey	4
c.	Very tough greenish grey clay	3
b.	Grey sand passing down into a fine white sharp sand	12 ?
a.	Light brown clay and green-coated flints beneath	2 ?
		66
4.	*Chalk**	15

I have found no fossils in these pits. The lower sand beds are more developed here than at the places before mentioned, being liable to rapid and considerable variations. In some places they are 10 to 20 feet thick, and in others not more than 2 or 3. Further, at Newbury, in the half mile of railway cutting, they pass (horizontally) from a nearly white colour to apple-green, and then to yellow. The same sands and clays are also worked in pits at Stock Cross and Donnington.

One (or rather two in adjacent works) of the best sections in this district occurs at Clay Hill, Shaw, one mile E.N.E. of Newbury. With the exception of a small break, the sequence from the London Clay down to the Chalk is complete. No fossils are met with in the upper part of the Reading series, but in the lower part the bed of *Ostrea Bellovacina* is extremely well developed, and the shells in a fine state of preservation, although friable. Many of them are very large, as much as 7 or 8 inches in diameter. In the same bed are also found fish-bones, teeth of *Lamnæ* and other fish, a few bones of *Chelonia*, minute spine of *Echinoderm*, a few *Foraminifera* (*Globulina*), and *Cythere Mulleri*.

* The depth to which the Chalk is penetrated in this and the following sections varies of course from time to time, and is only given approximately.

Clay Hill, Newbury (connected section of two adjoining chalk and clay pits). Pl. I. Diag. A, Loc. sect. 3.

		Feet.
III.	Brown clay and traces of shells* (*London Clay and Basement-bed*)	10
II.	*j.* Mottled red and bluish clay	15
	i. White sand	1
	h. Mottled clay	10
	g. Sands and loam, only partly exposed	10?
	f. Light-coloured and ochreous sand, laminated	3
	e. Laminated dark grey clay, grey and green sand, and a few pebbles†.	8
	d. Ditto, with *Ostrea Bellovacina*	1
	c. Dark grey clay mixed with green sand: no oysters	2
	b. Dark grey clay mixed with green sand, *oysters, teeth,* &c.: pebbly...	1
	a. Dark grey clay mixed with green sand, pebbles, and a few unrolled flints	1
		62
	Chalk, with tubular surface-perforations filled with green sand	20

In this part of Berkshire the mottled clays preponderate on the south side of the Tertiary area, whilst on the northern outcrop the sands are more largely developed. This latter is especially the case at Courage and Oare, a few miles northward of Newbury.

At Red Hill, seven and a half miles west of Reading, the section is as follows :—

Red Hill (pit in brick-field). Pl. I. Diag. A, Loc. sect. 4.

		Feet.
e	Red and purple clay passing down into red and green mottled, and then red alone	20
d.	Patch of angular chalk fragments, subangular flints, and flint-pebbles	1
c.	Mottled red and yellow sand	0½
‡*b.*	Light-coloured sand	6?
		27½

The peculiarity of this section is the occurrence of a patch of angular chalk fragments and flints, resembling ordinary gravel, beneath the main mass of mottled clay §. I found no organic remains in this place. At Sulham near Pangbourne the sands overlying the chalk are more than 20 feet thick. At Rose Hill, and again at Woodcot Common, to the north of Reading, there is a considerable outlier of unfossiliferous mottled clays and sands. The section at Katesgrove pit, Reading, is well known from the description of Dr. Buckland ||, who noticed also the rapid change by which, on the opposite side of the

* These were first noticed by Mr. Rupert Jones.

† I have recently found traces of fossils in this bed which require further examination.

‡ The letters affixed to the different beds of the Woolwich and Reading Series in the several sections do not mark equivalent strata, with the exception of "*a*," which is always confined to the commencing or lowest bed of the series. Where the letters begin further on in the alphabet, it is merely to indicate that the series is not complete—that some of the lower beds are wanting.

§ In digging a well at Bradfield, between this spot and Reading, the mottled clays are said to have been above 130 feet thick; but this seems to me doubtful.

|| Trans. Geol. Soc. 2 ser. vol. iv. p. 276. Since the period of Dr. Buckland's visit, the "Basement Bed of the London Clay" with its well-characterized fossils has been exposed by the extension of the pit further into the hill. (See Rolfe in Trans. Geol. Soc. 2nd ser. vol. v. p. 127.)

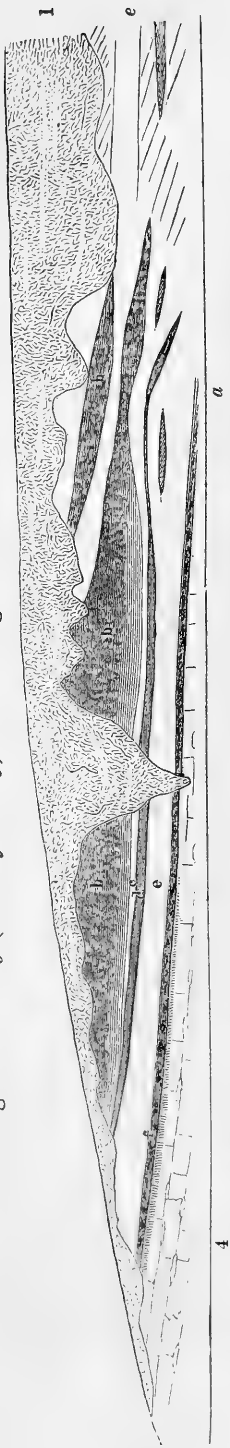


Fig. 3.—*Reading (Railway-cutting)*. Pl. I. Diag. A, Loc. sect. 5.

valley at St. David's Hill, sands almost entirely replace the clays of the Katesgrove pit (Pl. I. Diag. A, Loc. sect. 6).

A feature of considerable interest connected with this series was exhibited in the railway cutting for the Newbury branch line through the hill west of and adjoining Reading. Under the mottled clays there were a few feet of sand, and then a local and lenticular mass of very finely laminated light greenish clay abounding, in places, with the most beautifully preserved impressions of plants. Beneath this bed were strata of yellow sand succeeded by the bed of green sand with the *Ostrea Bellovacina*. I give this section in full, both to show these points and also as a good instance of the irregular deposition of the mottled clay series. (For the plants see Pl. IV.)

		Feet.
1.	Ochreous flint-gravel, varies greatly in thickness—averages	10
b.	Mottled red and light bluish grey clay passing down into slightly laminated light grey clays	20
c.	Laminated yellow sands	2
d.	Thin layers of light grey and greenish clays more or less sandy; some of the seams consist of a very pure and fine clay slightly mottled with a tinge of red. Extremely perfect and very numerous impressions of leaves are found in this bed	4
e.	Fine yellow sand with slight false stratification. Ferruginous clayey sand in patches—soft ferruginous casts of wood	8
a.	Green sand with a band of *Ostrea Bellovacina* at *f*	2
		46
4.	*Chalk*, with tubular surface-perforations filled with green sand at *f*	6

East of Reading the cutting of the Great Western Railway at Sonning Hill afforded an excellent section of the Reading series and of the Basement-bed of the London Clay. Here, the sands which, between Newbury and Reading, are often as fully developed as the mottled clays, disappear almost entirely, and pass into or are replaced by mottled clays. This section also shows the peculiar waved and irregular lines of bedding of these strata, which here as usual contain no organic remains*.

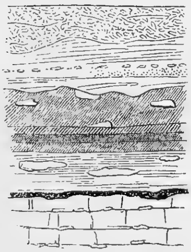
* The workmen however described to me a specimen which, from their account, would appear to have been the head or jaw of a fish that they had found in the middle of this series. The Basement-bed of the London Clay, which caps the hill, abounds in well-preserved fossils.

Sonning Hill (*Railway-cutting*). Pl. I. Diag. A, Loc. sect. 7.

			Feet.
		Subangular flint-gravel, ochreous,—varies in thickness, averages	12
III.		*Basement-bed of the London Clay*,—fossiliferous brown clay with yellow and green sand, pebbles, and septaria	5
II.	*l.*	Slightly mottled bluish and red, passing eastward into grey, clay	10
	k.	An irregular seam of sand, in some places yellow, in others of a light bluish colour	2
	j''.	Mottled brown and blue } clays	23
	j'.	Dark grey } clays	
	j.	Mottled red and grey, the lower part lighter } clays	
	i.	Irregular seam of white sand	2½
	h.	Red clay	1½
	g.	Light grey clay	0½
	f.	Very dark grey clay	6
	e.	Red clay	2
	d.	Light grey clay	1
	c.	Yellow sand with bands of brown clay*	2
			67½

At Twyford the section consists almost entirely of compact mottled green and red clay. Northward of this district we find several outliers of the lower tertiaries reposing upon the elevated chalk district of Oxfordshire, Berkshire, and Buckinghamshire. A very striking instance of this occurs at Nettlebed, nine miles due north of the main mass of the tertiaries at Reading, and only two miles distant from the edge of the chalk escarpment. The tertiary beds here attain a height of 820 feet above the sea-level. No fossils are found in this section, which is interesting, however, from its showing blocks of sandstone *in situ*.

Fig. 4.—*Nettlebed Hill* (*section from several small pits in brick-field*).



		Feet.
1.	Gravel, chiefly flint-pebbles—averages about	5
e.	White and yellow sands with ironstone nodules: flint and a few quartz pebbles occur in the lower part of this bed	12
d.	Light greenish clay, whitish sand and masses of sandstone, and red sands and clays	10
c.	{ Red, Black, Light green } slightly mottled clays	7
b.	White sand with some large and very compact concretionary sandstones in the upper part of it, also a few dark red ferruginous nodules	10
a.	Green sand and flints	1
		45
4.	*Chalk*	10

The two high and conspicuous hills between Maidenhead and Henley are formed by tertiary outliers. Another outlier forms the

* Beneath this bed, which was the lowest exposed, were said to be 10 feet of dark clay reposing upon 5 feet of ash-coloured sands, succeeded by the green-coated flints 1 foot, and then chalk.

high hills at Lane End, four miles west from High Wycombe. The summit of this hill consists of *London clay* with a thin layer of the "Basement Bed," with its characteristic fossils beneath it; this is succeeded by sands and mottled and laminated clays reposing upon the chalk. Sands predominate, and no fossils have been found.

On the chalk hills around Missenden, Amersham, and the Chalfonts, traces of the lower tertiaries frequently occur, but they are so covered and mixed with drift that it is rarely that clear sections can be obtained. One and a half mile east from Chesham is Tiler's Hill, where again we find, at a distance of nine miles north of the main mass of the tertiaries, an outlier of London clay reposing upon the lower tertiaries.

The falling in of the shaft of a chalk-pit has recently (1853) assisted in exposing a complete section of this hill from the London Clay down to the Chalk. Though not very accessible, it shows a clear unbroken sequence, and affords therefore a good key-section.

Tiler's Hill, Chesham (section from sand-pit and shaft of chalk-pit in the brick-field). Pl. I. Diag. B, Loc. sect. 1.

		Feet.
	Gravel, chiefly of flint-pebbles in clay, averages	4
London Clay.	*b.* Brown clay with a few nodular septaria	10
	a. Layers of laminated grey and brown clay	3
I. *Basement-bed of the London Clay, 3½ feet.*	*c.* Layer of imperfect septaria full of fossils*	0½
	b. Light brown sandy clay	2
	a. Flint-pebbles in clay	1
II. *Woolwich and Reading Series, 31 feet.*	*h.* Umber-coloured clay, in places slightly mottled red and yellow	2
	g. Fine siliceous sand, in places very white	3
	f. Light-coloured soft sandstone with an occasional pebble—variable	1
	e. Light-coloured siliceous sands with a few seams of grey clay, the lower part coarser, yellow, and brown	10
	d. Laminated grey and yellow clay and sand, with an under-seam of pebbles	1
	c. Yellow and ash-coloured sand with seams of grey clay	8
	b. Grey clay laminated with sand	4
	a. Large unrolled flints, apparently white-coated	2
		51½
Chalk		25

It is to be observed that here a layer of the sand passes in places occasionally into soft sandstone.

Returning southward we fall in with the main body of the tertiaries near Beaconsfield. In a section at Pitlands Wood, one and a half mile east of this village, thin patches of subangular flints occur apparently beneath the mottled clays. From Starveall to Hedgerley is a succession of sections which are interesting from their exhibiting the very rapid structural changes which take place in these sands and mottled clays.

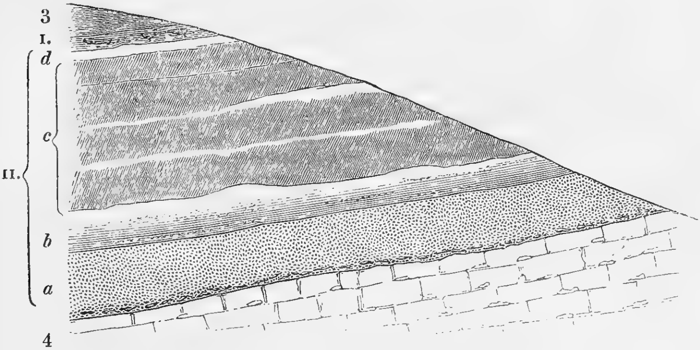
The two local sections, 12 and 13, in Plate I. Diag. A, are actual

* The *Ditrupa plana* abounds, together with *Ostrea Bellovacina*, a few *Natica glaucinoides*, a *Fusus*, and teeth of *Lamna*.

ones, less than half a mile apart. In this short distance the mottled clays almost entirely disappear and are replaced by sands *.

At Uxbridge and Pinner the mottled clays are largely developed. The shafts sunk to procure chalk at the latter place † give sections very similar to that at Hedgerley; but on Pinner Hill, in place of the mottled clays, sands and pebbles predominate, as shown on the side of the lane leading from the summit of the hill to Hamper Mill. At Watford a remarkable development of the rolled pebble bed immediately overlying the chalk occurs. It there forms a mass 15 feet thick, with a matrix of ochreous clayey sand, which gives it the appearance of the ordinary drift-gravel.

Fig. 5.—*Watford* (*general section on railway, Bushey cutting*).



			Feet.
3.	*London Clay.*		
I.	Basement-bed of the London Clay with numerous fossils		5
II.	*d.*	Sands	3 ?
	c.	Mottled clays with a few beds of sand	35 ?
	b.	Sand nearly white, with a few layers and patches of flint-pebbles	10
	a.	Shingle-bed of flint-pebbles in ochreous sand	15
			68
4.	*Chalk*		5

At Welwyn this division consists essentially of sands with irregular subordinate beds of grey clays, occasionally mottled red and green, layers of flint-pebbles, and thin seams of iron-sandstone. At Hatfield ‡ the mottled clays are entirely replaced by sands, which at Hertford again give way in part to clays. The oyster bed overlying the chalk is developed again in this neighbourhood. The sections are from pits in a brick-field at George's farm, one mile from Hertford, on the London road.

* For a section of the Hedgerley Pit (10) see Journ. Geol. Soc. vol. vi. p. 268.

† A section in full, taken by Mr. Morris, of the Pinner pits is given in Journ. Geol. Soc. vol. vi. p. 269.

‡ For the section at this place see Quart. Journ. Geol. Soc. vol. vi. p. 270.

Near Hertford (section from chalk-pit and pits in the brick-field).
Pl. I. Diag. C, Loc. sect. 2.

		Feet.
	Mixed clay and gravel	1
I. *Basement-bed of the London Clay*, 6½ *feet.*	*b.* Brown sandy clay laminated with tougher clay, containing casts of *Panopæa*, &c.	6
	a. Flint-pebbles in clay	0½
II. *Woolwich and Reading Series*, 32 *feet.*	*f.* Light greenish sand	4
	e. White or ash-coloured sand	6
	d. Light yellow sands	4
	c. Light-coloured mottled red and grey clays	10 ?
	b. Yellow sand with patches of the *Ostrea Bellovacina* in places at its base	6 ?
	a. Green-coated flints	1
		39½
Chalk		12

At Seacombe and Collier's End, north of Hertford, mottled clays seem altogether to replace the sands (Pl. I. Diag. C, Loc. sect. 1). The section at the latter place is peculiar from the circumstance of the flint-pebbles, which usually form, with the quartzose sand, the shingle bed at the base of this series, being here enveloped in, and forming part of, the mottled clays, which therefore come down in actual contact with the chalk*. To the south of Hertford, on the contrary, sands predominate, as at Northaw, which is noted for its fine bed of the *Ostrea Bellovacina* (Pl. I. Diag. C, Loc. sect. 3).

The mass of lower tertiaries capping the chalk hills between Ware and Bishop Stortford affords no good sections. Several small pits, of which that at Patmore Heath is the best, show the prevalence of mottled red clays with sands and pebble beds.

Patmore Heath, three miles west of Manewden.

	Feet.
Brown clay and gravel	1
Mottled red, brown and grey sandy clay	2
Ash-coloured sand with laminæ of brown clay and a seam of flint-pebbles	2½
Flint-pebbles in light greenish grey clay	1½

The *Chalk* crops out at about 6 feet lower.

I am doubtful whether the Thanet Sands range thus far north. If they do, they must be represented by the bed of sand which is to be seen reposing on the chalk in a few pits between Bishop Stortford and Newport. The sections, however, are so far between and so indistinct, that throughout Essex I do not know of one satisfactory exhibition of the Lower London Tertiaries; still enough is shown to lead to the belief that sands there prevail in this series almost exclusively. In Suffolk there are a few sections in the neighbourhood of Hadleigh and Ipswich†, where it appears that the space of 30 to 40 feet between the London clay and the chalk is occupied by sands only; but whether they belong to the Woolwich beds or to the Thanet

* This is the only spot in which I have seen the mottled clay come directly into contact with the chalk. Elsewhere it is always separated by a few feet of sand, green sand, or ferruginous clay.

† For sections of these pits at Gestingthorpe, Hadleigh, Ipswich, and Kyson, see my former paper in Quart. Journ. Geol. Soc. vol. vi. pp. 271, 272.

Sands, there is in these sections no evidence to show. I am inclined, however, to think that a portion, if not the whole of them, may possibly belong to the former group*. According to the Rev. W. B. Clarke, the evidence of its extension in Suffolk is more definite†. In well-sections at Harwich (p. 370) he mentions the occurrence of beds of *mottled clay*, sand, and shingle; also of vegetable impressions in a brown clay at Higham Bridge (p. 373)‡.

It would thus appear that mottled clays, irregularly interstratified with sands, prevail along the western portion of the northern outcrop of the Woolwich and Reading series, whilst north-eastward this series seems reduced generally to a simple thick bed (or beds) of sand. With the exception of the *Ostrea Bellovacina* found occasionally at the base of this group, no other shells are met with along that line. There is nowhere any appearance of the Woolwich group of fluviatile shells, but traces of vegetable matter and teeth of *Lamna* occasionally occur.

As the surface-sections do not afford us sufficient proof of the exact connection of the sands and mottled clays of Reading with the sands, clays, and pebble beds of Woolwich, we must retrace our steps to Uxbridge and Watford, and endeavour to follow the continuation of these beds underground to London and Woolwich. Although passing through a district in which several deep wells have been sunk, there are, owing to the want of correct details, but a few amongst the number which are available in evidence.

First is the well at the Hanwell Lunatic Asylum, of which general particulars were taken§ and rock-specimens‖ preserved.

* The foreman at the Kyson pit stated that large oysters (*Ostrea Bellovacina*?) were occasionally found in the sand beneath the pebble bed with the mammalian teeth.

† Trans. Geol. Soc. 2nd ser. vol. v. pp. 361–383.

‡ In many of this author's sections, some beds, which are described as "London Clay," "Plastic Clay," and "Plastic Sand," will, I believe, be found to belong to the Boulder Clay and the unproductive sands of the Crag (Nos. 33, 40 and 43, p. 376; Nos. 44 to 49, p. 377; Nos. 55, 56, 59, p. 378; No. 65, p. 379). At Balingdon Hill (p. 375) there should be 30 to 40 feet of the unproductive sands of the Crag and of the Lower Tertiary Sands between the diluvial clay and the chalk. These errors of description detract from the weight to be attached to this, in other respects, valuable document.

Since writing the above, I have learnt that in an artesian well at Colchester the "Lower London Tertiaries" were only 30 feet thick (Brown, Ann. & Mag. Nat. Hist. for October 1853).

§ In the *well-sections* the names given by the well-digger are throughout retained. I have however, in most cases, added another column with the geological grouping, as I interpret the descriptions, in italics. The italics in parentheses are also introduced in explanation of some of the terms.

It will be observed that the "Basement Bed of the London Clay" rarely appears in these sections. This I believe arises from the fact that, owing to its general thinness and not very striking mineral characters, it has been almost always overlooked in well-sections. Wherever specimens have been preserved, I have generally found evidence of its existence.

I may remark that many of these deep wells have been sunk within the last ten, and all within the last thirty or forty years.

‖ Amongst the specimens which I have examined, there were the following London Clay shells, but they were loose and not placed:—*Cancellaria læviuscula*, *Cytherea obliqua*, *Fusus bifasciatus*, *Natica*, *Nucula Bowerbankii*, *Panopæa intermedia*, *Rostellaria Sowerbyi*.

Well-section, Hanwell. (*As the exact limits of the different beds are not given in a printed section, the measurements here assigned to them must be considered only as approximate.*) Pl. I. Diag. A, Loc. sect. 15.

		Feet.
Surface soil and drift	Vegetable soil; Gravel, sand, sand and gravel	21
London Clay	Brick clay; Blue or London clay; Piece of fossil wood; Vein of stone (*layer of septaria*); Vein of stone (*septaria*); Fossil shell; Several shells; Vein of stone with shells imbedded (*septaria with Cyprina planata, Astarte, and fruit-like impressions*); Vein of stone (*septaria*); Indurated mud and sand	190
I. *Basement-bed of the London Clay, 4 feet.*	Mud, sand, and pieces of wood (*also tabular septaria with bivalve shells not determinable*)	2
	Pebbles (*flint*) and shells	2
II. *Woolwich and Reading Series, 75 feet.*	Mottled clay (*red, grey, yellow, light green and puce*)	23
	Sand	2
	Clay (*mottled light grey and red*)	13
	Indurated sand, clay, and mud (*light brown sandy clays with a seam of bituminous clay*)	10
	Clay (*mottled brown and light green*)	8
	Green sand and clay (*with some carbonaceous matter*)	8
	Bed of oyster-shells as hard as rock	3
	Pebbles (*flint*)	4
	Bed of flint-stones (*in green sand*)	4
		290
Chalk		30

In this section the mottled clays descend very near to the chalk, and are underlaid only by 3 feet of green sand, then by a concreted mass of the *Ostrea Bellovacina* reposing upon a bed of round black (flint) pebbles, under which comes the green-coated unrolled flints overlying the chalk. The next section is at Castlebear Hill near Ealing.

Well-section, Castlebear Hill. Pl. I. Diag. A, Loc. sect. 16.
(Communicated by Mr. R. W. Mylne*.)

		Feet.
London Clay.	Blue clay	300
II. *Woolwich and Reading Series, 60 feet.*	*e.* Sand and silt	30
	d. Coloured clays and black clays with pebbles	15
	c. Black, yellow, and green sands	5
	b. Pebbles and black clay	9
	a. Flints	1
	To the Chalk	360

* For this and several succeeding well-sections I am indebted to Mr. R. W. Mylne, the author of "Sections of the London Strata," towards the further illus-

In the collection of the Geological Society is a series of specimens and a section of a well at Twyford near Acton, particulars of which are annexed. A bed of black bituminous clay with appearance of decomposed shelly matter occurs about 20 feet down in the mottled clays.

Well-section, Twyford. Pl. I. Diag. A, Loc. sect. 17.

		Feet.
London Clay.	*b.* Yellow clay	38
	a. Blue clay	170
I. *Basement-bed of the London Clay.*	*c.* Rock	1
	b. Sand and clay with pebbles	1
	a. Pebbles	1
II. *Woolwich and Reading Series.*	*f.* Mottled clays	36
	e. Sand	3
	d. Clay, not traversed	2
		252

Stratum *b.* I. here contains, as at White Cliff Bay, small fragments or pebbles of the underlying mottled red clays, as well as flint-pebbles.

At Watford we have seen that the shingle beds of the Woolwich series repose immediately upon the chalk. The Thanet Sands are absent also at Pinner.

Section of a shaft at Pinner near Harrow.

(Mr. J. Morris.)

		Feet.
London Clay ...	Marly clay	12
I. *Basement-bed of the London Clay, 2 feet.*	*b.* Sand with shells and septaria	1
	a. Vein of pebbles	1
II. *Woolwich and Reading Series, 39 feet.*	*d.* Soapy marl	5
	c. Mottled clay—red, blue, green, &c.	26
	b. Pure white sand, sometimes ferruginous, and containing masses of sandstone, very irregular	4
	a. Green marly sand with flints	4
	To the Chalk	53

At Willesden there are several deep wells, but I have not been able to obtain an exact section of any of them. From a good supply of water, however, being obtained before reaching the chalk, it is probable that the Thanet Sands have here commenced. At Notting Dale this deposit evidently exists; but in the following section it is probably confounded with the shingle beds of the Woolwich series; the "Pebbles and Sand" including, I believe, two distinct beds.

tration of which subject that gentleman has collected an amount of evidence of this description, as will, I expect, throw much light on the local changes which these beds undergo.

Well-section, Notting Dale, near Notting Hill.

(Mr. R. W. Mylne.)

	Feet.
Made ground	12
Gravel	5
London clay	154
Mottled clay	35
Pebbles and sand	38
	244
Chalk	12

This point is made clearer by the following more careful section near Westbourne Grove.

Well-section, Westbourne Estate Waterworks.
Pl. I. Diag. A, Loc. sect. 18.

(Mr. R. W. Mylne.)

		Feet.
London Clay.	*b.* Yellow clay	29
	a. Blue clay	188
II. *Woolwich and Reading Series,* 62 *feet.*	*f.* Mottled clay	40
	e. Pebbles	2½
	d. Green sand, pebbles, and clay	7½
	c. Sand and small pebbles	3½
	b. Green sand	2½
	a. Sand, pebbles, and clay	6
III. *Thanet Sands,* 18 *feet.*	*b.* Grey sand	17
	a. Flints	1
		297
	Chalk	15

Having thus traced the Woolwich and Reading beds into juxtaposition with the Thanet Sands in this direction, we will now return to our starting-point at Hungerford and follow the former along their southern outcrop.

At Highclere, near Newbury, the section at the brick-pit is as under:—

Highclere.

		Feet.
	London clay	12
I. *Basement-bed.*	Large flint-pebbles in sand	1
II. *Woolwich and Reading Series.*	*e.* Fine ochreous sand	10
	d. Mottled light red, yellow and grey brick-clay, the upper part sometimes being a red tile clay	25
	c. Whitish sand	10
	b. Iron-sandstone	1

At Ewhurst the following section of a well near the church was given me from recollection by the man who had made it a few years previously*:—

* There is apparently some mistake in these measurements, although I believe the order of succession and the occurrence of *lignite* (*b*) to be correct.

Well-section, Ewhurst.

		Feet.
II. *Woolwich and Reading Series.*	*f.* Red and blue mottled clay	20
	e. Blue clay with pebbles	15
	d. Black clay with small oysters	15
	c. A bright ore (*iron pyrites*)	3
	b. Coal (*lignite*)	7
	a. Green sand and gravel (*flints*)	2
		62
	Chalk	17

At Chinham, near Basingstoke, mottled clays prevail, as they do also at Old Basing, where they are 50 to 60 feet thick, with only one bed of yellow sand about 5 feet thick above and 2 feet of sand below them. It is uncertain whether about 20 feet of fossiliferous brown clay, overlying the sand and mottled clays, should not be included in this division, but the railway section, when I saw it, was too imperfect to admit of a satisfactory examination. A further investigation of the organic remains at this locality would be desirable.

At Odiham and Farnham these beds present but little variety, consisting almost entirely of mottled clays about 30 feet thick. The following is the section of a well at Dogmersfield Park near Odiham:—

Well-section, Dogmersfield Park.

(A. Bond.)

		Feet.
Bagshot Sand	*b.* Clay and sand	15
	a. Fine light bluish sand	25
London Clay	Blue clay with septaria	330
I. *Basement-bed of the London Clay?*	*b.* Sand, quite green	1½
	a. Stone (*septaria*)	2½
II. *Woolwich and Reading Series.*	*g.* Sand, quite green	1½
	f. Clay, yellow, mottled red with some grey	5
	e. Clayey sand, bluish grey striped red	10
	d. Chocolate-coloured clay mottled with grey	11½
	c. Mottled light grey and red clay	15
		417

East of Farnham the band of *Ostrea Bellovacina* is found on the chalk. At Guildford we meet with the first traces of the Woolwich shell beds. They form on the top of the mottled clays a thin stratum with an eroded surface, on which reposes the "Basement-bed of the London Clay" (see Section in Journ. Geol. Soc. vol. vi. p. 260, and Pl. I. Diag. B, Loc. sect. 6 in this volume).

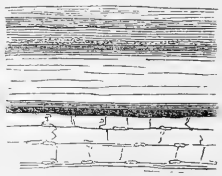
At Fetcham the sand bed immediately overlying the chalk is said to be 35 feet thick*, and to be underlaid by a band of the *Ostrea Bellovacina*. On the chalk hills south of Leatherhead are several outliers of the "Lower London Tertiaries" consisting chiefly of sands and pebble beds. The most important one is at Headley-on-the-hill,

* In open sections I have never seen it above 10 to 12 feet thick.

where there is a considerable thickness of mottled clays, capped by a thick pebble bed similar to that at Blackheath, and underlaid by 2 to 3 feet of sand with the *Ostrea Bellovacina.*

At Epsom the Thanet Sands commence: at least it is to that deposit I would refer the lower beds (III.) in the following section on the railway, half a mile north-east from that town.

Fig. 6.—*Railway Cutting, Epsom.*



		Feet.
II.	*d.* Brownish sand	3
	c. Green sand	2
	b. Coarse yellow and green sand with flint-pebbles in its lower part	4
	a. Laminated grey clay......	$1\frac{1}{2}$
III.	*c.* Fine white sand	12 to 15
	b. Grey sand	2
	a. Green sand and flints ...	$0\frac{3}{4}$

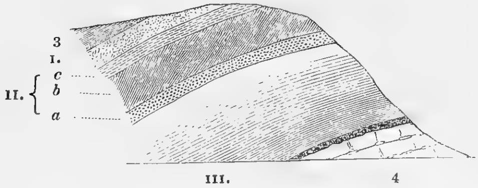
Near Ewell the mottled clays are worked at Nonesuch Park, but the section is very imperfect.

Thus far the middle division of the "Lower London Tertiaries" consists entirely of sands and mottled clays (with a comparatively small quantity of flint-pebbles at their base), remarkable for the absence of organic remains, excepting a bed of the *Ostrea Bellovacina* common, but not constant, in the thin stratum of sand and pebbles reposing immediately upon the chalk. We now, however, arrive at a point where a very considerable, and rather sudden, change takes place. Thick masses of rounded flint shingle, alternating with sands and less frequently with grey and carbonaceous clays often laminated, and characterized by a peculiar estuarine and freshwater fauna, now intervene between the "Basement-bed of the London Clay" and the "Thanet Sands." Into this mass the mottled clays, however, occasionally dovetail in a manner sufficiently clear to show the relation and synchronism of these two very distinct-looking groups.

This change takes place nearly on a line passing N. and S. through London. The Diagrams A. and C. Pl. I. exhibit the leading phænomena. The following sections will serve further to show the connection of these two groups of strata. It will be seen that the mottled clays do not hold, as might be supposed from some of the sections around Blackheath, any definite position either above or below the Woolwich fluviatile beds, but that they alternate with the whole series, sometimes appearing only above and sometimes only below the latter, and at other times both underlying and overlying them.

At Croydon there is no complete section of these beds, but the following may be considered as the approximate sequence at Park Hill, on the east of that town. It has been taken, with Mr. Flower's assistance, on different occasions when the several beds have been separately and partially exposed.

Fig. 7.—*Park Hill, Croydon.*



			Feet.
	3. *London Clay* (base not shown).		
I.?	Pebble beds	about	10
II.	*c.* Clay with *Ostrea, Melania,* and *Cyrena*	„	6
	b. Mottled clay	„	25
	a. Green sand and flint-pebbles	„	5
III.	Thanet sands	„	30
	4. *Chalk.*		

Owing to the number of *well-sections* which are necessary to trace the sequence of the beds across two other lines of section,—the one S. and N. from Croydon to London, and thence to Ware, and the other W. and E. from Esher to Chelmsford,—I have considered it better to remove them from this part of the paper, and to place them at the end, as an Appendix.

To resume now with the sections exposed by pits at the surface, eastward of the meridian of London.

Between a line drawn from Croydon to Orpington, and the Thames, is a district in which the pebble beds both of the Woolwich group and of the Basement-bed of the London clay* are largely developed. With the former group are constantly associated seams of fluviatile fossiliferous clays and occasionally even of considerable masses of the mottled clays. Very few sections are exposed in the central and south-western portions of this district: the whole series is extremely variable, and no very distinct order rules, except that on the whole mottled clays (thinning out eastward) prevail in the lower part, shelly beds in the central, and shingle in the upper part, but that not exclusively, of this group.

In proceeding eastward, the first sections of any consequence we arrive at are in the neighbourhood of Hayes Common. Two pits existed a few years since in a garden on the south side of the lane leading down from that Common to Nash Farm, whilst a more recent cutting made in deepening the same lane completed the section to the top of the hill. This general section, which showed tolerably well two zones of the Woolwich shells with the mottled clays between them, is rendered in Plate I. Diag. C, Loc. sect. 19. There is also a section showing the pebble beds, mottled clays, and shelly beds in the lane leading down from Hayes Common towards Wickham (Pl. I. Diag. C, Loc. sect. 18).

* The shingle beds of this division continue at intervals in considerable force, as at Abbey Wood near Erith, Rowhill Wood Hill south of Dartford, Windmill Hill, Gravesend, Shorne Hills, and Gad's Hill near Rochester.

At Orpington the Woolwich and Reading group decreases in importance. The following section was shown in a road-cutting at Crofton Pound near that village.

Orpington.

		Feet.
Woolwich and Reading Series.	*l.* Fine yellow sand	6
	k. Dark grey clay	$0\frac{3}{4}$
	j. Mass of comminuted shells, chiefly *Cyrena cuneiformis*	1
	i. Yellow clay and concretionary slabs of earthy limestone, full of the *Ostrea Bellovacina*	1
	h. Light brown clay	$0\frac{3}{4}$
	g. Rough thin concretionary limestone full of *Ostrea* and *Cyrena*	2
	f. Mixed brown and grey clay	$1\frac{1}{4}$
	e. Mass of broken shells (*Cyrena, Melania, Cerithium*) in yellow clay	$3\frac{1}{2}$
	d. Mottled bright red and light greenish clay	$2\frac{1}{2}$
	c. Brown clay, full of small flint-pebbles	1
	b. Bright yellow clay	$1\frac{1}{2}$
	a. Dark clayey green sand, passing down into very light-coloured loose green sand, with a few thin layers of flint-pebbles	8
		$29\frac{1}{4}$

Traces of the mottled clays are visible yet here. The lower part of this group now often assumes the character of the Thanet Sands, from which it can only be distinguished by a few scanty seams of pebbles. On the hill west of St. Mary's Cray the separation of the two groups is however extremely well marked, as the pebbles form a dense mass in a bed of green sand.

Immediately north of the line just passed over is a district where, amidst a most variable series and a large development of unfossiliferous flint-shingle and sands, one section stands out in bold relief, and almost alone there preserves the fauna of the group: for a short distance near Bromley and Chiselhurst portions of the usually loose and sandy beds are rendered solid by a calcareous cement; and at Sundridge Park, where they are occasionally worked, they present a mass 25 to 30 feet thick of a hard light-coloured conglomerate, with a few subordinate sand beds, abounding in fossils. The upper beds in particular of this section show a strong false stratification shelving 12° to 22° northward. The exact position of these strata cannot be recognised in this section: I believe them, however, to be synchronous with the upper sands at Lewisham and the pebbly sands overlying the fossiliferous clays at Woolwich. The same beds are occasionally solidified nearer to London, but nowhere to the same extent as at Sundridge and beneath Chiselhurst Hill.

Organic remains, Sundridge Park Pit.

Cerithium variabile, *Desh.*
Corbula Regulbiensis, *Mor.*
Cyrena cuneiformis, *Fér.*
—— deperdita, *Sow.*
—— tellinella, *Desh.*
—— cordata, *Mor.*
—— intermedia, *Mell.*
Fusus latus, *Sow.*
Glycimeris?
Melanopsis buccinoides, *Fér.*
Melania inquinata, *Desh.*
Modiola dorsata, *Mor.*
Natica glaucinoides, *Sow.*
Neritina globulus, *Def.*
Nucula fragilis, *Desh.*
Ostrea Bellovacina, *Desh.*

Ostrea tenera, *Sow.*
Hydrobia Parkinsoni, *Mor.*
Patella.
Pectunculus terebratularis, *Desh.*
Planorbis hemistoma, *Sow.*
Pholas.
Serpula.
Crustacea (Cancer ?).
Teeth of Lamna.
Scales of Fishes.
Flustra.
Cythere ?
Fragments of wood and imperfect vegetable impressions.

Further northward in this district we meet with some better and well-known sections. The lower part of the Woolwich series is here generally formed of pebbly sands, remarkable on account of their variable and peculiar characters. At Loam Pit Hill, Lewisham, the section of which has been given both by Dr. Buckland* and by Conybeare and Phillips† (see Pl. I. Diag. C, Loc. sect. 10, and explanation of the same), these sands are in greater part ferruginous and 18 feet thick. On the hill between Lewisham and Lee the pebbles, instead of being imbedded in sand, are in a matrix of mottled clays, which elsewhere occasionally entirely replace both sands and pebbles. No fossils are found either at Deptford or Lewisham. At Woolwich this portion of the series consists of 1 foot of pebbles in an argillaceous green sand, with about 18 feet of a slightly pebbly greenish and ochreous sand above them. In the sand are a few calcareo-ferruginous concretions, and in these are found casts and impressions of the *Cyrena cuneiformis* and *Cerithium variabile.* In all these localities this bed, when exposed, is seen to repose upon an eroded surface of the Thanet Sands, but it is more especially to the east of Woolwich that this is apparent. The pebbly sands there come down on the Thanet Sands in great sweeps, as shown in the following section on the North Kent Railway, representing a length of 200 to 300 feet and a depth of about 12 to 20.

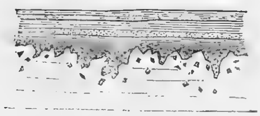
Fig. 8.—*Section on the Railway East of Woolwich.*

W. The vertical scale of this section is 100 feet to the inch. E.

II. Base of Woolwich and Reading series. III. Thanet Sands.

But the clearest and most singular exhibition of this phænomenon is in a small pit on the left of the road ascending the hill from Plumstead to Abbey Wood Common, where this pebbly bed has been as it were splashed into the soft and yielding surface of the underlying Thanet Sands.

Fig. 9.—*Abbey Wood Common*‡.



II. Dark pebbly argillaceous green sand.
III. Light-coloured Thanet Sands.

* Geol. Trans. vol. iv. p. 287, and Pl. 13. † Geology of England and Wales, p. 49.
‡ The last time (May 1853) I visited this spot this section was covered over.

This distinguishing feature is, however, so irregularly maintained, that at Erith, where in the Ballast pit this middle group overlies the Thanet Sands, the line of demarcation between them can hardly be traced : the two sands are almost exactly alike, and the pebble seams are wanting. But the organic remains here assist us, as a band, marked by the occurrence of the *Ostrea Bellovacina*, defines the line of separation of the two groups*.

Above this basement-bed are a series of fluviatile clays and pebbly sands generally abounding in fossils. It is in the lower part of this, or in the middle of the central division of the Lower Tertiaries, that the well-known fluviatile clays of Woolwich are placed. This stratum ranges from London† to Rochester, a distance of thirty miles, but with a breadth not exceeding five to six miles, except near London, where it extends from twelve to fifteen miles. The general character of this bed is well known from the descriptions of Dr. Buckland, Dr. Mitchell, Mr. Morris, and the Rev. H. De la Condamine, to whose papers I beg to refer‡ for some of the principal sections in this district.

As, however, the fossils of the Woolwich pits require both additions and corrections, I herewith annex a list of those found in the bed of dark grey clay (Nos. 7 & 8 of Dr. Buckland).

Organic Remains of the Woolwich Clay Bed, Ballast Pit §.

(Pl. I. Diag. A, Loc. sect. 25.)

Cyrena cuneiformis, *Fér.*
—— deperdita, *Sow.*
—— cordata, *Mor.*
Cerithium variabile, *Desh.*
—— gracile, *Mor.*
Cypris ?
Fusus latus, *Sow.*
Melania inquinata, *Desh.*
Melanopsis buccinoides, *Fér.*
Neritina globulus, *Def.*
Nucula fragilis, *Desh.*
Ostrea Bellovacina, *Desh.*
—— tenera, *Sow.*
Hydrobia Parkinsoni, *Mor.*
Planorbis hemistoma, *Sow.*
Psammobia Condamini, *Mor.* ?
Small Corallines.
Opercula (of Cerithium ?).
Eggs of Molluscs ?

The fossiliferous pebbly sands overlying this clay bed at the Woolwich pit must, I think, be referred to the upper part of this series. They contain the following fossils :—

Organic Remains of the Pebbly Sands, Woolwich Ballast Pit.

Arca depressa, *Sow.*
Auricula pygmæa, *Mor.*
Balanus ?
Buccinum (Pseudoliva) fissuratum, *Desh.*
Calyptræa trochiformis, *Lam.*

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* See also Journ. Geol. Soc. vol. vi. p. 443.

† Including the detached and isolated patch (which however belongs to a higher part of the series) at Guildford, the range of the fluviatile beds would be nearly sixty miles.

‡ *Ante*, p. 76.

§ The fossils of this pit have been most carefully worked out by Mr. De la Condamine, Mr. Lunn, and Mr. Rosser, in whose collections I found most of the rarer specimens of the accompanying lists.

Cardium Plumsteadiense, *Sow.*
Cerithium variabile, *Desh.*
—— Lunnii, *Mor.*
—— Bowerbankii, *Mor.*
Cyrena deperdita, *Sow.*
—— cordata, *Mor.*
—— cuneiformis, *Fér.*
—— intermedia, *Mell.*
—— tellinella, *Desh.*
Fusus latus, *Sow.*
—— gradatus, *Sow.*
—— planicostatus, *Mell.* ?
Melanopsis ancillaroides, *Desh.*
—— buccinoides, *Fér.*
Melania inquinata, *Desh.*
Modiola Mitchelli, *Mor.* ?
Murex foliaceus, *Mell.*
Natica glaucinoides, *Sow.*
Neritina consobrina, *Fér.*
Neritina globulus, *Desh.*
—— pisiformis, *Fér.*
—— vicina, *Mell.* ?
Nucula fragilis, *Desh.*
Ostrea Bellovacina, *Desh.*
—— tenera, *Sow.*
Hydrobia Parkinsoni, *Mor.*
—— Websteri, *Mor.*
Pectunculus terebratularis, *Lam.*
Pholas ?
Planorbis hemistoma, *Sow.*
Teredina personata, *Desh.*
Teredo antenautæ, *Sow.*
Teeth of Lamna.
Scales and teeth of Fishes.
Crustacea (Cancer).
Small seed-vessels (Carpolithes ?).
Cythere &c. (Entomostraca, list, p. 120.)
Small Bryozoa.

There are also two undescribed sections to which I must allude, as they present several peculiar and interesting features. The first is one by the side of the new road leading down the hill from Charlton: it is taken from two or three small pits, but the sequence is perfectly clear. On the top of the hill is the Blackheath pebble bed; then follows—

(Pl. I. Diag. A, Loc. sect. 24.)

		Feet.
II.	*e.* Light yellow sands striped with clay	12
	d. Light yellow sands with thin seams of iron sandstone	5
	c. Dark grey clay with shells	6
	b. Layer of hard concretionary limestone	2
	a. Pebbly green sand	10
III.	Thanet Sands.	

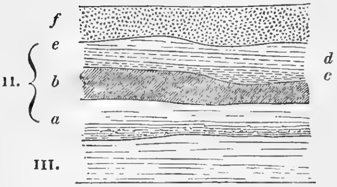
The beds "*a*, *b*, *d*, and *e*" are non-fossiliferous, but the clay bed "*c*" contains the same organic remains as at Woolwich.

The blocks of argillaceous limestone "*b*" are concretionary masses of frequent occurrence in this neighbourhood. They are exceedingly hard and tough, and contain here no organic remains. (This stratum is more fully developed beneath London, and is often a source of considerable difficulty to the well-digger.)

But the most important feature of this section is the occurrence on the upper surface of a thin seam of iron sandstone, interstratified in the upper part of "*d*," of well-marked *ripple-marks*, the ridges of which run nearly E. and W. This is the only instance I have met with of a ripple-marked surface in the Tertiary series of the London district.

The second section is at the entrance to the Tunnel on the S. side of Blackheath, and differs in several points from the preceding Charlton section.

Fig. 10.—*Section on the Railway near the Blackheath Station.*



		Feet.
	f. Blackheath pebble bed	10 to 12
II.	*e.* Brownish sand	2
	d. Comminuted shells in light-coloured clay with pebbles	4
	c. Comminuted shells in greenish grey clay* ..	2
	b. Light green sandy clays, mottled red and grey	7
	a. Light greenish sands with a few pebbles...	6
III.	Thanet Sands.	

Here the upper part of "*a*" of the preceding section passes into mottled clays. The fossils of "*c*" are similar to those of the same bed at Charlton and Woolwich: those of "*d* and *e*" are few and badly preserved, but at a distance of about half a mile further westward towards Lee these beds are richer in organic remains, which are for the greater part the same as those found in the "Pebbly Sands" at Woolwich, but not so well preserved. The main points of difference are, the far greater abundance of the *Modiola Mitchelli* at Lee,—a shell extremely rare at Woolwich,—and the absence or great rarity at the former place of the *Cardium* and *Pectunculus*.

In the neighbourhood of Blackheath this upper portion of the middle division of the Lower London Tertiaries often consists of alternating thin layers of light grey or brownish clays and yellow sand, which in the section of Loam Pit Hill, Dr. Buckland designated as "striped sands" and "striped loams"; and the former term has since been applied by Mr. De la Condamine to denote generally the upper part of this division,—a subdivision, however, which, although well-marked in that vicinity, can only be considered as a local feature.

The railway cutting at New Cross was interesting from its exposing a more freshwater condition† of the strata than usually prevails, and from its showing the relation of these upper beds of the Woolwich series to the London clay. Only the higher beds of the group were here exposed, consisting of—

(Pl. I. Diag. C, Loc. sect. 9.)

	Feet.
London clay	40
Basement-bed London clay (flint-pebbles in ochreous sand) ...	1 to 2
i. Yellow sand	$2\frac{1}{2}$
h. Clay and sand, with shells occasionally..........................	3
g. Band of freshwater limestone (*Paludina*)	$0\frac{1}{2}$ to 1
f. Sand and shells	6
e. Clayey sand and shells	5

The order of succession of the lower beds was made known by a well sunk at the Naval School, New Cross.

* At a distance of a quarter of a mile E. this bed becomes 6 feet thick, of a dark grey colour, and full of shells.

† The same beds extend to Peckham on one side, and to Counter Hill and Lewisham on the other.

Well-section, New Cross. (Pl. I. Diag. C, Loc. sect. 8.)
(Mr. R. W. Mylne.)

		Feet.
London Clay.	Yellow clay	10
	Blue clay	13
II. *Woolwich and Reading Series.*	*i.* Shells in sand	10
	h. Hard shells	3
	g. Sand with water	1
	f. Sand with shells	15
	e. Shells and clay mixed	5
	d. Sand	1
	c. Hard shells in sand	2
	b. Pebbles	15
	a. Green sand	2
III. *Thanet Sands.*	Hard sand	14
	Sand	34
		125
	Chalk	25

To the band of freshwater limestone, attention has been called by Mr. Warburton*. It is full of the following fossils:—

Melanopsis buccinoides, *Fér.*
Paludina lenta, *Sow.* var. *a*, *Mor.*
Hydrobia Parkinsoni, *Mor.*
Teeth, bones, and scales of Fishes.
Unio (Deshayesii, *Wat.*?).
Traces of vegetable impressions.

The *Unio* has only been found at a very short distance to the E. and W. of this place. The *Paludina*, which can scarcely be distinguished from the Isle of Wight species, hardly exceeds the limits of this area: it has been found however as far north as Limehouse. Beneath this bed are clays and sands also containing a somewhat different group of fossils. The following is a list of those which I collected during the cutting of the railway:—

Arca depressa, *Sow.*
Calyptræa trochiformis, *Lam.*
Corbula Regulbiensis, var. β, *Mor.*
Cyrena cuneiformis, *Fér.*
—— cordata, *Mor.*
—— deperdita, *Sow.*
—— tellinella, *Desh.*
Cerithium variabile, *Desh.*
Melania inquinata, *Desh.*
Melanopsis buccinoides, *Fér.*
Modiola Mitchelli, *Mor.*
Ostrea Bellovacina, *Desh.*
—— tenera, *Sow.*
Hydrobia Parkinsoni, *Mor.*
Cypris?
Bones and scales of Fishes.

———

Cythere, sp.
Foraminifera (last 3 sp. in list, p. 118).

To the above specimens may be added the following species from the Counter Hill pits:—

Pectunculus terebratularis, *Lam.*
Planorbis lævigatus, *Desh.*
Psammobia Condamini, *Mor.*
Impressions of plants.

When these upper beds contain subordinate seams of pebbles, it becomes difficult to separate them from the "Basement-bed of the London Clay," which reposes upon this division in a very irregular manner.

At Woolwich no line of separation can in the present section be drawn between the great mass of shingle, which I presume belongs to the Basement-bed of the London clay, and the fossiliferous pebbly sands; but about twelve or fifteen years since, when the section

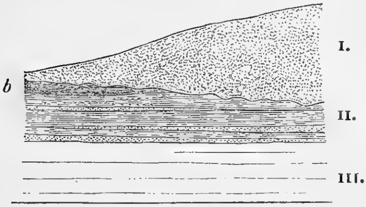
* Journ. Geol. Soc. vol. i. p. 172.

extended further southward, a waved irregular line generally separated these latter from some unfossiliferous pebbly beds above. The upper bed being derived in great part from the destruction of the lower, and the materials being so similar, renders it difficult to discriminate between them either here or anywhere in the immediate district. Viewed, however, on a large scale, this distinction is apparent. In conjunction with Mr. De la Condamine I had an excavation 10 feet deep made beneath the London clay at the north base of Shooter's Hill, and found that it reposed directly, and without admixture of pebbles, upon the great mass of sandy shingle spread over Plumstead Heath and Blackheath; just as at New Cross and Lewisham it reposes upon an equally compact bed of similar shingle, but which in these localities is only 1 to 2 feet thick. This latter bed I have before shown to extend uninterruptedly westward through the London district and as far as the Isle of Wight, maintaining throughout its range a general thickness not exceeding 2 to 5 feet. Although attaining such a remarkable thickness at Blackheath, still as no break or division can be detected in the mass, it may be considered as a development of the same bed,—a view confirmed by a constant character before shown to attach to the Basement-bed of the London clay, viz. that of reposing upon a worn and eroded surface of the underlying beds. This feature is very marked in the Blackheath district. Great hollows, swept out of the pebbly sands and fossiliferous clays, are filled up by these masses of shingle beds. In one locality on Blackheath the upper sands of the Woolwich group are 25 feet thick and come almost close to the surface, whilst in a pit a few hundred feet N.W. and on the same level the sands are entirely wanting, being replaced by the pebble beds. Very thick agglomeration of pebbles, and frequent false stratifications shelving down, generally northward, from 20° to 35°, mark these pebble beds, which in some places on Plumstead Heath attain the great thickness of 50 to 70 feet. Traces of shells are occasionally met with in them, but they are in so friable a state that it is difficult to determine their characters. The *Cardium*, *Nucula*, and *Cyrena*, all probably the same as the Woolwich species, have been recognised.

Proceeding eastward from Woolwich the Middle division of the Lower Tertiaries resolves itself more distinctly into—1st, upper beds of sand with subordinate layers of pebbles, clay, and containing many of the shells found in the pebbly sands of Lee and Woolwich; 2nd, beds of laminated brown or dark grey clay with *Ostrea*, *Cyrena*, *Melania*, and *Cerithium*, 6 to 10 feet thick; and 3rd, lower beds of pebbly light-coloured green sand varying in thickness from 10 to 30 feet.

The upper bed has, however, often been removed by the denudation preceding the deposition of the "Basement-bed of the London clay," —a denudation which has sometimes deeply eroded this middle division, as shown for instance in the section on the side of the lane leading from the Abbey Wood Station up the Abbey Wood hills, where the Basement-bed of the London clay reposes upon the lower beds of the Woolwich series. The middle bed (fossiliferous clays) exists further back (S.) in the hill and crops out by Wickham Church.

Fig. 11.—*Lane in Abbey Wood.*



		Feet.
I.	Basement-bed of London clay * (flint shingle-beds)	+10
II.	Light green sand with seams of pebbles; traces of laminated clays occur at *b*.	14
III.	Thanet Sands	+20

Numerous small sections of the fossiliferous clays and associated beds may be seen on the higher hills between the valleys of the Cray and the Darent, as at St. Paul's Cray Hill, Well Hill, Croking Hill, Joyden Wood's Hill, and elsewhere; and again, east of the Darent, on the Swanscombe Hills near Greenhithe, on Windmill Hill, Gravesend, and on the Shorne and Cobham Hills near Strood. The section east of Bexley on the hill leading to Dartford Heath, the one between Green Street Green and Betsham, and that traceable on the path and road-sides in descending from the summit to the south side of Windmill Hill, Gravesend, are represented under the Loc. sect. 29, 30, 31, and 32, Diag. A, Pl. I. The section at Shorne, Loc. sect. 33, is taken in the lane leading from the high-road near Gad's Hill to Shorne Ridgeway.

At Upnor near Rochester the section, which is unusally clear and distinct, shows the London clay with its Basement-bed reposing upon the fluviatile sands and clays, which in their turn overlie the Thanet Sands. These latter, however, do not appear in the larger pit where there is the capping of London clay, but in the sand-pit by the brick-field to the S.W. of it. (See Journ. Geol. Soc. vol. viii. pl. 15.)

The general view of the pits is as follows:—

(Pl. I. Diag. A, Loc. sect. 34.)

			Feet.
	London clay		+25
I.	Basement-bed of the London clay		$4\frac{1}{2}$
II. *Woolwich and Reading Series.*	*c.*	Light yellow and whitish sands, containing irregular patches of shells, chiefly *Ostrea* and *Cyrena*; occasionally the shells form a layer 1 ft. thick at the base of this bed. Upper surface worn and eroded by "I."	15
	b.	Dark grey clay full of shells, both perfect and comminuted, and with a subordinate thin seam of sand, $3\frac{1}{2}$ feet. Dark clay passing down into a brown sandy clay—a few casts of shells—selenite plentiful, 2 ft. Tough yellow clay, sand and ochre, and lignite, $\frac{1}{2}$ ft.	6
	a.	Fine white sand $2\frac{1}{2}$ feet. Sand, grey and brownish-red at top, passing down into light yellow, 20 ft. Light ochreous sand, 3 feet. Small flint-pebbles in greenish sand, $2\frac{1}{2}$ ft.	28
III.	Thanet Sands		+20

* In a cutting on the side of the new road just made a short distance east of this section, the "Basement-bed" reposes upon the pebbly sands of the Woolwich and Reading series. The division of these two groups is here perfectly well shown, the line of separation being distinct and irregular, and the pebbly sands, which are far more pebbly than at Woolwich, and contain numerous very friable and badly preserved shells, chiefly *Cyrena*, being in clear contrast with the overlying mass of non-fossiliferous and larger shingle.

The fossils* found in Stratum "*c*" are—

Cerithium variabile, *Desh.*
Cyrena cuneiformis, *Fér.*
—— deperdita, *Sow.*
—— cordata, *Mor.*
Melania inquinata, *Desh.*
Melanopsis buccinoides, *Fér.*
Ostrea Bellovacina, *Desh.*

In addition to the above, the following fossils occur in Stratum "*b*":—

Ostrea tenera, *Sow.*
Hydrobia Parkinsoni, *Mor.*
Planorbis hemistoma, *Sow.*
Psammobia Condamini, *Mor.*
Small vertebræ of Fishes.
Vertebra of Lepidosteus. Pl. III. fig. 1.
Cypris or Cythere?

In the light-coloured pebbly sands "*a*," no fossils have yet been found†.

The persistence of the fluviatile clays from Woolwich to Rochester is sufficiently apparent, but that of the associated pebbly sands beneath is not so. These latter, when the green grains and the pebbles are absent, assume so closely the appearance of the Thanet Sands, that in many places these two groups can scarcely be distinguished one from another; and the clays "*b*" repose upon sands which may easily be mistaken for the Thanet Sands, and to which therefore they might be considered subordinate, instead of being, as I believe them to be, subordinate to the Woolwich group. The separation of the two sands is, however, shown in a sufficient number of instances to be marked and definite; and even when this is not the case, a closer examination of them will generally show that some distinction in the mass does exist, however difficult it may often be in two such similar arenaceous beds to distinguish the line of separation.

Thus far either the mottled clays or the fluviatile clays of Woolwich have given a marked character to the middle division of the Lower Tertiaries, but these mineral and palæontological features cannot be traced eastward of Rochester, and we therefore become dependent upon other evidence for proof of the extension of the "Woolwich and Reading series" into East Kent. As before observed, the pebbly sands "*a*" at the base of this series often want distinctiveness even in West Kent, and this becomes still more apparent as the beds trend eastward; there is a difficulty therefore in connecting the Woolwich and Upnor sections with those of Herne Bay and Canterbury, owing to our having to rely almost entirely upon these beds (*a*) in our traverse across the intervening district. The outcrop of the Lower Tertiaries between the Medway and Faversham rarely extends beyond the low ground at the base of the chalk hills, and consequently there are few of those long lane-sections so common on the hills in West Kent. I have not in fact been able to find one clear section of the whole of the middle division anywhere between the above-named places. Of the Thanet Sands there is no want of sections, and occasionally there are small sections of the lower part of the middle division; scanty, however, as they are, they all exhibit the same features and prove the continued superposition

* For the fossils and details of "1." see Journ. Geol. Soc. vol. vi. p. 264.

† The fossils both of "*c*" and "*b*" require probably further working out. Both these beds vary slightly in structure in close adjoining pits.

of the two divisions, for wherever sections are open at 60 to 80 feet above the chalk we invariably find the Thanet sands capped by the pebbly sands "*a*" of the Woolwich series, the latter being distinguished from the former through this district by its coarser quartzose character, by the admixture of green sand, of small concretionary or tabular iron sandstone, of an occasional thin seam of a hard siliceous sandstone, and sometimes by the presence of a few pebbles; but this latter is a character which becomes less and less marked as we proceed eastward. These beds may be seen on the hill in the marshes W. of Ottersham Wharf, on those near Newington Street, and on the hills W. of Faversham. No organic remains have yet been found at any of these places.

At Boughton, three miles east of Faversham, we arrive at a range of hills extending from this village to Canterbury, and the summit of which consists of London clay, while round its slopes the different members of the Lower Tertiaries crop out and are tolerably well exposed. From several sections we find that the middle division or "Woolwich group" has here passed entirely into light ash-coloured and greenish, and ochreous sands 30 to 40 feet thick. At Boughton the following section is exposed:—

(Pl. I. Diag. A, Loc. sect. 40.)

		Feet.
L.	London clay	+10
I.	*b.* Fine whitish sands with layers of pebbles and traces of shells, and a few teeth of *Lamna*	7
	a. Grey clay	1
II.	Light green, and ochreous, sharp sands	30

No fossils are found in Strata "II." Just before the publication of my paper on the Thanet Sands, I discovered some silicified fossils in a hedge-bank at Oakwell. The superposition of the bed is not shown, and from the occurrence of the *Cucullæa crassatina** and *Cytherea Bellovacina*, I considered that it was probably a part of the Thanet Sands. From subsequent examination of the ground I am, however, led to believe that this bed belongs to the pebbly Woolwich sands ("*a*"), the more especially as I have since found similar fossils in a bed whose superposition to the Thanet Sands is clear. This is the first indication we have of a distinctly marine fauna in this part of the Woolwich group. The following are the species found there:—

Cardium.
Corbula Regulbiensis, *Mor.*?
—— (Arnouldi, *Nyst*?)
Cucullæa crassatina, *Lam.*
Cyprina Morrisii, *Sow.*
Cytherea Bellovacina, *Desh.*
Dentalium.
Ostrea.
Flustra.
Sponge spicula.
Nodosaria bacillum, *Defr.*
A very small undeterminable univalve, and some small bivalves, apparently *Cytherea.*

* The occurrence of this silicified shell in this neighbourhood was noticed some years since by Mr. Crowe of Faversham, and is mentioned in the 'Min. Conch.'; but the exact locality was not given, and its position has remained uncertain up to the present time. It appears to have been found nearer to Faversham, or there were formerly some excavations in Nash Park near Boughton whence some fossils are said to have been obtained.

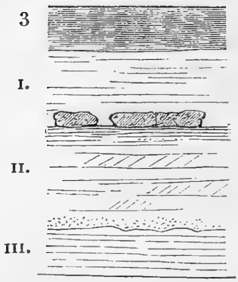
These fossils are, however, very rare: I have not found them elsewhere on this side of Canterbury.

On Shottenden Hill, three miles S. of Boughton, is an outlier of the Lower Tertiaries capping the chalk, and singular in that it exhibits the only instance in this district of the occurrence of the shingle-beds of the Basement-bed of the London clay, forming a mass as distinct as that on Blackheath, and from 30 to 40 feet thick.

Another interesting phænomenon is also met with at this place: beneath the shingle are the light-coloured quartzose pebbly sands of the Woolwich group, and in the upper part of this bed are occasional small masses of a soft concreted sandstone, the upper surface of which is often full of the holes of a boring mollusk, apparently a *Lithodomus*. I have found no other traces of organic remains in these beds.

The next clear section, or rather series of sections, is at the village of St. Stephen's, one mile N.W. of Canterbury. In one pit, the London clay reposing upon the Basement-bed, and in another the latter on the faint-green sands of the Woolwich group, may be seen. But the most complete section occurs at the entrance to the tunnel on the Whitstable Railway, where the sequence of the Lower Tertiaries from the London clay to the Thanet Sands is well exposed.

Fig. 12.—*Section on the Whitstable Railway, near Canterbury.*
(Pl. I. Diag. A, Loc. sect. 42.)



3. London clay.
I. Basement-bed (light sands with large blocks of pebbly ironstone*).
II. Woolwich series (light-coloured sands mixed with some green sand and a few pebbles).
III. Thanet Sands.

The fossils in the "Basement-bed" "I." are numerous; but none occur in the pebbly sands "II.": traces of sponge-like ferruginous concretions are, however, common. Both are about 20 feet thick.

The most important section, however, in this district is on the coast between Herne Bay and the Reculvers. Here, in addition to the large surface exposed, the beds are more fossiliferous than usual. The following is a description of the cliff immediately east of Bishopstone ravine (see Journ. Geol. Soc. vol. viii. p. 239. pl. 15).

* These blocks of ironstone extend to Boughton, from which locality the organic remains enumerated in my paper in the Journ. Geol. Soc. vol. vi. p. 264, were obtained. This bed has since been found to be sufficiently rich in iron to be profitably worked, and it is now, I understand, quarried and sent to the Staffordshire furnaces.

(Pl. I. Diag. A, Loc. sect. 43.)

		Feet.
Drift	Ochreous flint gravel	4 to 6
London clay	Tenacious brown and bluish clay, with few or no fossils	10 to 15
I. *Basement-bed of the London clay* (for the fossils of this division, see Journ. Geol. Soc. vol. vi. p. 265).	*b.* Fine light-coloured siliceous sands, with occasional large tabular masses of sandstone, white, grey, ferruginous, and brick-red. Lenticular twin-crystals of sulphate of lime, and small soft concretionary lumps of the black oxide of iron, common. Seams of flint-pebbles of occasional occurrence. False stratification of the sands not uncommon. Fossils common, occasionally dispersed in the sands, but more commonly in irregular patches, and in the sandstone blocks	22
	a. A layer of flint-pebbles in sand, (yellow, green, and ferruginous,) often concreted; abounds in organic remains	1 to 2
II. *Woolwich and Reading Series.*	*c.* Argillaceous green sand, passing down into yellowish sand with less clay	12
	b. Dark grey argillaceous sand, full of small ferruginous sandy tubular concretions and lumps, passes down into a brownish sandy clay, and then into a light greenish-grey clayey sand, with a very few small flint pebbles. Nodules and lumps of iron pyrites, with coarse green sand and very small quartz pebbles, are common. Wood in fragments and pieces in the state of lignite are of frequent occurrence. A very few teeth and palates of Fishes are found.	7
	a. Light ash-green and yellow sands with casts of shells, passing down into a coarser green sand, near the base of which a thin band of very coarse and bright green sand, sometimes concreted and abounding in silicified shells, occurs............................	9
III. *Thanet Sands.* (Journ. vol. viii. p. 262.)	Yellow, greenish, and grey fossiliferous sands. These only just appear at this spot.	

The strata *a*, *b*, and *c*, II. of this section I take to represent the Woolwich and Reading series. In its lower bed "*a*" there is a group of organic remains, consisting of the following marine species:—

Ampullaria subdepressa, *Mor.*
Cardium Laytoni, *Mor.*
—— Plumsteadiense, *Sow.*
Corbula Regulbiensis, *Mor.*
Cucullæa crassatina, *Lam.*
Cyprina Morrisii, *Sow.*
—— scutellaria, *Desh.*
Cytherea Bellovacina, *Desh.*
Dentalium.
Glycimeris Rutupiensis, *Mor.*
Pectunculus terebratularis, *Lam.*
Sanguinolaria Edwardsii, *Sow.*
Teredo antenautæ, *Sow.*
Thracia oblata, *Sow.*?
Teeth of Lamna.

Fragments and pieces of wood in the state of lignite, frequently bored by the Teredo, are not uncommon, and in an ironstone concretion I found a fine specimen of a Fir Cone (Pl. III. fig. 4). This bed also contains, nearer to the Reculvers, specimens of silicified wood likewise sometimes bored by the Teredo, and with the structure beautifully preserved.

The middle bed "*b*" passes towards Herne Bay into a dark clayey sand full of traces of vegetable matter and with a large number of concretions of iron pyrites. This may possibly represent the carbonaceous and fluviatile clays of Upnor and Woolwich. The only other fossils I have found in this bed were in the cliff at Bishopstone ravine. They consisted of a few rare fragments of *Myliobates, Edaphodon,* and *Chelonia,* but the specimens were too small and imperfect to distinguish the species. A few fish-vertebræ and teeth of *Lamna* also occur.

The upper bed "*c*" is an argillaceous green sand without fossils.

Although rather dissimilar in appearance, the base of these three beds is nevertheless alike, consisting in each case of quartzose sands and green sand. This common character becomes more apparent as the beds trend towards the Reculvers, where they pass into a light greenish quartzose sand easily separable from the Basement-bed above, but without any well-marked line of separation from the Thanet Sands beneath. This want of clear divisional surfaces, and the occurrence of several of the same species of shells in the two series, might be considered an objection to their being thus separated. The fossils, however, taken as a group, are different from those of the Thanet Sands, whilst the sands are more siliceous and contain a larger proportion of green sand and some disseminated flint-pebbles—two mineral characters deriving some importance from their breadth and constancy.

The indistinctness of the separating surfaces is, I believe, to be attributed merely to the lithological structure of the beds; for, owing to the soft and yielding nature of the Thanet Sands on which the sands of the Woolwich series were deposited, the upper surface of the former would be liable to be moved and stirred up by the currents which brought down the latter, and as both must have been in the state of muddy sand, an intermixture of the surfaces in contact would be almost inevitable. An illustration in point is furnished in the same cliff-section between the Bishopstone ravine and the Reculvers. There, in one place, a *drift* of light brown brick-earth reposes upon the Woolwich sands. The difference of age of these two deposits will not be disputed, but nevertheless there is no defined line of demarcation between them, and the "Drift" appears to pass down into these old Tertiary beds.

At Richborough the division of the Thanet Sands from the Woolwich group is still less apparent. A close examination will, however, show the prevailing sharp quartzose and slightly green-sand character of the latter, whilst a thin seam of green sand full of the *Corbula Regulbiensis,* and with an occasional large *Cyprina,* occurs precisely in the position as the same fossiliferous band at Herne Bay. I have recently had this view confirmed by the small but beautiful series of fossils obtained from this bed by the Rev. James Layton of Sandwich at the railway ballast-pit, adjoining Richborough Castle. They consist of the following species:—

Ampullaria subdepressa, *Mor.*
Cardium Plumsteadiense, *Sow.*
—— Laytoni, *Mor.*
Corbula Regulbiensis, *Mor.*
Cucullæa crassatina, *Lam.*
Cyprina scutellaria, *Desh.*
Cyprina Morrisii, *Sow.*
Cytherea Bellovacina, *Desh.*
Dentalium.
Glycimeris Rutupiensis, *Mor.*
Pectunculus terebratularis, *Desh.*
Sanguinolaria Edwardsii, *Mor.*

All these species are silicified, and many of them in the most perfect and delicate state of preservation. (For the description of this section see Journ. Geol. Soc. vol. viii. p. 251 and pl. 15.)

On Woodnesborough Hill and at Ash the Woolwich sands are 26 to 30 feet thick, and consist entirely of one mass, nearly uniform throughout, of light-coloured quartzose sands with green sand in disseminated grains and patches, and with a few dispersed pebbles and slight ochreous patches and concretions. No shells have been found at these latter places, but Mr. Layton has procured from several pits in that district, especially the one at Marshborough, a number of specimens of silicified wood with the structure beautifully preserved. Some of them are pierced by the Teredo, which in one specimen is quite in its young state, just adhering to the wood. These specimens appear identical with those found in these beds at the Reculvers.

I have not met with any beds of the Woolwich group in the Isle of Thanet.

§ 3. *Organic Remains.*

As local lists of the organic remains have been given in the preceding pages, it now only remains to consider their general distribution, association, and condition, and to tabulate the whole.

It has been shown that the Woolwich and Reading series, far from being characterized throughout by similar fossils, exhibit peculiar assemblages in different districts. Where the mottled clays prevail, as over the greater part of the Hampshire and throughout all the London district west of London, organic remains seem altogether wanting, with the exception of the irregularly distributed layer of the "*Ostrea Bellovacina*" at the base of this group, and of the local plant remains at Reading, a few feet higher in the series, but still near its base.

The Woolwich beds continue comparatively barren until they reach the neighbourhood of London. Concomitant with the lithological change before-described, the peculiar group of fresh and brackish water shells of Woolwich appear, and attain their maximum development at London, New Cross, Deptford, Woolwich, Bromley, Chiselhurst, and then decrease in variety and abundance as the beds range to Rochester and Upnor. The species are not many, but the individuals of several are very numerous.

The more strongly marked freshwater conditions are confined to nearly the upper portion of this series at New Cross and a short distance around, where the *Unio*, the *Paludina*, the small *Hydrobia Parkinsoni*, and the *Melanopsis buccinoides* are abundant. The sands, pebbles, and clays just beneath the above contain a more mixed group, of which the prevailing species are the *Cerithium variabile*, *Melania* *inquinata*, *Neritina globulus*, the two species of *Melanopsis* and of *Fusus*, the several species of *Cyrena*, especially the *C. cordata*, *Modiola Mitchelli*, *Planorbis hemistoma*, and *Ostrea Bellovacina*. To these succeeds the well-marked and wide-spread Woolwich clay-bed characterized by the *Cyrena cuneiformis* and *deperdita*, *Hydrobia Parkinsoni*, *Melania inquinata*, *Cerithium variabile*, *Melanopsis buccinoides*, *Ostrea Bellovacina* and *tenera*, and *Planorbis hemistoma*. The other species given in the list p. 117, as occurring in this area (C.), are comparatively scarce.

Traces of plants and seed-vessels have been found in this series at Lewisham, apparently nearly in the same part of it as at Reading; but the earliest mention of plants from this group is by the late Dr. Mantell, who, in his description of Castle Hill, Newhaven, figures one or two specimens which agree apparently with some of the Reading species*. Coniferous wood, in the condition of patches of lignite, occurs in the pebbly sands just above the Thanet sands.

The remains of vertebrate animals are of rare occurrence. I have found fish-bones and a few scales in the Paludina-limestone of New Cross, and they occasionally occur together with teeth of *Lamna* and some smaller fish-teeth in some of the Woolwich beds. Small fish-vertebræ are not uncommon at Upnor, where also the vertebra of a large species of *Lepidosteus* has been found. Remains of the *Edaphodon* and *Myliobates* exist near the Reculvers. Mr. Alport has made known the occurrence in one of the conglomerate beds of this series of the remains of a *Coryphodon* or *Lophiodon*, a tooth of this animal having been found in sinking a well at Sydenham†; and Dr. Mitchell alludes in his manuscripts to the circumstance of the bones of some large animal having been discovered about 15 feet beneath the limestone band at the Counter Hill pits, Deptford. Fossils of this latter description have never come under my notice; but it is to be observed that this pit is only occasionally opened down to these beds. Of the remains of Crustacea I have only found part of the claw of a Crab at Sundridge Park‡.

The fauna of the Woolwich and Reading series in this area (C.), though rich, is very irregularly distributed, the strata being by no means continuously fossiliferous; in some places the organic remains are extremely numerous, whilst at others close adjacent they are wanting§. The fossils are more persistent in the clays than in the

* "Geology of Sussex," p. 257, and pl. 8.

† The Geologist, vol. i. p. 66.

‡ Mr. Rosser has since found a similar specimen at Woolwich.

§ Although the pits in the neighbourhood of London have been so long known, few additions were for a long time made to the list of shells collected by Parkinson and Sowerby. Within the last few years, however, the zeal and industry of the Rev. Mr. De la Condamine, of Blackheath, has brought to light several new species. In addition to the *Lepidosteus* mentioned above, he has discovered the *Psammobia Condamini*, *Planorbis lævigatus*, and a species of *Cythere*, with some peculiar vegetable remains, at Counter Hill, apparently in or near the same bed as that in which Dr. Mitchell noticed the remains of bones. This *Planorbis* has been found nowhere else in England, whilst the *Psammobia* has only been observed in one other specimen at Upnor by Mr. De la Condamine, and one at Newhaven by myself. The *Teredo personata* is a single specimen, also found by Mr. De la sands. With regard to their state of preservation, the Paludina limestone exhibits well-preserved specimens. In the beds beneath this there are considerable bands formed almost entirely of comminuted fragments of shells, whilst in some associated beds the shells are preserved entire, but they are generally very friable. In the clays, although not unfrequently crushed, they are sometimes in an excellent state of preservation. In both these parts of the series the several species of *Cyrenæ* are often found with their two valves together. This fact was especially observable in the pebbly calcareous rocks of Deptford*, where scarcely a single valve either of the *Cyrena* or *Modiola* is found separate.

A very interesting example of this description, and of tranquil entombment, has been pointed out by Mr. De la Condamine at Woolwich, where, in one part of the pebbly sands overlying the bed of clay, the *Cyrena tellinella*, in an excellent state of preservation and the two valves united, occurs in its normal vertical position, as when living it bored into the sands.

The perfect condition of the *Ostrea Bellovacina* at Woolwich and Sundridge has often been noticed†.

In the neighbourhood of Bromley, Chiselhurst, and Lewisham there are beds or bands abounding almost exclusively with this oyster, frequently with the two valves united, and in the position in which it lived. The lowest bed of pebbly green sand immediately overlying the "Thanet Sands" is in this area also characterized by the *Ostrea Bellovacina*; not that it is so generally abundant as in some of the upper beds of this group, but it there constitutes, as in the western area, almost the sole fossil. It has been found in this position in sinking several wells in London (Barclay and Perkins's, Truman and Hanbury's, the Bank, the Mint, and others). It is nevertheless scarcely ever met with in this stratum at its outcrop in Kent; at Erith it occurs occasionally in this bed and of a large size; and I think it exists also at Oakwells near Boughton. North of London this old eocene Oyster-bed is largely developed at Northaw, where it lies, as it does also at Hertford, immediately upon the chalk without the intervention of the Thanet Sands. On the south of London it is again found overlying the chalk at Headley-on-the-hill and Fetcham. These fossil oysters frequently exhibit a much-worn and

Condamine at Woolwich. The upper part of the Woolwich series at Lee and Blackheath has likewise furnished him with several rare species of *Neritina* and a Bracheux *Buccinum*. These latter, together with some new species of *Cerithium* and a *Murex* of the neighbourhood of Laon, exist also in the fine collection from the Woolwich pits made by Mr. Lunn. It was not until the recent close and careful investigation of Mr. Rosser, that *Cytheres* were known to occur in such abundance in the pebbly sands of Woolwich, together with well-preserved fish-scales, numerous small indeterminable bones, the eggs and opercula of Molluscs, a variety of small *Bryozoa*, and *Foraminifera*. These were chiefly found in the interior of the larger shells.

* In the railway cutting.

† Dr. Buckland, in particular, alludes to this circumstance, and to the frequent agglutination of several of these oysters together on some of the large flint pebbles.

eaten surface full of the small holes made by some minute boring sponge.

The surface of the chalk beneath the Oyster-bed is frequently perforated with numerous irregular tubes, running about 6 inches to a foot perpendicularly into the chalk, and filled with green sand from the superincumbent bed. This is particularly visible at Kembridge, Clay Hill, near Newbury, and at Reading.

The shells in this area are found in all stages of growth; many attain a large size. Some of the *Ostrea Bellovacina* measure 5 or 6 inches by 4 and 5; the *Pectunculus* $1\frac{1}{2}$ to $1\frac{3}{4}$ inch in both directions; the *Cyrena deperdita* and *cordata* have a breadth of $1\frac{1}{2}$ inch; and the *C. cuneiformis* sometimes as much as 2 inches; whilst the *Melania inquinata* is often $2\frac{1}{2}$ to $2\frac{3}{4}$ inches long, the *Cerithium variabile* nearly 2 inches, and the *Melanopsis* $1\frac{1}{4}$ to $1\frac{1}{3}$ inch.

The brown epidermis of some specimens of *Cyrena* can sometimes be distinctly traced, and the ligament occasionally remains. Sometimes even the colouring of the shells has not entirely disappeared, and the fine marking on some of the small *Neritinæ* is often retained. The dried animal matter of the animal itself is sometimes preserved in small brown pieces in the interior of some of the shells. Some of the small seed-vessels and portions of leaves also occasionally retain their elasticity and traces of their brown colouring matter.

In the few pits between Upnor and Boughton, which exhibit sections of the lower part only of the "Woolwich and Reading series," I have not, any more than in the same beds at Upnor, been able to discover organic remains. At Boughton, where there is a change in the lithological structure of the Woolwich beds, it is accompanied at the same time by a complete alteration in the organic remains. All traces of the fluviatile shells of Woolwich are lost, and the equivalent beds, which are however imperfectly exposed, appear here to be unfossiliferous; but the light greenish sands on the level of the pebbly green sands and *Ostrea Bellovacina* beds of the central and western areas contain, with a few of the Woolwich forms, a new group of marine fossils in the state of fine siliceous casts. Several of the shells found here, such as the *Cucullæa crassatina, Cytherea Bellovacina,* and *Corbula* (*Arnouldi*?), are common to the underlying Thanet Sands; but there are others which are peculiar to these overlying beds, such as the fine *Cyprina scutellaria,* the *Pectunculus terebratularis,* the *Cardium Plumsteadiense,* and the *Corbula Regulbiensis.*

In the neighbourhood of Canterbury this division is unfossiliferous, but in the cliffs between Herne Bay and the Reculvers we again meet with the zone of silicified fossils (*ante,* p. 111).

Nearer the Reculvers these beds contain silicified wood, of which, however, better specimens have been found by the Rev. James Layton of Sandwich in the pits between Ash and Wodnesborough. The structure of this wood is in general coniferous, but some specimens show a remarkable form of dicotyledonous texture. No shells are found there. At Richborough the lower part of this group again presents a thin band of silicified fossils of the same species as those of Herne Bay and Boughton, and in a beautiful state of preservation with every marking retained. As at the two former places the characteristic shell is the *Corbula Regulbiensis*, which occurs aggregated in masses; the *Cucullæa crassatina* is also abundant, as likewise the large *Cyprina scutellaria**. Although silicified and hard, they are, when first found, extremely brittle; and perfect specimens, except of the *Corbula*, are difficult to be procured.

In Essex and Suffolk I have not been able to find any organic remains in the few sections exposed in this division, with the possible exception of an oyster at Kyson. Nor does the Rev. W. J. Clarke, who was well acquainted with Suffolk, mention the occurrence of any fossils in the numerous localities he describes†.

List of the Organic Remains of the Woolwich and Reading Series‡.

[The second column gives their synonyms, and the third indicates whether their range is in the Western (W.), Central (C.), or Eastern (E.) areas. See the area-divisions in p. 78. The "n. sp." refer to the new species described by Mr. Morris, and figured in Pl. II. of this volume.]

Bivalves.

Arca depressa, *Sow.*	*A. striatularis*, Melleville?	C.
Cardium Laytoni, *Mor.*, n. sp.		E.
—— Plumsteadiense, *Sow.* (*a*).	*C. semigranulosum*, Desh. n. Sow.	C. E.
Corbula (Arnouldii, *Nyst*?) (*b*).		E.
—— Regulbiensis, *Mor.* (*c*), n. sp.		E.
—— —— var. β. *Mor.*		C.
Cucullæa crassatina, *Lam.*	*C. decussata*, Park.	E.
Cyprina Morrisii, *Sow.*	*Venus ovalis*, Sow. M. C. pl. 567. fig. 2, non fig. 1?	E.
—— scutellaria, *Desh.*	non *C. scutellaria*, Nyst	E.
Cyrena cordata (*d*), *Mor.*, n. sp.	an *C. obovata*, var. *a*. Sow. pars?	C.
—— cuneiformis, *Fér.*	*Cyclas deperdita*, Pk. text, non fig.	C.
—— deperdita, *Sow.*	non *C. deperdita*, Desh. or Park.	C.
—— intermedia, *Mell.*	an *C. Deshayesii*, Héb.	C.
—— tellinella, *Desh.*		C.
Cytherea Bellovacina, *Desh.* (*e*).	*C. orbicularis*, Mor.	E.
Dreissena serrata, *Mell.*? (*f*).		C.
Glycimeris Rutupiensis, *Mor.*		C.? E.
Lithodomus		E.
Modiola Mitchelli, *Mor.* (*g*), n. sp.		C.
—— dorsata, *Mor.*, n. sp.		C.
Nucula fragilis, *Desh.*		C.
Ostrea Bellovacina, *Desh.*	*O. pulchra, edulina, undulata*, S.	W. C.
—— tenera, *Sow.*	*O. angusta* & *plicatella*, Desh.?	C.
Pholas?		C.

* Some specimens of this shell measure 4 inches by 3.

† The recent section at Chelmsford (Artesian well, Appendix) would seem to show that shells do there exist. I was, however, unable to see the specimens, or to learn exactly whether any had been kept. They would probably be crushed by the auger, as the bore-hole was very small.

‡ I have to express my obligations to Mr. Morris, Mr. Edwards, and M. Deshayes for their kind aid and assistance in the comparison of many of these fossils. To Mr. Morris I am further indebted for the description of the new species.

Pectunculus terebratularis, *Lk.* (h)	*P. Plumsteadiensis*, Sow.	C. E.
Psammobia? Condamini, *Mor.*, n.s.	....	C.
Sanguinolaria Edwardsii, *Mor.*...	....	E.
Teredina personata, *Desh.*	*Teredo antenautæ*, S., pars, f. 4-8	C. E.
Teredo antenautæ, *Sow.*	*Ibid.* fig. 1–3	E.
Unio (Deshayesii, *Watelet* ?) (i)..	....	C.
Thracia oblata, *Sow*..........	*Lutraria*, Sow.	E.

Univalves.

Ampullaria subdepressa, *Mor.*, n.s.	....	E.
Auricula pygmæa, *Mor.*, n. sp...	....	C.
Buccinum (Pseudoliva) fissuratum, *Desh.* ? (j)	....	C.
Calyptræa trochiformis, *Lam.* ..	*Infundibulum echinulatum*, Sow.	C.
Cerithium Lunnii, *Mor.*, n. sp...	....	C.
—— gracile, *Mor.*, n. sp.......	....	C.
—— Bowerbankii, *Mor.*, n. sp...	....	C.
—— variabile, *Desh.*, var. *c, f, & g.*	*C.* (*Potamides*) *funatum, intermedium & funiculatum*, Sow. (k)	C.
Dentalium	....	E.
Fusus latus, *Sow.* (l)	*F. deceptus*, Desh.; an *Buccinum granulosum*, Mell.?	C.
—— gradatus, *Sow.* (m)	....	C.
—— planicostatus, *Mell.* ?	....	C.
Hydrobia Parkinsoni (n), *Mor.*, n.s.	....	C.
—— Websteri, *Mor.*, n. sp.....	....	C.
Melania inquinata, *Def.*	*Cerithium melanoides*, Sow. ..	C.
Melanopsis ancillaroides (o), *Dh.* ?	....	C.
—— buccinoides, *Fér.* (p)......	*M. fusiformis*, Sow., pars, f. 3-5.	C.
Murex foliaceus, *Mell.* ?	....	C.
Natica glaucinoides, *Sow.* (var.?)..	non *N. glaucinoides*, Desh.; an *N. labellata*, Lam.	C.
Neritina consobrina, *Fér*.......	....	C.
—— globulus, *Def.*	*N. uniplicata*, Sow..........	C.
—— pisiformis, *Fér*..........	or *N. ornata*, Mell. ?	C.
—— vicina, *Mell.* ? (q)	....	C.
Paludina lenta, *S.*, var. β. *Mor.* (r)	....	C.
Patella	....	C.
Planorbis hemistoma, *Sow.*	....	C.
—— lævigatus, *Desh.* ?........	....	C.

Entomostraca*.

Cythere Wetherellii, *Jones*. Pl. III. fig. 9	C.
—— Kostelensis, *Reuss*, sp. Pl. III. fig. 10	C.
—— plicata, *Münst*. Pl. III. fig. 11	C.
—— angulatopora, *Reuss*. Pl. III. fig. 12	C.
—— (Cytheridea) Mulleri, *Münst*. Pl. III. fig. 7	W. C.
—— —— *var.* torosa, *Jones*. Pl. III. fig. 8	C.
Candona Richardsoni, *Jones*. Pl. III. fig. 13................	C.

Foraminifera.

Globulina..	W.
Nodosaria bacillum, *Defr*.	E.

* For the determination of this and the following group, I am entirely indebted to Mr. Rupert Jones.

Truncatulina	C.
Textularia	C.
Globigerina	C.

Pisces.

Edaphodon (not determinable)	E.
Lamna (*Odontaspis*) [L. Hopei and dubia, *Agas.* ?] (*s*)	W. C. E.
Lepidosteus, n. sp. Pl. III. fig. 1	C.
Myliobates (not determinable)	E.
Small undeterminable teeth, scales, and vertebræ and other bones	C. E.

Miscellanea.

Lophiodon or Coryphodon, *Owen, Brit. Foss. Mam.* p. 306. f. 105	C.
Chelonia (fragments of carapace)	W. E.
Cancer (part of claw)	C.
Spicula of Sponge	E.
Serpula, n. sp. Pl. II. fig. 26	C.
Microscopic Bryozoa (Lunulites urceolatus, fragments)	C.
Flustra	C. E.
Opercula (of Cerithium ?)	C.
Eggs of Molluscs ?	C.
Wood, coniferous	W. C. E.
—— dicotyledonous	E.
Impressions of leaves and seed-vessels (Pl. III. figs. 4–6, and Pl. IV.)	W. C. E.

NOTES.

(*a*) M. Deshayes figures a specimen from the "Sables Inférieurs" of Bracheux which he calls the *C. semigranulosum*, Sow., and gives as synonymous the *C. Plumsteadiense* of the same author. M. Deshayes' specimens must, however, be probably referred only to the latter species of Sowerby; the first-named species of Sowerby is not therefore identical with the species to which M. Deshayes gives that name.

(*b*) These occur only in casts, which on a previous occasion were referred to the *C. globosa*, Sow.; but this shell is more equivalved and less globose than the Barton species, and more resembles the French species, which is found in the "Argile plastique" of Rilly, and has been described, but not figured, by Nyst.

(*c*) This shell was first referred to *C. revoluta*, Sow., of Barton, but it is more equivalved and the beak is less incurved. In my paper on the Thanet Sands it was considered as the *C. longirostris*, Desh.; but this shell, which M. Deshayes quoted from the "Sables Inférieurs" of Bracheux, was figured from a bad specimen, and the name has since been restricted by this able conchologist to the species from the Grès Moyens of Beauchamp. The former is therefore undescribed, and is probably the same shell as that here described and named.

(*d*) With the exception of the *C. cuneiformis* and *tellinella*, which are well-marked species, these *Cyrenæ* form a very perplexing group. The other three species here given, although in many cases presenting well-marked and distinct characters, pass commonly into forms so nearly resembling one another and the *C. cuneiformis*, that I almost hesitate to adopt the specific distinctions here given. They have, however, been adopted after a long and careful comparison of a very large series.

(*e*) The artist had so badly represented the figure of the French species, that it was not until the specimens were compared that the mistake of naming it anew could be discovered.

(*f*) This shell is here in too imperfect a state to admit of a positive determination.

(*g*) There are two French species, the *Dreissena antiqua*, Mell., and *Modiola angularis*, Desh., which require comparison with this. They are both found in the "Sables Inférieurs," but I have not met with them; and although the figures and descriptions do not quite agree, I suspect a closer resemblance than is apparent.

(*h*) The *P. terebratularis* is a very variable shell. M. Deshayes has in his "Coquilles Fossiles" quoted it from Bracheux and from Etampes, but has since restricted it to the former locality, and therefore to the "Lower Tertiaries." This species apparently includes the *P. Plumsteadiensis* and *P. brevirostris* of Sowerby.

(*i*) This has been referred to the *U. Solandri*, but, as well as the crushed and imperfect state of the specimen will allow us to judge, incorrectly; it rather closely resembles the French species which has lately been figured by M. Watelet from the "Lignites" of the Soissonnais.

(*j*) This, which is a very rare shell at Woolwich, is referred with a doubt to a French species that it seems identical with, except that it is always very much smaller. This, however, may arise from the more freshwater conditions at this locality.

(*k*) These species of Sowerby, although now considered only as one, form, as do also his species of the *Ostrea*, well-marked varieties constant in most cases to different beds of the Woolwich and Reading series, and caused apparently by this difference of habitat.

(*l*) The *Buccinum ambiguum*, Desh., also resembles some varieties of this shell, to which I have also referred the *B. granulosum* with a doubt. Having seen M. Deshayes' specimen of the *Fusus deceptus*, I have little hesitation in identifying it with the Woolwich species.

(*m*) Sowerby gave originally four species of *Fusus* from Woolwich. Two of these have since been excluded, and upon comparing a large series of these other two species, I cannot feel satisfied that even they are distinct. The *F. gradatus* seems to me to be the young of the *F. latus*.

(*n*) Several very small univalves are figured by Deshayes and Melleville from the Lower Tertiaries of France. I cannot quite identify any of them with the Woolwich species, although I suspect that some of them, especially the *Melania tritacea*, Desh., and the *Paludina miliola* and *intermedia*, Mell., may prove to be the same. From the figures of Deshayes, the Woolwich species, however, seem to have a closer resemblance to some specimens from the Calcaire Lacustre of St. Ouen and Montmorency.

(*o*) M. Deshayes has specimens of this shell from the Lignites of the Soissonnais, and it appears to resemble some of the Woolwich specimens. It is difficult however to distinguish the species of this genus, and although at Woolwich there seems at first sight to be two or three species, it is doubtful whether they will not all prove varieties of the next species.

(*p*) This is a very variable shell, the fusiform variety being the specimens figured by Sowerby as the *M. fusiformis*. This latter must however, I think, be confined to the fluvio-marine series of the Isle of Wight.

(*q*) This and the preceding species require comparison with the French specimens, as the figures given of them are not sufficiently distinct.

(*r*) It is doubtful whether this may not be a different species; but in this.

as in the other freshwater species, the distinction between the older and the newer forms is remarkably small, a fact which can be readily understood when it is considered how many of the Woolwich species were originally identified with species of the Upper Eocene fluvio-marine beds of the Isle of Wight. The representative forms of these two periods present, in fact, a remarkable and close analogy.

(s) Three varieties of the teeth of *Lamna* are found, two of them bearing a close resemblance to these two London clay (Sheppey) species, but they do not seem to me to be quite identical. They may, however, only be varieties.

In addition to the fossils of the foregoing list, the following species have been quoted from Woolwich upon the authority of the early numbers of the 'Mineral Conchology,' but, I believe, in error, which has been partially corrected in a later index.

Cyrena (*Cyclas*) *obovata*, var., Min. Con. pl. 162. figs. 4 to 6. Confined to the Middle and Upper Eocenes of Hampshire.

Fusus (*Buccinum*) *labiatus*, Min. Con. pl. 412. figs. 1, 2. Confined to the Middle and Upper Eocenes of Hampshire.

Melanopsis fusiformis, Min. Con. pl. 332. figs. 1 to 7. Confined to the Middle and Upper Eocenes of Hampshire.

Neritina concava, Min. Con. pl. 385. figs. 1 to 8. Confined to the Middle and Upper Eocenes of Hampshire.

Potamomya (*Mya*) *plana*, Min. Con. pl. 76. fig. 2. Confined to the Middle and Upper Eocenes of Hampshire.

Fusus costatus β. (*Murex rugosus*, Park.), Min. Con. pl. 199. fig. 2. Confined to the Crag.

The Rev. H. M. De la Condamine has also given, in his paper before referred to, eight species of *shells* and one of *Lamna* from Woolwich and Blackheath not in the above list, and which, I think, he will now agree with me have been introduced by some error in the specific determinations which it is desirable to correct, in order to prevent, as is the case with the above, any confusion, or difficulty to subsequent observers.

The *Corbula revoluta*, Sow., has been quoted from Herne Bay. It should be confined to Barton and Hampshire.

§ 4. *Lithological Structure.*

It happens with this, as with the preceding chapter, that the descriptions of the several local sections embrace the mention of almost all the varieties of mineral character presented by this group, and render it therefore unnecessary to give more than a general summary, and to allude to a few special points of inquiry: of these may in particular be instanced the origin of the Druid sandstones of Marlborough Downs and Salisbury Plains, and of the Hertfordshire Pudding-stones.

Viewed as a whole, the Woolwich and Reading series consist, 1st, of mottled clays, tenacious, free from carbonate of lime, and with a prevailing red base; 2nd, of sharp light-coloured quartzose sand, more or less mixed with green sand and with flint-pebbles. These two component parts usually form distinct and separate beds, extremely irregular in their range and development; the clays prevailing almost to the exclusion of the sands in the Isle of Wight and in part of the Hampshire district, and the sands increasing as the group trends through Wiltshire, Berkshire, and Surrey, but thick-bedded mottled clays still preponderating, until, on the confines of Surrey and Kent, Middlesex, and Essex, the latter are rather abruptly displaced by the sands, which finally in East Kent prevail exclusively. The two principal subordinate features are, 1st, the occurrence of rolled flint-pebbles, black, and worn perfectly smooth and rounded*, usually of a small size, $\frac{1}{2}$ to 2 inches in longest diameter, but occasionally attaining a length of 10 to 15 inches. These pebbles are generally dispersed in layers or imbedded in the sand, but they are in few cases associated with the clay beds. It is within the area wherein the change from mottled clays to sands takes place that the pebbles are developed in their greatest profusion, forming at those places thick and extensive beds of shingle. To the eastward beyond this area the sands are still characterized by dispersed pebbles, whilst to the westward of it the pebbles are restricted to a thin bed, either just overlying the green-coated flints which repose on the chalk, or else intermingling with these flints. 2nd, Green sand, which is usually either disseminated in dispersed grains, or else occurs in small patches or seams, and is chiefly confined to the lower portions of this division, and at the base of which it forms, mixed with clay and peroxide of iron, a thin and nearly constant layer. In Kent this green sand exists in larger proportion, often constituting irregular beds of light green sands, which are never, however, persistent over any wide range, and are always subordinate to the light quartzose sands. These grains of green sand vary in size from a pin's point to a pin's head, the larger ones being botryoidal-shaped, of a malachite-green colour, and rather soft. These green grains have usually been indiscriminately referred to Chlorite and Green Earth, but the physical characters of these grains differ so widely,—some being light green, soft, opake, and earthy, whilst others are very hard, of a dark green or nearly black colour, translucid, and show facets,—that I would suggest whether or not, in addition to the former of these minerals, there may not be, mixed with the common quartzose sand, debris of Hornblende and Pyroxenes† in this state of small grains.

As minerals of more local occurrence may be noticed, 1st, The peroxide of iron, occasionally giving an ochreous and ferruginous colour to the strata, and sometimes cementing the sands into thin tabular iron-sandstones. 2nd, The hydrated peroxide of iron, or limonite, in concretions, and occasionally forming ochres. 3rd, Iron pyrites, which is of comparatively rare occurrence except in the mixed green sands of Herne Bay. 4th, Carbonate of lime, which in this group must be considered as quite a subordinate mineral, being almost altogether restricted to the central area beneath and around London, occasionally acting as a cement to some of the sandstone conglomerates, and sometimes forming an extremely hard fine-grained concretionary rock. 5th, Carbonaceous clays, and thin bands or rather

* Some of these pebbles are shivered and broken *in situ* (usually by pressure). Others again have been broken before being rolled into their present position, presenting a fractured surface with the sharp edges worn off.

† I have not had time to proceed further in this inquiry, which is one of considerable interest in a theoretical point of view.

patches of lignite, are occasionally met with in the lower part of the mottled clays; but they occur more commonly in association with the fluviatile beds of Woolwich: they do not possess any importance, although occasionally expanding in some places to the thickness of a few feet, but are more often measureable by inches. The local sections and details (§ 3.) give some of the main points of its occurrence *.

It is at the base of this division that I should place the *Websterite* and *Hydrate of Alumina* found by Dr. Mantell at Castle Hill, Newhaven. I have since found the latter with the pebbles and flints in immediate contact with the chalk, at Northaw.

Small crystals of sulphate of lime occur occasionally in the clays and sands of the fluviatile group. A thin seam of clay found by Mr. De la Condamine at Counter Hill, showed on the faces of lamination a surface covered with very small sharp cavities, formed apparently by crystals of selenite having been dissolved out. I have not met with selenite in the mottled clays.

A singular fact was noticed a few years since in the 'Annales des Mines,' in connection with the mottled clays of the "Argile Plastique" of the Paris basin, viz. that they contained a very considerable proportion of gelatinous or soluble silica, *i. e.* silica in an active chemical state, and soluble in alkaline solutions without fusion†. I have recently tested the mottled clays from various places in the London district, and find that they also contain this gelatinous silica, which can be readily separated out by boiling in a solution of caustic potash. The proportion, however, is very variable. This peculiar condition of the silica has an important theoretical bearing.

§ 5. *Druid Sandstones.*

The position in the Tertiary series which should be assigned to the large blocks of white saccharoid sandstone found scattered over the surface of many parts of the chalk districts, and met with occasionally within the tertiary area itself, has long been and still remains an unsettled question. As these isolated blocks are always siliceous, not unfrequently exhibit traces of rootlet-like impressions, and occasionally contain round flint-pebbles and subangular slightly worn flints, they present, with the latter exception, a lithological structure very similar to that of the blocks found irregularly dispersed sometimes in the lower, but more especially in the upper division of the Bagshot Sands between Esher and Strathfieldsaye; and, as no other tertiary formation presents on first appearance so good a *primâ facie* right of possession, they were, in the absence of all distinct or-

* It is too impure for use. At Lewisham a heap of pyritous lignite which had been thrown on one side, caught fire, and burnt for several months. It was the occasional occurrence of lignite in these beds, here and at Blackheath, that gave rise to the popular belief of coal beds existing at the latter place.

† This was in 1846. The first notice of this peculiar condition of silica is, I believe, that by M. Sauvage in 1840 (Ann. des Mines), when he detected the presence of it in some of the beds of the lias and in some beds between the Chalk and the Gault.

ganisms to assist in the determination, generally referred to the age of those sands*. The weight of evidence is however, I think, against the origin usually assigned to them, although that evidence is circumstantial rather than direct.

In the first place, if they were derived from the Bagshot Sands, it is difficult to conceive why they should not be scattered as commonly over the generally broad belt of London clay intervening between the area of the Bagshot Sands and the Chalk, as they are over the area of the latter;—that connecting links should not have been left between the parent beds and the groups of greyweathers scattered over Marlborough Downs and the Chiltern Hills. But no such general phænomenon is exhibited within the London-clay area. It is further to be observed, that the Bagshot Sands (the lower division) themselves, although well developed between Strathfieldsaye and Newbury, do not in that district contain any large blocks of sandstone †. In Kent, over no part of which county do the Bagshot Sands extend, the Druid sandstone is abundant on many parts of the chalk hills. No fringe, in fact, of detached sandstone blocks skirts the Bagshot Sands, whereas wherever such scattered groups do occur they invariably subtend either the main body or detached outliers of the Lower Tertiaries.

On some of the high hills towards the borders of the extensive chalk downs forming Salisbury Plains, especially to the northward and eastward of Amesbury, or between that town, Bedwin, and Kingsclere, cappings of the lower tertiary sands and clays are not uncommon; whilst other hills, where no mass of tertiaries remain, show by the presence of numerous tertiary flint-pebbles on their summit the wreck of tertiary strata once spread over this area. The drift of the district also often abounds with these characteristic pebbles. At Marlborough the tertiary strata range up close to where the dispersed blocks of sandstone commence. A ridge of hills formed of these lower tertiaries on a base of chalk dominates over the platform of the latter formation for some miles in a direction W.N.W. from Newbury. As it trends westward the bed of sand immediately over the chalk expands, becomes extremely white and pure, and in one place, just below Wickham Church, contains at its base a few seams of pebbles and worn subangular flints. It is precisely the unconsolidated substance of the Druid sandstone; still I could not find, nor had the foreman who had worked twenty-one years in some adjoining pits ever found, a block of sandstone *in situ* in the sands. But then it must be considered how small an extent of this bed is opened out,—only two or three regularly worked pits in the distance of six miles,—and the extremely small proportion

* Not, however, universally so: by some geologists the origin of these blocks has been correctly referred to the "Plastic Clay Formation," but no proofs have yet been offered in support of the suggestion.

† So rare is it, in fact, to find any blocks of stone in that part of the country, that a small mass of about a foot square, lying on the gravel of Silchester Common, has been considered of sufficient importance to have a local name assigned to it—"The Nymph Stone."

this bears to the mass, in which these concretions are of a merely local and rare occurrence. Nevertheless on the slopes of this ridge, especially along its south-western flank, the number of blocks of Druid sandstone scattered over the surface of the ground just below the outcrop of the sands is very considerable; as they become more numerous they also become larger. These hills, if prolonged, would pass by Lambourne six miles further to the N.W., and it is on the downs about that village that the Druid sandstones are particularly numerous and large. That the tertiary strata ranged in that direction is proved by a few traces of them yet remaining *.

Again, in Buckinghamshire, Oxfordshire, and Hertfordshire, grey-weather sandstones and pudding-stones occur in districts throughout which are scattered numerous outliers of the Lower Tertiaries, once continuous over the whole area, and in the wreck of which, at their denudation, these blocks seem, as in Wiltshire, to have been left behind. So also with the large accumulations of sandstone blocks on the north downs above Maidstone.

If therefore we admit the distribution of the Druid sandstones to be in accordance with the range of the Lower London Tertiaries rather than with that of the Bagshot Sands, the next question is to ascertain what evidence there is of the occurrence *in situ* of similar masses of stone in the different groups of the former series.

1. With regard to the Thanet Sands:—Although often presenting favourable elements, and occasionally semi-indurated, they are rarely consolidated. At the Reculvers, however, they contain a bed of concretionary sandstone; but it has a calcareous cement, contains no pebbles, and exhibits frequently the impressions of shells; whereas the erratic sandstones of Kent, Bucks, and Wiltshire are neither calcareous nor fossiliferous, and are not uncommonly sub-conglomerate. Further, the Thanet Sands do not range more than six to ten miles westward of London. It is therefore not probable that the Druid sandstones belong to beds of this age.

2. The Basement-bed of the London Clay presents a very small development westward of London, and although concretionary blocks are often found in it, they are all comparatively of so small a size, besides being generally calcareo-argillaceous, and almost invariably fossiliferous, that it is not in this direction we must look for the origin of these sandstones. But to the eastward of London this bed becomes more important, and at Boughton it contains a subordinate bed of a siliceous sandstone, often extremely hard, very local and very variable, and of a character which would harmonise perfectly well with some of the blocks on the slopes of the East Kent Chalk ranges.

3. My belief, however, is that the greater portion of the blocks known as Druid Sandstones, Greyweathers, Sarsen Stones, and Pudding-stones are derived from the middle division of the Lower London Tertiaries. It is very rarely that solidified portions of the strata are found *in situ*, but the same difficulty occurs in as great

* As, for instance, at Liquid Farm, five miles W.N.W. from Wickham.

a degree with the sandstones of the Bagshot Sands. As usual with concretionary masses, they occur in patches in particular districts, and are far from being a general accompaniment of the sands. In Hampshire I know only of one group of them which has the appearance of being *in situ*,—the one before referred to (p. 81) as occurring near Dorchester*. Still the case there is not clear. In the western part of the London tertiary district the middle division of the Lower Tertiaries always contains more or less extensive beds of quartzose sand, with patches or layers of pebbles in the lower part more especially of the group, while patches of subangular flints are also occasionally met with; consequently we have the elements necessary to produce the required results whenever circumstances, as might so easily happen, occurred to consolidate the materials. Although instances of this fact are not numerous, still they are in sufficient number to prove the probability of the supposition.

On the eastern slope of Bagshot Hill, near Hungerford, there is a spot from which blocks of sandstone and of sandstone conglomerate have been removed†. This pit, which is now abandoned, is so shallow as not to show the superposition of the beds: they appear, however, immediately to overlie the chalk. The case is clearer at Nettlebed Hill; I have there seen, a few feet above the chalk, blocks of sandstone, some of large size, *in situ* in the sands interstratified with the mottled clay (see fig. 4. p. 89).

At Tiler's Hill near Chesham the white quartzose sand underlying the Basement-bed of the London clay contains a thin subordinate band of a soft saccharoid sandstone. Near Batler's Green, two and a half miles northward from Elstree, Herts, there existed a few years since a shallow pit, in which beneath the gravel there was exposed a surface of thick tabular pudding-stone overlying the chalk and apparently *in situ*. A bed perfectly identical in composition, *i.e.* consisting of a fine pure white quartzose sand full of black flint pebbles, but not consolidated, was opened a few years ago in a pit one and a half mile from Ware, on the London road: it was 3 feet thick, reposed directly on the chalk, and underlay some sandy mottled clays. Blocks of sandstone and of sandstone conglomerate are also found in the sands subordinate to the mottled clays beneath the London clay at Pinner (see p. 91). These cases are few and local, but so also is the distribution of the greyweathers themselves, and it is to be observed that the occurrence of the latter is exactly coincident with the development and preponderance of the sand beds of the mottled clay series. Thus around Reading, where mottled clays preponderate, there are few sandstone blocks on the surrounding chalk hills; but in proceeding towards Newbury the clays give way to sands, which, three miles north of that town, constitute the main

* In Hampshire the Bracklesham series contains several solid seams, both in the Isle of Wight and the Isle of Purbeck, yet but few blocks are found scattered on the surface. The chief one is that known as the Agglestone, near Studland.

† I am indebted for a knowledge of this locality, and for much other information respecting Salisbury Plains and the Wiltshire Downs, to Mr. W. Cunnington of Devizes.

feature of this series. At Newbury the proportion of sands decreases, but these beds again become more important in proceeding from Newbury towards Marlborough. Now it is precisely in these directions that the blocks of greyweather sandstone set in and attain their greatest development*. On the hills above Goring sandstone blocks are not uncommon ; and I have here recently found the mottled clays, associated with a thick bed of white quartzose sand, ranging close to the edge of the chalk escarpment from Woodcot Common to near Combe End Farm. Crossing the gorge of the Thames the same beds are found capping the hills at Bassildon, and a trace of them apparently exists near Aldworth. In fact, throughout the chalk district of Wilts, Berks, Oxfordshire, Bucks, Herts, and Kent, the tertiary outliers are far more common than has been supposed. They distinctly show the former spread of the Lower Tertiaries, the Woolwich and Reading series especially, over the whole area, up even to the very edge of the chalk escarpment.

In the direction of High Wycombe and Nettlebed the sand beds are again in excess. On the chalk hills above Bradenham, three miles northward of the former town, sandstone blocks are very numerous, and, although enveloped in a ferruginous clay-drift, they are, I believe, nevertheless nearly *in situ*†. Around Hedgerley and Uxbridge, where mottled clays prevail, few sandstone blocks occur. In the neighbourhood of Hatfield, Hertford, and Ware, the sands of the Reading series, perfectly white and siliceous, are often, if I may use the expression, glutted with flint-pebbles; it is over this area more particularly that the Hertfordshire pudding-stones are so abundant.

Beneath and also to the south and south-east of London, a very hard, light-coloured, fine-grained, calcareo-argillaceous rock, usually without fossils, is often present in the lower part of the Woolwich beds just under the shelly clays. This bed, however, rarely exceeds the limits of the fluviatile and estuarine clays, and forms therefore a mere local feature. At Gravesend we find in nearly the same position a thin tabular layer of hard siliceous sandstone. These agree with the numerous thin hard tabular pieces of sandstone found scattered over the surface of the ground around Apchurch near Sittingbourne. On the hill above Stifford Bridge, Essex, where the lower tertiaries were cut through, there are a few blocks of pudding-stone. In the neighbourhood of the conspicuous tertiary outlier at Cobham near Gravesend, large mammillated blocks of siliceous sandstone are common on the chalk hills. Blocks of a larger size, but more even-surfaced, abound on the downs above Maidstone; they are also

* The remarkable and thick trail of sandstone blocks in the valley of rocks near Marlborough is well known. Many other valleys in that district, as those to the south of East and West Kennet, Dean, Clatford, and others, exhibit the same phænomena, although not on so large a scale. The hills on the sides and at the heads of these narrow vales are also strewed over with numerous detached blocks.

† At Walter's Ash and Napple Common; they are equally abundant on Denner Hill, three miles west from Great Missenden.

numerous in many places between this spot and the downs above Folkestone, as near Charing. On the chalk hills sloping from this line of escarpment down to the Thames, such masses are likewise common.

It is possible that in Kent the upper and lower divisions of the Lower Tertiaries may have partially contributed to the supply of these dispersed sandstone blocks; but on the hills of Hertfordshire, Oxfordshire, and Wiltshire, and the extensive elevated chalk-platforms forming Salisbury Downs, where these masses are occasionally so numerous, I believe that they are all derived from the middle division of the Lower Tertiaries, outliers of which still remain to prove the former extension of these strata over those areas, for they have, with these few exceptions, been wholly removed by subsequent denudation*.

The absence of all organic remains, so peculiar a feature of the sands of the Woolwich and Reading group westward of London, strengthens the supposition of these equally unfossiliferous sandstones being derived from this source†.

With the large softer masses of saccharoid sandstone of Salisbury Plains and Marlborough Downs, there are however found a number of small blocks and pieces of a very fine-grained, hard, compact, siliceous sandstone generally of peculiar botryoidal forms, not conglomerate, and often with traces of long rootlet-like processes‡; but I have not seen such rock-specimens in the Lower Tertiaries§, nor have I been more successful in finding them *in situ* in the Bagshot series. Their age must be considered uncertain; at the same time the occurrence of specimens with these rootlet-like processes weighs certainly in favour of their origin from the Bagshot Sands, as we know that similar impressions exist, although very rarely, in the blocks of sandstone found in the Upper Bagshot Sands. But in the sands or the laminated clays associated with them such impressions are not met with, although, as in the Lower Tertiaries, impressions of plants and leaves have been found. These rootlet-like casts and impressions are, however, organisms too indistinct to be of any definite value as a proof of age.

As before observed, much weight must not be attached to the rarity

* It may be objected that no blocks of sandstone are now found scattered over the surface of Salisbury Plains. They are certainly scarce, but I have found a few in the valleys, although generally there hidden by the drift. Their very scarcity has, however, probably hastened the destruction of the few that have existed, and have been used for various economical purposes.

† At least the only exception is the occasional bed of the *Ostrea Bellovacina* and shark's teeth at the base of this series, but the concretionary masses and the white sands occur more in the body of the strata. Still, traces of these fossils may possibly be found in some of the blocks around Newbury, or in some of the Hertfordshire pudding-stones; but hitherto no such impressions have, I believe, been met with.

‡ They are common also in the flint-gravel of the valleys of the district.

§ That is to say, in the district westward of London. The fine-grained hard concretionary stone, before mentioned (p. 103) as occurring in the Woolwich series beneath or near London (Charlton), sometimes presents however a very similar appearance and fracture.

of concretionary sandstones in the sections and cuttings of the Lower Tertiaries. In the Bagshot Sands themselves they are confined to a comparatively small range of country, and even in that district I have never seen them in sand-pits or road-side cuttings. They are sought out specially at a few spots on the hills by dipping iron rods into the sands. Again, although at and near London the Lower Tertiaries so often contain subordinate concretionary or conglomerate rocks, how rarely do such masses show at their outcrop: at Sundridge only are some of these latter beds worked.

The flint-gravel which caps the hills around Newbury contains a few rather large specimens of the harder sandstones, but the gravel of that system of valleys which wind down from the chalk hills on the north-west of Newbury abounds with such blocks, together with a good many large blocks of the more saccharoid and softer stones. The course of this drift is towards, and not from, the area of the Bagshot Sands; and as we have no proof of the extension of this formation over the Chalk Downs, whereas we know that detached outliers of the Lower Tertiary sands extend far over those hills, we should expect to find, in the drift, the debris derived from the latter and from the chalk, and not from the Bagshot Sands. Whence also, as well as from their association, I am inclined to consider that both descriptions of sandstones are derived from the Lower Tertiary sands.

Further, admitting the fact of an occasional and local consolidation of the sand beds of the Lower Tertiaries, we have an *à-priori* argument in favour of the whole group of the Druid Sandstones of Wilts, Hants, Bucks, and Kent, and of the Pudding-stones of Herts, being derived from this source, from the circumstance that the lithological structure of each variety is respectively in accordance with the mineral components forming the strata in the immediate vicinity of the places where these rock-blocks are found; *i. e.* that the concretionary stone in each case represents the component parts of some portion of the adjacent "Woolwich and Reading series," with the difference that they are consolidated.

This conclusion is corroborated by the very definite and distinct proofs furnished by the cliffs of St. Marguerite near Dieppe. We there find the Woolwich fluviatile clays with the *Cyrena cuneiformis*, *Melania inquinata*, and *Cerithium variabile* underlaid by a bed of whitish quartzose sand reposing upon a very uneven surface of the chalk. The section is between one and two miles in length, although it is only near the lighthouse (le phare d'Ailly) that the fluviatile beds exist. These sands contain in several parts of the section subordinate blocks of a white saccharoid concretionary siliceous sandstone, which is worked to some extent, and affords masses frequently measuring many feet in length. These sandstones also often contain, like the Druid sandstones of Wilts, rolled flint-pebbles and subangular flints. As these beds are evidently a prolongation of the Woolwich beds on the Sussex-district type, the phænomena thus exhibited in the neighbourhood of Dieppe may fairly be admitted in collateral proof of the argument with respect to the origin in this country also of the Druid Sandstones from beds of the age of the "Woolwich and Reading series*."

§ 6. *Conclusion.*

The sectional diagrams, A, B, C, Pl. I., which, owing to the want of some connecting links, were not completed until after the preceding pages were written, confirm, in my mind, by the structural fitness of their parts, the conviction, before expressed, and derived from lithological and palæontological evidence, of the independence† of the "Middle division of the Lower London Tertiaries," with regard to the "Thanet Sands,"—the latter forming a distinct and underlying marine deposit; and that, notwithstanding the nearly total difference of all its characters, the estuarine and freshwater group of fossiliferous strata at Upnor and Woolwich must be regarded as strictly synchronous with the unfossiliferous mottled clays of Alum Bay, Reading, and Hedgerley. Cases are common where such changes of condition, as those displayed in this "Woolwich and Reading division," take place in particular beds of a series; in this instance, however, the alteration affects the whole depth of the group, not as a recurring change at different periods, but as a maintained development at different places. It shows an accumulation of materials not within the range of a single river action, howsoever variable, but of contemporaneous strata deriving, in the same sea, supplies from different and independent sources. Still, notwithstanding the variable character of the mass as a whole, there are two subordinate features, the one mineral and the other palæontological, sufficiently well maintained, although not constant, over both the Reading and the Woolwich areas to afford a common base-line. It has been shown that the

* I find that M. Passy, in his 'Descrip. Géol. du Dép. de la Seine Inférieure' (Rouen, 1832), takes the same view of the relation of the "Grey-weathers" of Wiltshire and of the "Grès à silex pyromaques" of the Dieppe Cliffs, drawing his conclusions, however, with respect to the former, simply from their lithological resemblance to the latter (pages 127–131).

† At all events so far as the central and eastern areas are concerned. The only point about which I feel slightly doubtful, is whether some of the thick pebble beds under and around Shooter's Hill may not belong to the upper part of the Woolwich series, rather than to the Basement of the London Clay, inasmuch as the character of the former is so variable as often to render it lithologically undistinguishable from the latter, except when seen in actual superposition, and for this extremely few opportunities occur. For the same reason the beds which at Upnor and Herne Bay I have included in the "Basement-bed" may also possibly belong to the upper section of the Woolwich series, in which case the Basement-bed itself might be considered in this area to merge into the thin seam of sandy clay (with fossils at Upnor and with a few pebbles at Herne) just at the base of the great mass of the London Clay. It is also difficult to say positively whether some lower portion of the Reading series may not possibly be synchronous with the Thanet Sands. In the absence of sections which alone could clearly settle this point, I have given the best conclusion I could arrive at upon collateral evidence. I mention these doubts, which, however, do not affect the superposition and grouping of the three divisions here proposed, although it would modify the exact lines of separation, in order to direct attention to any new facts which may arise to throw light upon those questions where I consider the evidence not quite conclusive.

20 feet of pebbly light greenish sands overlying the Thanet Sands in West Kent, consist of a clear sharp quartzose sand mixed more or less with grains of green sand, flint pebbles, and argillaceous matter. Now, although the latter are almost always present, still the proportion of them becomes in places so small that their presence is not readily apparent, and a bed of sand, more or less pure and white, remains. The great development of pebbles in this bed takes place in the neighbourhood of London. As the beds range eastward they pass into sands, often apparently forming with the "Thanet Sands" one nearly undistinguishable mass ; and in the same way as they range westward they occasionally put on, from this loss of the pebbles and green grains, almost exactly the characters presented by the Thanet Sands at Woolwich and Lewisham, and for which they have hitherto been mistaken. Still, on the whole, the presence at the base of the Woolwich and Reading series of slightly argillaceous sands, more or less mixed with green sand and flint pebbles, is a most permanent lithological character of this division. We have, further, some evidence, scanty though it is, of organic remains, the *Ostrea Bellovacina* and teeth of *Lamna* occurring at intervals at the base of the mottled-clay series of Reading, from Hungerford and Newbury to Headley, Hanwell, Northaw, and Hertford, and again beneath London (sections in Appendix), where the mottled clays of Reading become intercalated with the fossiliferous beds of Woolwich ; and further eastward in the same position at the base of this series at Erith, where the Woolwich type alone obtains. This organic link does not extend further eastward, unless the *Ostrea* at Oakwell should, when better specimens are obtained, prove to belong to that species ; but the teeth of *Lamna* are, however, met with. Under ordinary circumstances but little weight could be attached to the evidence of two such fossils, or of such common mineral characters ; still, when we take into consideration the chances of their association, their conjoint evidence becomes of much greater value, although after all the aid of superposition is necessary. On these data taken together, the pebbly sands, with their zone of *O. Bellovacina*, may be considered as a sufficiently definite and well-marked horizon between the Woolwich and Reading series and the Thanet Sands. In the neighbourhood of London this lowest bed of the Woolwich series further shows, by the occasional presence of the *Cyrena cuneiformis*, *Melania inquinata*, and *Cerithium variabile*, a fauna distinct from that of the Thanet Sands ; but in East Kent, where the change of condition between the two periods is not so marked, part of the marine fauna of the latter is continued upwards into the former deposit, many species of which may be particularly specified, the *Cucullæa crassatina*, *Sanguinolaria Edwardsii*, *Corbula Regulbiensis*, *Cyprina Morrisii*, *Thracia oblata*, *Cytherea Bellovacina*, *Ampullaria subdepressa*, and *Glycimeris Rutupiensis*, passing from the Thanet Sands into the Woolwich series. Other species, however, as the *Panopæa granulata*, *Pecten Prestvichii*, *Pholadomya cuneata* and *Koninckii*, *Scalaria Bowerbankii*, *Trophon subnodosum*, and *Leda substriata*, do not extend higher than the "Thanet Sands," whilst

several new species, including the fine large *Cyprina scutellaria*, the *Pectunculus terebratularis* and *Cardium Plumsteadiense*, and some peculiar fossil woods, make their first appearance in the Woolwich group. The *Corbula Regulbiensis*, which is comparatively rare in the Thanet Sands, becomes also most abundant in places.

This fauna is, in East Kent, confined to the lowest bed of the Woolwich series. The upper beds are unfossiliferous, with the exception of the rare occurrence of the small fragments of the *Myliobates*, *Edaphodon*, and *Chelonia*. As we approach London, however, the middle and upper members of this deposit become well marked by their organic remains. Of the marine fauna of Herne Bay, the *Corbula Regulbiensis*, *Nucula fragilis*, *Cardium Plumsteadiense*, and *Pectunculus terebratularis* (var. *Plumsteadiensis*), occur at Woolwich and Bromley, whilst in addition to this group we have the remarkable local development of those estuarine and more freshwater forms,—the *Cyrena*, *Paludina*, *Melania*, *Melanopsis*, *Planorbis*, *Unio*, and *Neritina*. These latter forms prevail more especially in the centre of this division, in that portion of it so well exhibited at Woolwich, extending beneath London on one side, and stretching to Upnor on the other. Above these Woolwich clays in the same central area are beds with a more estuarine fauna at first, but showing as they pass upwards conditions still more freshwater than those which prevail in the beds beneath. To this upper part of the series belong the Paludina-limestone and the Unio bed at New Cross. As this series trends towards London all the members of it disappear and are replaced by mottled clays and sands, the Woolwich clays being alone prolonged, and forming beneath London a single fossiliferous zone distinctly intercalated between two masses of the mottled clays (see Well-sections, Appendix). This is shown in the sectional Diagrams A & C, Pl. I.; but to the south of the line here intersected we find another zone of the *Cyrena*, *Melania*, and *Ostrea*, intercalated on a higher level with these mottled clays, and of which examples are found in the sections at Balham Hill, Wandsworth, and Mitcham (Appendix). It is only by connecting these beds by underground sections that the probable position of the well-known Sundridge, Bromley, and Chiselhurst beds may be inferred; for, owing to the want of surface-sections, no direct connection can be established between the beds of the Woolwich and Sundridge pits; but if we pass round by London, Clapham, Wandsworth, Mitcham, and Croydon, we find this upper zone, at first only slightly developed, assuming as it trends southward and then south-eastward an increased importance, and eventually expanding and replacing the upper group of sands and mottled clays, whilst on the contrary the underlying lenticular mass of Woolwich clays thins out and is replaced by mottled clays, so that this division then presents a large development of mottled clays below, with shelly estuarine clays, limestones, and conglomerates above. I believe that the insulated shell-bed at Guildford belongs to this upper series. Here, as before mentioned, the traces of animal life are confined merely to a thin superposed layer. Beyond both to the westward and northward, the great bulk of the sands and mottled clays, which now prevail exclusively, are perfectly barren; and the contrast which they afford with the common occurrence of organic remains in the field we have just quitted is very striking,—the more so from the circumstance of the unfossiliferous masses preponderating so largely, and the fossiliferous beds being confined to so comparatively small an area of the Woolwich and Reading series.

It is this Woolwich and Reading series which, of all the Lower Tertiaries, presents the greatest resemblance in France and England. The mottled clays of Paris and Montereau are not to be distinguished from those of Reading and Newbury, whilst the *Melania inquinata, Neritina globulus, Melanopsis buccinoides, Ostrea Bellovacina, Cerithium variabile,* and *Cyrena cuneiformis,* constitute at Epernay, Soissons, and Dieppe, as at Woolwich and Upnor, the common and characteristic species of the fluviatile and estuarine areas of this period.

The total number of Molluscs found in the "Woolwich and Reading series" amounts to 53, of which 25 are peculiar to it, whilst of the remaining 28 species 12 are found in the "Thanet Sands," 22 range up into the "Basement-bed of the London Clay," and 6 are common to the three divisions. Again, taking these three divisions of the "Lower London Tertiaries" together, the species of fossil shells now enumerated from them amounts to as many as 82, of which 29 are found in the "Basement-bed of the London Clay," 23 in the "Thanet Sands," and 53, as mentioned above, in the Woolwich and Reading series*. Further, of these 82 species 27 range up into the London Clay, and 6 have a further extension upwards into the middle Eocenes, whilst 55 species are peculiar to these Lower London Tertiaries. A fauna of this class and of this extent (and which I believe is yet far from being fully worked out†), in addition to which there is to be noted a not inconsiderable list of *Entomostraca, Foraminifera,* and *Plants,* entitles, I consider, these Lower London Tertiaries to a more important and independent position than has hitherto been assigned to them.

* A further examination of some of the species enumerated in my lists of fossils of the Basement-bed of the London Clay and of the Thanet Sands, has shown the necessity of an alteration in the determination of some of the species which were then identified with known species of some of the more important overlying Eocene deposits; amongst these there will be found in the first-named list (Journ. Geol. Soc. vol. vi. p. 281, Table A.) the species given in the first column; the second column gives the corrections.

Corbula revoluta, *Sow.* —— longirostris, *Desh.*	*C. Regulbiensis* (see note *c*, p. 119).
Cyrena obovata, var. *Sow.*	*C. cordata* (note *d*, p. 119).

And in the second list (Journ. Geol. Soc. vol. viii. p. 248),—

Dentalium nitens, *Sow.*	*This identification is doubtful.*
Corbula, as above.	
Cytherea orbicularis, *Mor.*	*C. Bellovacina,* Desh.

† In addition to the above there are about 20 to 25 specimens of apparently new species, but not in a state sufficiently perfect to determine.

In my last paper on the Thanet Sands I showed the probability of the Wealden elevation having commenced at that early Tertiary period; and of a small island, without any important river, having existed somewhere in the central position of the present Weald. It was further shown that the Thanet Sands present in part of their range a worn and eroded upper surface, on which the Woolwich series reposes. Now as that surface was one of sand, the edge of which would have been softened even by a small and prolonged ordinary quiet action of the sea currents, which would also have produced an intermixture of the two beds, I conceive that where there is erosion and clear demarcation the change has been sudden and abrupt; but where on the contrary there is a passage in the beds, as for example at Herne Bay, we must suppose a point more distant from the centre of disturbance, and where the change both in lithological structure and in the fauna only became apparent subsequently, as the new order of things gradually prevailed over the preceding one. Where, therefore, we have phænomena of this description, and a distinct alteration, taken as a whole, in the lithological structure of the beds above and below such divisional lines, I cannot but think that, however slight those alterations may be, they indicate a change in the hydrographical condition of the then existing land and sea caused by movements sudden and powerful in proportion to the effects exhibited on the pre-existing sea-bed by the scouring power of the sea during the translation of its mass; whilst the permanent alterations in mineral composition show that such effects were not transitory or momentary, inasmuch as they led to maintained changes in the nature of the materials carried down from the land or worn from the cliffs, indicating in fact a different arrangement of the rivers and the coast lines. In this case the change is proved also by the alteration in the character of the organic remains, which in the lower sands (Thanet Sands) are marine, whilst the Woolwich series contains a superimposed group of estuarine and fluviatile shells.

That the pebbles were rolled from time to time into the position in which they are now found, and that they were not worn there, may be inferred from the fact of their association with delicate and friable shells which have remained uninjured amongst them; from Molluscs having bored undisturbed into the bed of mixed sand and pebbles; from *Ostreæ* and *Serpulæ* having so often attached themselves to, and grown upon, some of the pebbles; and from the circumstance that broken pebbles occasionally occur, the fractured surfaces of which only show worn edges, with no approach to a restoration of the pebble form*.

* The sand of the Woolwich Series I have heard attributed to the wear and destruction of the chalk-flints which produced the pebbles. That a certain quantity of sand resulted from such an action is inevitable, but that the whole mass was derived from that source cannot be. The grains of the sand consist usually of pure transparent quartz, worn but not rounded. The presence further of grains of Chlorite and other allied minerals shows that there were other sources of supply

The prevailing set of the currents or tide is shown by the prevailing dip of the layers of false stratification being northward, or from off the presumed island, at angles varying from 10° to 35°.

The irregularity of this river-accumulation is shown in the extreme irregularity of the beds, which constantly exhibit the shiftings and changes seen in the sand-banks of existing estuaries. Not only are the several members of the "Lower London Tertiaries" divided by irregular surfaces, but the Woolwich series itself often presents in its central area instances of its several beds being deposited upon slightly eroded surfaces one of another.

Further, the occurrence of *Lithodomus* in the eastern area, and of *Pholas* in the central area, shows the near proximity of a coast-line. The beautifully preserved plants of Reading also indicate neighbouring dry land.

Judging from all these phænomena I infer that the period of the Thanet Sands was brought to a close by a movement of elevation, which threw off the sea from the shores of the island we have alluded to, and swept down into the changed and shallower sea-bed the coarser sand and rounded shingle existing ready-formed on the coast-line. To such a movement I attribute the pebbly light green sands forming the base of the Woolwich and Reading series; the ordinary currents of the sea having, after the first movement of elevation, distributed the debris thus amassed and formed the beds on which the *Ostrea Bellovacina* lived. In the mean time the size of the island was necessarily increased by this movement of elevation, and its drainage having thereby become larger, and its streams and rivers more important, one of these rivers, still not a large one, must, during a slightly subsequent period of quiet, have brought down and accumulated the Woolwich shelly clays with their estuarine and fluviatile shells. This settled state of things was, however, not long-continued; renewed, but slow movements, probably of subsidence, must have taken place; the Woolwich river action must have ceased, or rather its direction changed; for that its debouchure was slightly altered, is indicated by the fact that the next fluviatile zone was not accumulated over the older beds, but on one side of them; instead of being chiefly at Upnor, Woolwich, and London, it took place from Bromley to Deptford, Wandsworth, and Guildford.

In the mean time in the more open sea of East Kent these slight changes were less felt, and the marine condition of the strata and their character as they existed at the "Thanet Sands" period remained for a time comparatively unaltered. To the westward, on the contrary, some new and large river-action appears to have been opened out from another land by the changes which led to the formation of the Woolwich and Reading series. The debris forming the mottled

than mere chalk cliffs, and that source was probably some of the subcretaceous arenaceous strata, which present a lithological base similar to that of the Lower Tertiary sands, although the materials are somewhat differently sorted and some few of the more soluble and finer portions are washed out.

clays resemble that which might be brought down from decomposing granitic or basaltic districts, probably from some land to the S.W., towards Brittany or the coast of Spain. The general aspect of a large proportion of the mottled dark red clays favours this view, which is further corroborated by the fact before alluded to of the presence of gelatinous silica, or silica in that condition in which we may presume it to be when derived directly from the decomposition of felspathic rocks, without having gone through any intermediate geological stage. The influence of such river-action was evidently greater in Hampshire than in Berkshire, the beds in the former county being of nearly double the thickness of those in the latter, and far more homogeneous. Compared to the Woolwich clays, the mass of materials forming the mottled clays is out of all proportion larger. Its arrangement is also very peculiar, its lines of bedding being almost always waved and curved, as though brought down and deposited by fits and starts, as by the freshets of a large river. The smaller mass of sands with which they are interstratified were probably brought down continuously by the Weald-Island rivers, chiefly from an area of Lower Greensand, spread by sea currents, and thus intercalated with the great mass of these mottled clays derived from this other more distant source. The almost total absence of carbonate of lime and the presence of the gelatinous silica are causes probably sufficient to account for the absence of organic remains wherever these mottled clays prevail.

After a time this Lower Tertiary period was brought to a close, and its islands, with their streams, whose action we have been studying, were submerged, by the great movement of subsidence, at first rapid,—and productive of the transport of the conglomerate and mixed strata forming the Basement-bed of the London clay over the whole of the varied surface of the Woolwich and Reading series,—and which subsidence was afterwards continued by that quiet and prolonged movement, which we have shown to be necessary for the accumulation of the like materials of, and transmission of a like fauna throughout, the great mass of the overlying London clay.

The reasons for believing that the temperature of the sea at the "Thanet Sands" period* was lower than that which prevailed during the period of the London Clay, apply in some measure, but probably less forcibly, to this intermediate epoch of the "Woolwich and Reading series." The general character both of the fauna and flora shows a preponderance of forms such as, on the whole, we might expect to meet with at present in more moderate climates than the one in which the more tropical-seeming vegetation and animals of the London Clay could have flourished. For a subject, however, of this problematical nature, the data are too limited to arrive at any very satisfactory or definite result. I merely state the general impression, rather than any sufficient conviction, I have received from the inquiry into this subject.

* Quart. Journ. Geol. Soc. vol. viii. p. 260.

Note.

The observations on the age and structure of the Tertiary series, from the Chalk up to the Fluvio-marine strata of Hampshire, which this paper completes, having been brought forward at intervals during a period of seven years, some changes have necessarily suggested themselves during the progress of the inquiry. On the main points connected with the Marine Eocene strata, I have nothing material to alter; but as in my first paper (Journ. Geol. Soc. vol. ii.) I retained the term "London Clay" to the clays of Barton, from its having been previously so applied, and termed the brown clays with organic remains (Strata 4–6) the "Bognor clays," and which I had occasion afterwards to show were the equivalents of the London Clay proper, I dropped the latter name with regard to the Barton clays, and retained it for those beds only which I had before called the "Bognor clays." This, I believe, has caused some uncertainty as to the arrangement which I proposed; I therefore have annexed a diagram, showing the relations of the London and Hampshire Tertiary systems, and the order of superposition of the different formations, according to the terms last employed (Pl. I. General section).

I had hoped to have been able to resume the examination which I commenced, in the lower part of the Tertiary series of the Isle of Wight, in 1839; but want of time and other engagements interfered with that intention. It was therefore with great pleasure that I found the inquiry with regard to the structure and age of the Fluvio-marine series taken up by Prof. E. Forbes. Having necessarily had occasion, in the course of the investigation of the Woolwich beds described in the preceding pages, to inquire into the range and character of the fossils of that group more particularly than in the indirect reference to its fossils made in my Isle of Wight paper, I found that some identities which I had given in proof of several species being common to the "Lower London Tertiaries" and to the Isle of Wight Fluvio-marine series, were wrong. This arose in some measure from errors of observation of my own, and from confounding together species differing in character, but which had the same specific name given to them by different authors; also from taking the localities of the species from the figures and descriptions in Sowerby's 'Mineral Conchology,' without being aware at the time of several corrections which that author had introduced in a supplementary list published at a later period; and partly from the range and identities given to some species in M. Deshayes's 'Coquilles Fossiles des Environs de Paris,' respecting which the author appears to have been wrongly informed. As the results at which Prof. Forbes has arrived are of very great interest and importance, I hasten to correct these mistakes, lest any partial argument adverse to his views might perchance be founded upon them.

In the paper above referred to I gave a list of 78 species of shells from the Fluvio-marine beds of Headon Hill; and I endeavoured to show that a certain number of these ranged downwards into Lower Tertiary beds; and that 27 species were found in the French Tertiaries. The following are the determinations which I believe to be wrong:—

1. *Limnea pyramidalis*, Brard. It must have been by mistake that I referred this species to the *L. cornea*, Brongn. They are different.
2. *Melanopsis ancillarioides*, Desh. This, again, is referred in error to the *M. buccinoides*, Fér. M. Deshayes, however, mentions (Coq. Foss. vol. ii. p. 21) that a variety of the latter, common in the "Argile plastique" of Epernay, is found in the Isle of Wight.
3. *Corbula nitida*, Sow. This is not the *C. nitida*, Desh., as the use of the same specific name led me to assume.
4. **Cerithium acutum*, Sow. Non *C. acutum*, Desh.
5. —— *ventricosum*, Sow. Non *C. ventricosum*, Desh.
6. —— *funatum*, Sow. *C. variabile*, Desh., figured by Sowerby from Newhaven and Hordwell, but since restricted to the former.
7. *Cytherea incrassata*, Desh., must, I believe, be considered synonymous with the *Venus incrassata*, Sow.
8. *Cyrena cuneiformis*, Fér. Quoted by M. Deshayes from Headon Hill; but the Isle of Wight species is certainly not identical with the Woolwich one. The latter appears to be the true *C. cuneiformis* of Férussac. The former is probably the *C. semistriata*, which again M. d'Archiac had stated he had found at Woolwich.
9. *Cyrena deperdita*, Sow. Non *C. deperdita*, Desh.
10. —— *obovata*, Sow. Barton; the var. figured from New Cross does not apparently belong to that species.
11. *Paludina lenta*, Sow. M. Deshayes gives it from the Isle of Wight and from the "Argile plastique" of Soissons. It appears, however, that though very closely resembling the Woolwich species, it may possibly be considered as a variety of that species.
12. *Potamomya plana*, Sow. Figured from Plumstead, but afterwards quoted only from the Hampshire series. M. d'Archiac, however, gives it from the "Argile plastique" of the Aisne, together with the *Tellina antiqua*, Sow.
13. *Fusus labiatus*, Sow. Quoted from both Hampshire and Woolwich; the latter reference was subsequently dropt.

With regard to the correlation of the Alum Bay and White Cliff Bay sections, Prof. E. Forbes informs me that he has reason to question my identification of Stratum No. 60 of the former locality with No. 36 of the latter. As far as I can judge, without revisiting the spot, his reasons appear to me to be well founded.

* I should also have given the *Cerithium margaritaceum*, Sow., which is the *C. involutum*, Lam.

Appendix.

Well-sections to follow, for reference, after the section at Park Hill, Croydon: *ante*, p. 99.

South to North sections,—from Croydon to Ware.

At Mitcham Mr. Nightingale kept the following careful record of his well, and preserved a series of specimens, but I found the shells generally too much crushed by the auger to be determinable.

*Well-section, Nightingale's Factory, Mitcham**, 1850.

		Feet.
	Black mould	$3\frac{1}{2}$
	Gravel	$0\frac{1}{2}$
London Clay.	Blue clay	101
II. *Woolwich and Reading Series,* 46 *feet.*	*o.* Blue clay mixed with *shells*	2
	n. Rock (*septaria*)	3
	m. Blue sand with a small quantity of water	3
	l. Blue clay mixed with *shells*	3
	k. Black clay, very hard	1
	j. Blue clay	3
	i. Peat earth, very soft and open (*lignite*)	3
	h. Bright blue clay	3
	g. Black clay mixed with white shells (*Cyrena*)	1
	f. Slate-coloured marl mixed with yellow (*Mottled clay*)	3
	e. Yellow mixed with pink (*do.*)	4
	d. Red and pink (*do.*)	4
	c. Blue sand mixed with clay	5
	b. Green sand mixed with clay, galt, and light blue sand	1
	a. Green hard sand mixed with black pebbles and white galt	7
III. *Thanet Sands,* 38 *feet.*	*c.* Blue-drab coloured sand	22
	b. Darker sandy loam	15
	a. Green-looking flints, black and brown inside: a good spring of water	1
		189

Chalk, with layers of flints every 3 feet, and an abundance of soft water in every layer, finishing the well at 211 feet.

Well-section, Copper Mills, Garret, near Wandsworth.

(Mr. E. I'Anson, Jun.)

		Feet.
	Gravel	9
London Clay...	Grey clay	70
I. *Basement-bed of the London Clay,* $1\frac{1}{2}$ *feet.*	*b.* Indurated clay	1
	a. Rolled pebbles	$0\frac{1}{2}$
II. *Woolwich and Reading Series,* 54 *or* $62\frac{1}{2}$ *feet.*	*u.* Grey clay	4
	t. Yellow grey clay	2
	s. Blue clay	2
	r. Carbonaceous matter and clay	$0\frac{1}{2}$
	q. *Shells*	1
	p. Grey clay	2
	Carried forward	92

* For the section of a well at Streatham Common, see Trans. Geol. Soc. 2nd ser. vol. ii. pt. 1. p. 135.

		Feet.
	Brought forward	92
II. *Woolwich and Reading Series, 54 or 62½ feet.*	*o.* Sandy and water	1
	n. Yellow clay	2
	m. Mottled grey and yellow clay	4
	l. Sandy and water	2
	k. Yellow mottled clay	3
	j. Grey clay	3
	i. Red clay	3
	h. Mottled clay	1
	g. Yellow clay	6
	f. Mottled clay	4
	e. Mottled clay	8
	d. Dark blue clay	4
	c. Septaria ?	1
	b. Clay and gravel	1
	a. Green sand and water	8
	Chalk not reached.	143

a. II. may possibly be the upper part of the Thanet Sands.

The following section is given by Mr. Lapidge, in the 'Geologist,' vol. ii. p. 20 :—

Well-section, Surrey County Lunatic Asylum, near Wandsworth.

		Feet.
London Clay, 231 feet.	*b.* Yellow clay mixed with veins of sand	20
	a. London clay with large clay-stones	211
II. *Woolwich and Reading Series, 55 feet.*	*r.* Sand with clay and *shells*	6½
	q. Dark sand	4
	p. Shelly rock	5
	o. Brown sand	1½
	n. Sand and clay	2
	m. Mottled Potter's clay	4
	l. Sand and clay	2
	k. Dark sand and *shells*	5
	j. Pure light-coloured sand	1
	i. Dark sand	2
	h. Sand and clay	1
	g. Pink and yellow mottled clay	4
	f. Light brown and white clay	4
	e. Dark red and white clay	4
	d. Chalk and pebbles	1
	c. Green sand	3
	b. Variegated green and brown sand	6
	a. Green sand	4
Thanet Sands, 40½ feet.	*d.* Brown sand, wherein was water, which rose to within 36 feet of the surface	5
	c. Fine dark grey sand	33
	b. Sand and pebbles, from which the water rose to within 28 feet of the surface	2
	a. A hard stratum (uncertain)	0½
	Chalk	1½
	Flints	4
		347

The "chalk" is probably merely some calcareous bed overlying a thick mass of the green-coated flints ("Flints"), below which would be the true chalk, or else the figures are reversed.

Well-section, Balham Hill, near Clapham Common.

(Dr. Mitchell's MSS. vol. iv. p. 205*.)

		Feet.
	Mould	1
	Yellow clay	4
	Sand	4
	Gravel	6
London Clay.	*b.* Brown clay	6
	a. Blue clay or burl	233
II. *Woolwich and Reading Series, 53 ft.*	*i.* Oyster-shell rock	5
	h. Brown clay	13
	g. White clay	4
	f. Yellow clay	3
	e. Red clay	2
	d. Light blue clay	5
	c. Black clay	3
	b. Brown clay	13
	a. Pebble-stones	5
Thanet Sands.	Sand	40
		347

Well-section, York-mead, Lambeth.

(Parl. Report, "Supply of Water in the Metropolis," 1828, p. 111.)

		Feet.
	Made ground, gravel, and clay	30
	Stony blue clay (*London clay*)	139
I.?	Clay stone	0½
	Hard rock	1½
II.	Hard mixed clay and sand	20
	Shell and pebble stones	6
	Green soft sandstone came up in sand	14
		211

The complete suite of specimens preserved by Mr. A. K. Barclay enables me to give the following section in greater detail than usual. It establishes the important fact of the well-marked local occurrence of the *Ostrea Bellovacina* at the base of Group II. (*a, b.*), and shows clearly the Woolwich shell bed (*g*) placed between two considerable masses of mottled clays.

Well-section, Barclay and Perkins's Brewery, Southwark.

	Feet.
Made ground and silt with vegetable remains	20
Grey clayey sand with specks of phosphate of iron	1
Gravel	6½
Carried forward	27½

* Although the publications on Tertiary Geology of the late Dr. James Mitchell are not numerous, he was an indefatigable observer and collector in this field, and was ever ready to assist others unreservedly with his facts and profusely with his specimens, as I can testify from personal experience. On many points his views were often peculiar, and not in conformity with prevailing opinions; but his convictions were always honest and boldly expressed. He has left five folio MS. volumes of valuable rough notes on the Geology, Botany, and Wells of the neighbourhood of London. These are now in the possession of his nephew Mr. James Templeton of Exeter, who has been good enough to allow me the free use of them. This and several other well-sections are from this MS. work.

Series	Bed	Description	Feet.
		Brought forward	$27\frac{1}{2}$
London Clay.	Brown and blue clay.	At 84 feet a thin layer of pebbles	$77\frac{1}{2}$
		At 92 feet a layer of septaria	
		At 96 feet a layer of septaria	
		At 99 feet a layer of septaria	
		At 99 feet a mass of wood pierced by Teredo	
II. *Woolwich and Reading Series,* 62 *feet.*	*j.* Mottled clays.	Red and light greenish at 100 feet	22
		Light brown and grey at 112 feet	
		Very light-coloured mixed sand at 113 ft.	
		Brown and light grey at 114 feet	
		Brown and light grey at 128 feet.........	3
		Light greenish at 129 feet	
		Brown at 130 feet...........................	4
		Greenish and sandy at 134 feet	
	i.	Light brown sand and grey clay	1
	h.	Grey clay and vegetable matter	2
	g.	Grey clay with a few shells (*Cyrena* ?)......................	3
	f. Mottled clays.	Greenish, brown and grey at 141 feet...	8
		Red, full of race, at 146 feet	
		Red and green at 147 feet	
		Brown and greenish at 148 feet	
	e. Sandy clays, partially mottled:	Brown and greenish, with flint pebbles, at 149 feet...............................	7
		Do., with middle-sized pebbles, at 150 ft.	
		Do., with larger-sized pebbles, at 152 ft.	
		Very small pebbles, subangular, 154 ft.	
	d.	Clayey green sand with pebbles and wood	2 ?
	c.	Green sand with larger pebbles	1
	b.	Green sand, bright-coloured, a few pebbles, and *Ostrea.*	6
		,, ,, large and worn *Ostrea* and a few pebbles	
	a.	Grey clayey sand, with a few *Ostrea Bellovacina* at 167 ft.	3
		,, ,, darker and more argillaceous, and *Ostrea* more numerous at 169 feet	
III. *Thanet Sands,* 36 *feet.*	*b.*	Grey sands, dark and greenish	35
		,, ,, lighter..	
	a.	Green-coated flints in argillaceous green sand	1
			203
		Chalk..	100

Well-section, Fishmongers' Hall, north end of London Bridge.

(Sections of Borings published by the Metropolitan Commissioners of Sewers, 1849; Sheet 3.)

Series	Description	Feet.
	Made ground, black boggy soil and peat ...	27
	Clay and sand....................................	7
	Gravel	14
London Clay.	Blue clay	129
II. *Woolwich and Reading Series,* 60 *ft.*	*d.* Mottled or coloured clay	20
	c. *Shell* rock	11
	b. Green sand......................................	5
	a. Fine sand mixed with pebbles	24
	Chalk.	237

If the chalk is correctly placed in this section, which seems doubtful, it must be a boss rising through the Thanet Sands.

Well-section, St. Mary's Woolnoth, Lombard Street.

(Dr. Mitchell's MSS. vol. v. p. 21.)

		Feet.
London Clay.	Gravel / Blue clay	164
II. *Woolwich and Reading Series,* 53 *feet.*	*c.* Sand	2
	b. Sands and mottled clay	35
	a. Black flints and sand	16
III. *Thanet Sands,* 36 *feet.*	*b.* Sand, greenish	35
	a. Flints	1
	To the Chalk	253

The following well, of which, like that at Messrs. Barclays, specimens and particulars were carefully taken, is particularly interesting from its confirming the same facts, and yet showing marked variations in the relative character of the beds *a* to *o*. II.

Well-section, Bank of England, 1851.

(From section published for private distribution, and from inspection of the specimens), Pl. I. Diag. A, Loc. sect. 20.

		Feet.
	Made ground	22
	Gravel	4
	London clay	111
II. *Woolwich and Reading Series,* 58 *feet.*	*o.* Light yellow mottled clay	2
	n. Light yellow mottled clay, sandy	6
	m. Red and brown mottled clay	2
	l. Light-coloured sand	5
	k. Light-coloured mottled sandy clay	1½
	j. Light blue and brown mottled clay	8
	i. Carbonaceous clay and lignite	1½
	h. Light grey sand	2
	g. Light grey clay and shells (*Cyrena, Melania*)	1
	f. Dark grey clay and shells (*Cyrena, Melania, Ostrea*)	2½
	e. Hard light-coloured concretionary limestone	3
	d. Red, blue, and brown mottled clay	1½
	c. Flint-pebbles in clay	5
	b. Bright dark green sand and flint-pebbles	13½
	a. Dark green sand with shells (*Ostrea*)	4
III. *Thanet Sands,* 39 *feet.*	*b.* Light grey sands, the lower part darker and more argillaceous	38
	a. Bed of flints	1
		234½
	Chalk	100
		334½

In the next section the Woolwich clay beds are probably represented by Stratum *f*. II.

Well-section, Shoreditch Workhouse. (Pl. I. Diag. C, Loc. sect. 6.)

(Mr. R. W. Mylne.)

	Feet.
Made earth	10
Gravel	8
London clay	58
Carried forward	76

		Feet.
	Brought forward	76
I. *Basement-bed of the London Clay.*	*b.* Shelly rock	1
	a. Sand	1
II. *Woolwich and Reading Series, 40 feet.*	*j.* Light clay	2
	i. Coloured clay (*Mottled clay*)	7
	h. Dark red clay (*ditto*)	3
	g. Bluish clay	3
	f. Black clay	7
	e. Sandy clay	3
	d. *Oyster shells*	3
	c. Pebbles	2
	b. Green sand	9
	a. Pebbles in green sand	1
III. *Thanet Sands, 39 feet.*	*b.* Light sand with water	38
	a. Flints	1
		157
	Chalk	100
		263

Well-section, Hoxton.

(Mr. R. W. Mylne.)

		Feet.
	Made earth and gravel	18
	London clay	69
II. *Woolwich and Reading Series, 34 feet.*	*c.* Mottled clay	16
	b. Pebbles, black and green, mixed with sand	10
	a. Green sand	8
III. *Thanet Sands.*	Black sand	30
	To the Chalk	151

Well-section, New City Prison, Holloway (from inspection of specimens in the possession of Mr. Bunning).

			Feet.
	London Clay		135
II. *Woolwich and Reading Series, 61 feet.*	*i.* Mottled clay	about	22
	h. Coloured sands	,,	5
	g. Yellow sand	,,	2
	f. Clayey green sand	,,	6
	e. Yellow and greenish sands	,,	8
	d. Pebbles and green sand	,,	6
	c. Sand and brown clay with traces of vegetable matter	,,	7
	b. Dark green sand	,,	6
	a. Sand with clay and pebbles	,,	7
III. *Thanet Sands.*	Sands ?		12 ?
	Flints		1
			217
	Chalk		102
			319

I could not exactly make out from the specimens where the Chalk begins in this section. The last Tertiary bed named is *a.* II., but as that seems to leave a space unoccupied, I have inserted "sands" with a doubt. At the Pentonville Prison the Mottled clay series is 55 feet thick and the Thanet Sands 35 feet.

Well-section, Hornsey.

(Mr. N. T. Wetherell.)

		Feet.
	Vegetable mould	2
	London clay	138
I. *Basement-bed of the London Clay?*	Clay and green sand	2 ?
II. & III. *Woolwich and Reading Series and Thanet Sands.*	Sand	8
	Wood or imperfect coal (*lignite*)	4
	Several beds of Plastic clay and sand, and sand. The last bed above the chalk consists of green sand and pebbles	71
	To the Chalk	225

Well-section, Colney Hatch Lunatic Asylum.

(13th Report of the Committee of Visitors, 1850.)

		Feet.
London Clay.	*b.* Brown clay	36
	a. Blue clay	98
I. *Basement-bed of the London Clay, 3 feet.*	*b.* Hard stone	1
	?*a.* Green sand	2
II. *Woolwich and Reading Series, 27 feet.*	*c.* Coloured clay	8
	b. Coloured clay, various colours	13
	a. Black pebbles	6
III. *Thanet Sands.*	Dark grey sand	25
		189
	Chalk	141
		330

Well-section, Winchmore Hill.

(Dr. Mitchell's MSS. vol. iv. p. 59.)

		Feet.
London Clay.	Blue clay	186
II. *Woolwich and Reading Series.*	*b.* Red clay	36
	a. Sands and gravel	8
	To the Chalk	240

The preponderance of green sands in the place of the mottled clays, which are so well developed at Tottenham*, is a peculiarity in the following section. *a.* and *b.* II. may possibly belong to the Thanet sands.

Well-section, Waltham Cross.

(Mr. R. W. Mylne.)

	Feet.
Mould	2
Loam	4
Gravel	7
Gravel, very rough	3
Carried forward	16

* "Geol. England and Wales," note, p. 24.

		Feet.
	Brought forward	16
London Clay.	b. Blue clay	24
	a. Blue clay, mixed with dark sand	10
I. *Basement-bed of the London Clay?* 6 *feet.*	b. Blue clay, lighter-coloured, and sand ...	5
	a. Black pebbles	1
II. *Woolwich and Reading Series,* 51 *feet.*	i. Light green mottled sand.................	7
	h. White live sand.............................	3
	g. Light green sand, slightly mottled	1
	f. Green sand, but darker.....................	3
	e. Green sand, mixed with flint-pebbles ...	3
	d. Dark bay green sand........................	7
	c. Green sand and pebbles	1
	b Green sand, getting darker	16
	a. Green sand, very little difference	10
	Chalk not reached.	107

Well-section, Hoddesden Brewery.

(Mr. R. W. Mylne.)

		Feet.
	Gravel	20
Lower part of the London Clay and the Woolwich and Reading Series.	c. Loam and marly sands	45
	b. White sand	24
	a. Flints	1
		90
	Chalk	4

The sections in continuation northward of this line have been given in a preceding part of this paper (p. 92).

We will now take an East and West line, commencing near Esher where the principal changes take place in the structure of the Lower Tertiaries, and passing also through London to Chelmsford.

Well-section, Claremont.

(J. Day.)

		Feet.
Lower Bagshot Sands.	Sand	50
London Clay.	Blue clay	450
Woolwich and Reading Series, 60 *feet.*	c. Mottled clays	48
	b. Brown sand	10
	a. Green sand and flints	2
	To the Chalk	560

Well-section, Isleworth.

(Trans. Civ. Eng.)

		Feet.
	Gravel and sand	24
London Clay.	Blue clay...	216
Woolwich and Reading Series, 87 *feet.*	f. Clay, mottled light red, becoming darker as it deepens..................	68
	e. Blackish clay	3
	d. Yellow sand passing into light green	6
	c. Dark green clay	10
	Chalk not reached.	327

Well-section, Mortlake Brewery.
(Dr. Mitchell's MSS. vol. iv. p. 207.)

		Feet.
	Gravel	10
London Clay.	*b.* London clay (ash-coloured compost)	90
	a. Mottled red passing into red	109
II. *Woolwich and Reading Series,* 58 *feet.*	*h.* Green sand	9
	g. Yellow sand	3
	f. Greenish sand and clay	17
	e. Purplish clay with lignite	4
	d. Yellow sand	2
	c. Light green sand	4
	b. Ash-coloured clay with *shells*	15
	a. Green sand	4
		267
	Chalk	3
		270

The term "Mottled clay" applied to Stratum *a.* II. is, I suspect, a wrong term. I have therefore grouped it as part of the London Clay, which gives a thickness to that formation agreeing with neighbouring sections.

Well-section, Griffin Brewery, Chiswick.
(Mr. R. W. Mylne.)

		Feet.
	Earth and gravel; Sand and fine gravel; Gravel and sand	40
London Clay.	Blue clay	140
II. *Woolwich and Reading Series,* 90 *feet.*	*e.* Mottled clay	6
	d. Blue clay mixed with sand	9
	c. Brown and sandy mottled clays	15
	b. Bright red, yellow, pink and bluish mottled clays	53
	a. Pebbles in bluish mottled clay	7
III. *Thanet Sands,* 29 *feet.*	*e.* Yellow sandy clay	1
	d. Variegated sand	2
	c. Green and brown sand	23
	b. Hard green sand; *a.* Flints	3
		299
	Chalk	46

Well-section, Kensington Workhouse.*
(Mr. R. W. Mylne.)

		Feet.
	Made ground	8
	Gravel	3
	London clay	179
Woolwich and Reading Series and Thanet Sands.	Mottled clays	38
	Pebbles and sand	42
		270
	Chalk	100

* In this section, as in that at Notting Dale, the lower sands and pebbles of the Woolwich series have, I believe, been confounded with the Thanet Sands.

Well-section, Elliott's Brewery, Westminster.

(Mr. R. W. Mylne.)

		Feet.
	Made ground and gravel	32
London Clay.	Blue clay	140
II. *Woolwich and Reading Series, 68 feet.*	*j.* Mottled clay	6½
	i. Sand	1
	h. Red and yellow clay (*mottled clay*)	12½
	g. Blue sand	1½
	f. Red marl (*mottled clay*)	13½
	e. Blue clay and *shells*	10
	d. Yellow clay	3½
	c. Red clay (*mottled clay*)	7
	b. Yellow clay	3½
	a. Gravel, rock, and blue sand	8½
III. *Thanet Sands, 31 feet.*	*b.* Green sand	9½
	a. Running sand	22
		271
	Chalk	127

Well-section, Thorne's Brewery, Westminster.

(Mr. R. W. Mylne.)

		Feet.
	Made earth, gravel, &c.	27½
	London clay	100
II. *Woolwich and Reading Series, 66½ feet.*	*c.* Sand and clay	11
	b. Coloured clay	49
	a. Sand and pebbles	6½
III. *Thanet Sands, 36 feet.*	*c.* Sand with water	14
	b. Sand	20
	a. Flints	2
		230
	Chalk	70

Well-section, front of the National Gallery, Trafalgar Square.

(The Illustrated London News for April 5, 1845.)

		Feet.
	Made ground	9
	Gravel	5
	Shifting sand	7
	Gravel	2
	London clay	141
I. *Basement-bed L. C.?*	Thin layer of shells	1
II. *Woolwich and Reading Series, 40 feet.*	*b.* Plastic clay (*mottled clay*)	30
	a. Green sand, pebbles, &c.	11
III. *Thanet Sands*	Green sand	42
		248
	Chalk	147

Well-section, Apothecaries' Hall, Blackfriars.

(Mr. R. W. Mylne.)

	Feet.
Made ground	12
London clay	114
Carried forward	126

		Feet.
	Brought forward......	126
II. *Woolwich and Reading Series,* 48 *feet.*	*c.* Dark sand..........	13
	b. Mottled clay..........	30
	a. Clay, sand, and pebbles	5
III. *Thanet Sands,* 44 *feet.*	*b.* Green sand	20
	a. Light black sand	24
		218
	Chalk	76

Well-section, Royal Mint, Tower Hill. (Pl. I. Diag. A, Loc. sect. 21, & C, Loc. sect. 7.)

(Sect. Bor. by Metrop. Comm. of Sewers, 1849, Sheet 4, and from examination of specimens.)

		Feet.
	Made ground	11
	Gravel and sand	13
London Clay.	Blue clay	94
II. *Woolwich and Reading Series,* 55 *feet.*	*k.* Light sand	4½
	j. Light-coloured sand	14
	i. Dark-coloured sand	4
	h. Mottled clay	5½
	g. Loamy dark sand and clay	5
	f. Shelly blue clay (*Cyrena, Melania, Ostrea*)	3
	e. White rocky soil, very hard	2½
	d. Green sand and pebbles, hard and dry	3½
	c. Loamy green sand and black pebbles	5
	b. Green sand and pebbles	6
	a. Green sand and shells (*Ostrea*)	4
III. *Thanet Sands,* 20½ *feet.*	Dark sand	15
	Flints	5½
	To the Chalk	195½

Well-section, Truman, Hanbury and Co.'s, Shoreditch.

(Mr. R. W. Mylne.)

		Feet.
	Made ground .... / Clay .... / Gravel and sand ...... / Clay	23½
	London clay	79½
II. *Woolwich and Reading Series,* 53 *feet.*	*m.* Light blue mottled	11
	l. Blue mottled	2
	k. Dark mottled	6
	j. Rock	1½
	i. Bluish green	4
	h. Hard blue loam and *shells*	6
	g. Hard yellow clay and pebbles	5
	f. Pebbles	4
	e. Green sand and black pebbles	2
	d. *Shell rock*	1½
	c. Green sand and pebbles	5
	b. Dark sand and pebbles	4
	a. *Oyster-bed*	1
III. *Thanet Sands.*	Dark grey sand and pebbles	43
		199
	Chalk	201

In this and the following section the development of the pebble beds in the lower part of the Woolwich series is remarkable.

Well-section, Walton's Sugar-house, Angel Court, Whitechapel.

(Dr. Mitchell's MSS. vol. iv. p. 48.)

		Feet.
	Mould and soil	6
	Gravel	12
London Clay.	*b.* Yellow clay	3
	a. Blue clay	97
II. *Woolwich and Reading Series, 69 feet.*	*p.* Light green sand and some clay	6
	o. Blue clay and sand	2
	n. Dark brown clay	12
	m. Blue clay and sand	2
	l. Blue clay and sand with *shells*	2
	k. Hard sand	1
	j. Hard green sand and clay	1
	i. Red and grey clay	2
	h. Yellow clay with pebbles	4
	g. Clay and gravel conglomerate, very hard, with large pebbles	9
	f. Sand, pebbles, and a little clay	6
	e. Yellow clay	1
	d. Green sand, very hard	2
	c. Loose sand, black pebbles	4
	b. Blue clay	3
	a. Sand and black pebbles	12
		187

At Osborne-street, near the above, chalk was found about 26 to 30 feet lower, through a bed of fine white sand (*Thanet Sands*).—Dr. M.

Stratum *p.* II. may possibly be the Basement-bed of the London Clay.

Well-section, Kirk and Dycks', Osborne-place, Whitechapel.
(Pl. I. Diag. A, Loc. sect. 22.)

(Dr. Mitchell's MSS. vol. iv. p. 50.)

		Feet.
	Mould and soil	6
	Yellow clay	6
	Gravel	12
London Clay.	*b.* Yellow clay	1
	a. Blue clay	95
II. *Woolwich and Reading Series, 54 feet.*	*h.* Yellow-red clay	6
	g. Sand	1
	f. Yellow-red clay	12
	e. Green sand	5
	d. Yellow-red clay	10
	c. Sand	3
	b. Gravel rock, very hard	9
	a. Green sand and black pebbles	8
III. *Thanet Sands.*	Sand	16
		190

Chalk not reached.

Judging from some adjoining wells, I think that *d.* II. is wrongly described, and that it represents the Woolwich shell bed.

Well-section, City of London Union, Mile End Road.

(Mr. R. W. Mylne.)

		Feet.
	Made earth and vegetable earth	4
	Yellow dry earth	2
	Coarse gravel mixed with fine sand	15
	Fine gravel and sand	14
London Clay.	? Mixture of clay, sand, and water	$20\frac{1}{2}$
	a. Hard dry blue clay	40
II. *Woolwich and Reading Series,* 41 *feet.*	*k.* Soft blue clay with fine silky running sand	$12\frac{1}{4}$
	j. Sandy clay, yellow-coloured, and small stones	$2\frac{3}{4}$
	i. Hard yellow sand	1
	h. Sandy clay, yellow and green	4
	g. Compact sandy clay	2
	f. Compact green clay	1
	e. Compact yellow and green	2
	d. Hard yellow clay and large pebbles	7
	c. Green sand	1
	b. Black sand	2
	a. Black sand and small pebbles	6
III. *Thanet Sands,* $38\frac{1}{2}$ *feet.*	*e.* Black sand, compact	4
	d. Black sand, less compact	5
	c. Black clay, sandy grit	1
	b. Black sand mixed with black clay, and soft	$27\frac{1}{2}$
	a. Black flints, small	1
		175
	Chalk	10

I feel very uncertain where I should draw the lines of division in this section. They must be considered as doubtful. I am almost inclined to carry Group II. down to *c.* III. inclusive.

Well-section, Bromley near Stratford. (Pl. I. Diag. A, Loc. sect. 23.)

("Geology of England and Wales," p. 45.)

		Feet.
	Loam, clay, gravel, and sand	18
	London clay	44
	Blue clay	2
Basement-bed of the London Clay, 5 *feet.*	*b.* Clay, sand, and *shells* mixed	1
	a. Gravel, sand, and *shells*	4
II. *Woolwich and Reading Series,* 51 *feet.*	*i.* Fine sand	4
	h. Blue and yellow clay	9
	g. Sand and *shells*, with large lumps of pyrites...	4
	f. Blue clay, with abundance of broken *shells*, some resembling *oysters*, and pyrites	9
	e. Solid limestone	1
	d. Black sand, passing into small round pebbles, like the Blackheath pebbles; *c.* Black sand, veined; *b.* Some small pebbles in the sand, which is still hard and compact	22
	a. Blue clay, very hard and firm	2
Beneath this last bed are probably the *Thanet Sands.*		120

Well-section, South side of the Export Dock, West India Docks.

(Dr. Mitchell's MSS. vol. iii. p. 85.)

		Feet.
	Made gravel (?)	15
	Clay	5
	Gravel	25
Thanet Sands?	Clear sand..	30
	Sand and *shells*	45
		120
	Chalk	240

I give this section from its peculiarity. The occurrence of shells above the Chalk I have not had confirmed.

Well-section, Trinity Wharf, Blackwall.

(Mr. R. W. Mylne.)

		Feet.
	Made ground	18
	Gravel	45
	London clay*	68
II. *Woolwich and Reading Series,* 34 *feet.*	*d.* Grey sand	8
	c. Shells and iron pyrites	2
	b. *Oyster-shells* and sand	14
	a. Stiff green sand	10
III. *Thanet Sands,* 71½ *feet.*	*b.* Grey sand	65
	a. Stiff sand and clay	7
		237
	Chalk	10

Well-section, West Ham, Essex.

(Mr. R. W. Mylne.)

		Feet.
	Made ground	8
	Black gravel	9
	Peaty clay	16
II. *Woolwich and Reading Series,* 58 *feet.*	*g.* Pebbles	2
	f. Shelly	4
	e. Light brown sand	18
	d. Clay and *shells*	6
	c. Hard *shells*	5½
	b. Green sand	1½
	a. Pebbles	5
III. *Thanet Sands.*	Sand	57
		132
	Chalk	306

* In the section of this well, and of the one at Bromley, I feel considerable hesitation in retaining the designation of "London clay" here given by the well-digger; for I am rather induced to think, from the outcropping of the Woolwich conglomerate in the river at Blackwall and of the Basement-bed of the London clay at Stratford, that the London clay does not exist in the first-named localities. It certainly may be there, and be thrown out by a fault on a line near adjacent. I consider it however more probable that the mineral character of the stratum has led to some mistake, and that the bed here taken to be the London clay may be a peculiar condition and unusual development of the mottled clays, where they clash and mix with the upper part of the Woolwich clays and sands, losing their

For a small section of the Basement-bed and of the upper part of the Woolwich series at Stratford see Journ. Geol. Soc. vol. vi. p. 262.

The sections of wells which I have from Ilford, Romford, Brentwood, and adjacent districts give us no particulars of the Lower Tertiaries, as water was in all cases obtained almost directly after passing through the London clay. Some preliminary works for an artesian well by the Local Board of Health at Chelmsford have, however,

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mottled character and passing into a brown micaceous sandy clay. An instance of this has recently come before me in the section of a trial boring made opposite Blackwall. Beneath 33 ft. of peat and gravel were 55 ft. of brown clay, which had been mistaken for the London clay. At first sight it certainly a good deal resembled it, but on a closer examination it presented characters decidedly differing from that clay, which is of a lighter brown, or else bluish, more homogeneous, and is not so micaceous. It is in all cases very necessary to guard against well-sections not recorded with sufficient care. Several of those collected by Dr. Mitchell are in all probability given wrong by the well-digger, as one near Waterloo Bridge (W.), which brings the London clay too near to the chalk.

W.	Feet.
Gravel and sand	40
Blue clay	110
Red clay	10
Sand	5
To the Chalk	165

Whilst in another well at Finsbury the mottled clays are omitted altogether.

	Feet.
Gravel and London clay	160
Sand and pebbles	10
To the Chalk	170

The same fact is observable in some of the sections collected by the Commissioners of Sewers; as for instance—

Well-section, Goding's Brewery.

	Feet.
Made ground	15
Gravel	15
Blue clay	160
To the Chalk	190

Well-section, Thorne's Brewery.

	Feet.
Made ground and gravel	40
Blue clay	162
To the Chalk	202

(See p. 148.)

	Well-section near Westminster Bridge. Feet.	*Mortlake.* Feet.	*Barnes.* Feet.
Made ground and gravel	27	10	18
Blue clay	160	180	180
To the Chalk	187	190	198

Some mistake is evidently made in these sections in carrying the London clay down to the chalk. In some others too great an extension has apparently been given to the beds of flint pebbles (called gravel), as they appear to occupy the place of the Thanet Sands as well as their own :—

Well-section, Bermondsey.

	Feet.
Bog earth and peat	9
Silt	3
Quick sand	20
Blue clay	60
Gravel	110
	202

Well-section, Seager's, Milbank.

	Feet.
Made ground	$22\frac{1}{2}$
Gravel	3
Blue clay	93
Blue rock	2
Sand and gravel	$77\frac{1}{2}$
To the Chalk	198

recently afforded a section of part of the beds beneath the London clay at that place.

Trial bore at Chelmsford.

(Specification paper.)

		Feet.
Drtfi.	Dark mould	3
	Yellow clay	1
	Gravel	15
	Sand (dark)	51
London Clay.	*b.* London clay	100
	a. London clay and silver sand	50
II. *Woolwich and Reading Series?*	Dark sand	$12\frac{1}{2}$
	Clay-slate (?)	$0\frac{3}{4}$
	Clay and sand	4
	Clay-slate (?)	$0\frac{1}{4}$
	Dark sand, with fine clay at intervals	$9\frac{1}{2}$
	Clay, sand, and *shells*	$2\frac{1}{2}$
	Clay and *shells*	$0\frac{1}{2}$
	Pebbles	$1\frac{1}{2}$
	Sand (spring)	$4\frac{1}{2}$
		256

As I have not had the opportunity of seeing the specimens, I am unable to say positively to what part of the Lower Tertiaries these beds may belong: it is probable, however, that those beneath the London Clay down to the "Pebbles" inclusive may belong to the Woolwich series, and that the "Sand (spring)" may be the top of the Thanet Sands. The beds called "clay-slate" are, I presume, hard laminated clay or shale.

I have also recently been furnished by Mr. A. C. Veley of Braintree with the following section of a well at Halsted.

Well-section, White Hart, Halsted.

(Letter from the Rev. W. Clements.)

		Feet.
	A layer of sand and gravel	7
	A bed of yellowish clay	8
	The London clay	89
II. *Woolwich and Reading Series.*	A layer of yellow sand passing into brown clay	7
	A bed of plastic clay	19
	A greenish sand	15
III. *Thanet Sands.*	Several layers of sand gradually passing from a light colour to nearly a black, about	25
	Chalk	30
		About 200

The Rev. W. B. Clarke also gives sections of two wells at Harwich, in which the mottled clays appear, but no fossils. (Trans. Geol. Soc. 2nd ser. vol. v. pp. 369, 370.)

Notes on some Miscellaneous Fossils *from the* "Woolwich *and* Reading Series."

Corbula Arnouldii, Nyst. Pl. II. fig. 3.

Described, but not figured, by M. Nyst in his "Descr. des Coquilles fossiles des Terr. Tert. de la Belgique," p. 67. This is a not uncommon shell in the Lignites of Rilly in Champagne. The French specimens in my possession are rather larger than the English species; and, further, as these latter are merely casts, they can only be referred with a doubt to this foreign species. From Oakwells, near Boughton.

Cyrena intermedia, Melleville. Pl. II. figs. 10, 11.

Melleville, in his "Mém. sur les Sables Tert. Inf. du Bassin de Paris," figures and describes a *Cyrena* from Châlons-sur-Vesle, which, although rather larger, bears a close resemblance to a small and elegant shell common in the upper beds at and around Woolwich. The specimen here figured is referred with a doubt to this French species, which latter appears from the figure to be slightly more rounded.

Ampullaria (Natica) subdepressa, Morris. Pl. II. fig. 16.

In my paper on the Thanet Sands, Mr. Morris briefly described a new species of *Ampullaria* under the above specific appellation; but it was not figured, owing to the imperfect condition of the specimen. Having better specimens from the Woolwich series and also from the Basement-bed of the London Clay, the shell in question is here figured. (For description, see Quart. Journ. Geol. Soc. vol. viii. p. 267†.) Richborough.

Patella. Pl. II. fig. 24.

This is a single specimen found attached to a fragment of an Oyster at Sundridge Park by Mr. Lunn. It does not seem to agree with any of the French patelliform shells; but, owing to the want of the exterior shell, no exact specific determination can be made.

Dentalium. Pl. II. fig. 25.

In the memoir on the "Thanet Sands" (Quart. Journ. Geol. Soc. vol. viii. p. 248), the *Dentalium*, apparently the same species as this, was considered to be the *D. nitens*. This determination, however, seems to me to be very doubtful. I should rather refer this species from Herne Bay to an undescribed form from the "Lower Tertiary Sands" of Beauvais. The specimens are too imperfect for exact determination.

† In a paper by M. Watelet on the "Sables Tertiaires des environs de Soissons" (Soc. Hist. Archéol. et Scient. de Soissons, 1853), which I have just received, is a fossil bearing a very close resemblance to this English species figured: it is, however, in a much better state of preservation. M. Watelet has named it *Natica infundibulum*.—[J. P., Jun., January 1854.]

Serpula. Pl. II. fig. 26.

This is a very common fossil at Sundridge Park, although it rarely occurs elsewhere in the Woolwich series; but, although abundant, its characters are too indistinct for a specific name to be satisfactorily applied. It is a fine, thin, convoluted species. The specimen figured is part of a mass attached to an Oyster.

Fir-cone. Pl. III. fig. 3.

This beautiful specimen, the cast of a Fir-cone in a ferruginous sandstone nodule, is from the Woolwich series of the Reculver Cliffs. It presents distinct differences from the Fir-cones of the London Clay, and from that figured by Mr. Dixon from Bracklesham (Dixon, Foss. Sussex, pl. 9. figs. 3, 4). The specimen from the Reculvers is a true and well-marked Fir-cone, belonging apparently to some species of *Abies*.

Seed-vessel (Pl. III. fig. 4), and other Vegetable Remains. (Pl. III. fig. 5).

These fossils from the Planorbis-bed at Counter Hill are figured rather for reference and record. At present no specific determination can be attempted. They differ from described specimens.

Two Dicotyledonous leaves have been found by Mr. De la Condamine in the Paludina-bed of the same locality.

Fern-leaf. Pl. III. fig. 6.

One of the recent discoveries by the Rev. Mr. De la Condamine at Counter Hill. This Fern is probably an *Asplenium*; the leaflets occur in some numbers, and are associated with fragments of Monocotyledonous leaves (especially *Phyllites* "*r*," Pl. IV. figs. 22, 23), and one or more Dicotyledonous leaves.

Remains of Fishes.

*Vertebra of Lepidosteus**. Pl. III. fig. 1.

This specimen was discovered by the Rev. Mr. De la Condamine at Upnor, and I am indebted to Prof. Owen for the following observations on this interesting fossil:—

"The body of an anterior abdominal vertebra of a large species of *Lepidosteus*, a genus of Ganoid Fishes now peculiar to the rivers and lakes of North America. The specimen is fossilized; similar, but smaller, fossil specimens have been discovered in the Eocene Tertiary deposits of Hampshire."—[Oct. 15, 1852.]

* The dark enamelled scales of the *Lepidosteus* have since been found by the Rev. H. De la Condamine at Counter Hill, and by Mr. Rosser at Woolwich: in both places in the upper beds of the Woolwich series. From the former locality Mr. De la Condamine has also obtained, in the Paludina-bed, another vertebra, belonging to a much smaller species of *Lepidosteus* than the above-described.

Fish Vertebræ.

The vertebræ of *Lamnæ* are not rare in the "Lower Tertiary Sands," and with them occur in rather greater abundance the vertebræ of some osseous fish, one of which is here figured (Pl. III. fig. 2); many of them are, however, of a much smaller size.

Fish-scales. Pl. III. figs. 2*, 2**.

These are the large scales of some Cycloid? fishes, to which possibly the last-mentioned vertebræ may also be referred. With these are found smaller scales of similar character, and a few very small conical teeth belonging probably to the same class of fishes. Localities: Woolwich and Sundridge.

Cycloid scales and fish-bones occur also at Counter Hill, in the Paludina-bed.

Bird Remains.

A very interesting specimen of a small, irregularly cylindrical bone, about half an inch in length, discovered by the Rev. H. M. De la Condamine at Counter Hill, whilst these pages were passing through the press, has been determined by Prof. Owen, who has kindly examined it, to be *the first phalangeal bone of the foot of a bird.* It is the only such specimen found. [J. P., Jun., April 10, 1854.]

Descriptions of some New Species *of* Shells *from the* "Woolwich and Reading Series." By John Morris, F.G.S.

Cardium Laytoni, n. sp. Pl. II. figs. 1, 2.

Testâ trigonali, inæquilaterali, posticè subangulatâ, obliquatâ, costatâ; costis numerosis, planulatis; margine dentato; umbonibus incurvis, approximatis.

A trigonal, inequilateral, and somewhat oblique shell, with the posterior portion slightly angulated; the surface is marked with numerous flattened ribs and linear interspaces, which become more distinct and separated on the posterior angulated side; the margins are strongly dentated. This shell is distinguished from *C. Plumsteadiense* by its smaller size, more uniform marking, and the posterior side not being so much produced or angular.

The specimen figured was found at Richborough by the Rev. J. Layton, of Sandwich, after whom the species is named.

Corbula Regulbiensis, n. sp. Pl. II. figs. 4, 5.

Testâ ovato-transversâ, subgibbosâ, rostratâ; striis tenuissimis irregularibus ornatâ.

——— —————, ——, var. β. Pl. II. fig. 6.

Testâ irregulari, vix rostratâ.

An ovate and somewhat quadrangular shell, with the posterior margin but very slightly produced, except in the variety from Herne

Bay, which is generally so. The surface is covered with irregular fine laminæ, slightly raised; the umbones very small, and approximate.

This species has been identified with an undescribed form from Bracheux, given to Mr. Prestwich by M. Deshayes, but which is not published. Named after the locality (the Reculvers) where this species is most common.

From Mr. Prestwich's collection.

CYRENA CORDATA, n. sp. PL. II. figs. 7, 8, 9.

Testâ subtrigonali, crassâ, gibbosâ, rugosâ; umbonibus prominentibus, antico rotundato, postico subrostrato, depresso, attenuato.

The general form of this shell is trigonal; the beaks are prominent and incurved; the ventricose character of this shell towards the umbones gives it, when viewed anteriorly, a cordiform appearance (whence the name); the posterior side is attenuated and slightly truncate. The surface of the shell towards the anterior side is very rugose by the lines of growth.

This species is intermediate to *C. cuneiformis* and *C. deperdita*, and also resembles in its cordate form the *C. antiqua* of the Paris basin; it does not, however, possess the depressed character of the posterior cardinal edge.

From Mr. Lunn's collection.

MODIOLA MITCHELLI, n. sp. PL. II. figs. 12, 13.

Testâ tenui, lævi, subtrigonâ, anticè obtusâ, posticè dilatatâ; cardine marginali recto.

A somewhat trigonal, depressed, and dilated shell, with the umbones obtuse, the dorsal line straight, and the byssal margin nearly straight, or but very slightly curved; the surface nearly smooth, or faintly marked by lines of growth.

This species is near to *Dreissena antiqua*, Mell., but the dorsal margin is more produced, and the general contour of the shell more spathulate.

Not rare in the upper part of the Woolwich series at New Cross, Deptford, Lee, and Blackheath. It is rarely found perfect. Named after the late Dr. Mitchell, who obtained the best-preserved specimens of this shell at New Cross, during the cutting of the Croydon railway.

MODIOLA DORSATA, n. sp. PL. II. fig. 14.

A rare species—the specimen is hardly sufficiently perfect for an exact determination of its characters. It differs from the preceding species in the umbo not being so terminal, and the form being less spathulate and more compressed.

From Sundridge. Mr. Prestwich's collection.

PSAMMOBIA? CONDAMINI, n. sp. PL. II. fig. 15.

Testâ ovato-transversâ, inæquilaterali, depressâ, subinæquivalvi, concentricè et irregulariter striatâ; margine antico rotundato, postico rostrato, attenuato, sinuato; margine postico subincurvato, declivi.

An ovate and somewhat spathulate-form shell, inequilateral, the surface marked with concentric irregular striæ; anterior margin rounded, posterior extremity produced and sinuated, posterior dorsal margin somewhat incurved.

This shell, which is referred with some doubt to the genus *Psammobia*, from its association with fluviatile forms, appears to be readily distinguished from the other Eocene species by the more spathulate form and the position of the umbones being nearer to the anterior margin.

This interesting form was found by the Rev. H. De la Condamine, in the clay bed at Counter Hill, Deptford.

Auricula (Conovulus) pygmæa, n. sp. Pl. II. fig. 17.

A few small shells, apparently belonging to this genus, have been found by Mr. Rosser in the upper beds at Woolwich.

The shells are conical, and consist of four or five somewhat depressed volutions, and an ovate aperture with one fold in the columellar lip, and another towards the base.

Cerithium Bowerbankii, n. sp. Pl. II. fig. 18.

Testâ turritâ, brevi; anfractibus subplanis, longitudinaliter nodoso-costatis; costis obliquis, transversim 3–4-plicatis; suturâ subprofundâ.

A turrited shell with nine or ten somewhat depressed volutions, with six to eight nodose costæ, which are obliquely arranged in longitudinal rows, and crossed transversely by three or four transverse obtuse ridges.

Rare in the upper beds of the Woolwich series. From Mr. Bowerbank's collection.

Cerithium gracile, n. sp. Pl. II. fig. 19.

Testâ elongatâ, gracili; anfractibus depressis costatis; costis parvis subobliquis; suturâ lineâ ornatâ.

An elegant and slender shell with numerous volutions, furnished with eight or nine small oblique costæ; suture slightly depressed and marked with a fine line.

Rare in the clays and fossiliferous sands of Woolwich. From the Rev. Mr. De la Condamine's collection.

Cerithium Lunnii, n. sp. Pl. II. fig. 20.

Testâ turritâ, brevi; anfractibus 7, transversim bicarinatis; interstitiis longitudinaliter striatis.

A small conical shell of about seven carinated volutions; the two principal obtuse carinæ occur on the body of each volution, with a smaller one near to the suture: the intermediate spaces are longitudinally striated.

A rare shell. It occurs with the last species. From Mr. Lunn's collection.

HYDROBIA PARKINSONI, n. sp. PL. II. fig. 21.

Testâ ovato-conicâ, lævi; anfractibus 5 rotundatis, ultimo ventricoso; aperturâ obliquâ, ovatâ; suturâ subprofundâ.

A very small conical shell, with five or six rounded and smooth volutions; the last volution is somewhat ventricose, with an ovate aperture.

This species much resembles *Paludina intermedia*, Melleville, but that shell is smaller, more obtuse, and the form of the aperture different.

Common in the Woolwich beds from Guildford to Upnor. Named after Mr. J. Parkinson.

From Mr. Prestwich's collection.

HYDROBIA WEBSTERI, n. sp. PL. II. fig. 22.

This species much resembles the preceding, but is very slightly larger, and has a more expanded and rounded mouth, which gives it a more elegant appearance. It is a rarer form, and occurs in the same beds.

Named, like the preceding species, after a well-known investigator of the geology of our Tertiary districts.

PALUDINA LENTA, Sow., var. β. Mor. PL. II. fig. 23.

Testâ ovato-conicâ, lævi; anfractibus 5–6 subrotundatis; apice obtuso; aperturâ subovatâ.

A smooth conical shell, with five or six rounded volutions, the apex obtuse, and the aperture somewhat ovate. This form, which is difficult to distinguish from the *P. lenta*, Sow., is also considered by M. Deshayes to occur in the Soissons (Lower Eocene) beds, and to be the same as that found in the Isle of Wight.

Common in the Woolwich beds at Peckham, New Cross, and Counter Hill.

Notes on the ENTOMOSTRACA *of the* WOOLWICH *and* READING SERIES. By T. RUPERT JONES, Esq., F.G.S.

1. CYTHERIDEA* MULLERI, Münster, sp. PL. III. fig. 7. Bosquet, *Entomostracés fossiles des terrains tertiaires de la France et de la Belgique*, p. 39. pl. 2. fig. 4 *a–f*.

The valves of individuals of this species have been collected in great number by Mr. Rosser in the Woolwich beds; both in the shelly clays (of the middle of the series), and in the pebbly sand above the clays. I have also found them in some plenty in clay with remains of oyster shells from Woolwich, and I have met with rare specimens in the "Oyster-bed" at Clay Hill, Shaw, near Newbury.

Generally the English specimens slightly differ from M. Bosquet's

* Cytheridea (*Bosquet*) is a subgenus of Cythere (*Müller*), a minute bivalved Crustacean inhabiting salt and brackish waters.

figures in almost wholly wanting the longitudinal parallel furrows on the ventral surface, which are continued transversely and concentrically across the anterior half of the valve; faint traces only of the concentric furrows being occasionally seen, though irregular transverse furrows full of pittings are conspicuous in old specimens. One such transverse furrow, immediately posterior to the "lucid spots" near the centre of the valve, is always present, even in young specimens. I have not yet met with well-preserved individuals retaining the setæ of the surface.

Varieties of *Cytheridea Mulleri* occur throughout the Tertiary formations; being found in Hesse, Austria, Bohemia, Westphalia, France, Belgium, and the Netherlands, in the *Eocene*; in Touraine (*Miocene*); and in the Netherlands (*Pliocene*). M. Bosquet also records this species as recent,—living in the Zuyderzee, Holland. In England varieties of this species occur in the Coralline Crag, the Barton Clay, and the tertiary sands of Coldwell Bay.

2. Cytheridea Mulleri, Münster, sp.; var. torosa, Jones. Pl. III. fig. 8.

The variety differs from the typical *C. Mulleri* in having the surface of the valves raised up into 1–7 irregular lumps or bosses. Of these knobs, which are often but ill-defined, sometimes seven can be counted on one valve. The spots most usually occupied, when the bosses are but few, are the posterior part of the valve and the central part immediately in advance of the place of the "lucid spots."

This variety has some resemblance to the *C. tribullata*, figured and described by Dr. A. E. Reuss, Haidinger's Verhandlungen, vol. iii. p. 60. pl. 9. fig. 10, one specimen of which (since lost) I have found in the Barton Clay. In general form *C. torosa* resembles that variety of *C. Mulleri*, in which the posterior extremity is contracted and acuminate (var. *acuminata*, Bosquet?).

Found plentifully together with the typical form in the above-mentioned Woolwich deposits by Mr. Rosser.

3. Cythere Wetherellii, Jones. Pl. III. fig. 9 *a*, 9 *b*.

This elegant little species of *Cythere* proper has valves of an ovate shape, contracted posteriorly, compressed on the ventral surface, and with a somewhat triangular indentation at about the middle of the dorsal part. The profile of either valve is almost a parallelogram. The surface of the valves is ornamented by a delicate reticulation, the meshes of which are formed by slightly raised anastomosing borders.

I found several specimens of *C. Wetherellii* in clay with oyster-shell fragments from Woolwich.

The name borne by this new species is well known to the students of Tertiary Geology.

4. Cythere Kostelensis, Reuss, sp. *Haidinger's Verhandlungen*, vol. iii. p. 68. pl. 9. fig. 22. Pl. III. fig. 10.

Two specimens of a minute oblong *Cythere* from amongst Mr.

Rosser's series of Entomostraca from Woolwich appear to agree with the figures and description of Dr. Reuss's *Cypridina* Kostelensis*, described in his memoir on the Entomostraca of the Austrian Tertiaries, and found in the Leithakalk of Moravia and Austria, in the salt-rock of Galicia, &c.

5. CYTHERE (CYTHEREIS †) PLICATA, Münster. Bosquet, *op. cit.* p. 60. pl. 2. fig. 13 *a–d*. PL. III. fig. 11.

This species I found to occur not unfrequently in some clay with fragments of oyster-shells from Woolwich.

C. plicata has been found in the *Miocene* of Dax; in the *Eocene* of France, Belgium, North-east Germany, Bohemia, Austria, and Moravia. I have met with it in abundance in the white tertiary sands of Colwell Bay; also in the Barton Clay.

6. CYTHERE (CYTHEREIS) ANGULATOPORA, Reuss, sp. Bosquet, *op. cit.* p. 68. pl. 3. fig. 5 *a–d*. PL. III. fig. 12.

Two broken valves of this beautiful species occurred in the clay with fragments of oyster-shells from Woolwich which supplied me with *C. Wetherellii*, *C. plicata*, &c.

C. angulatopora occurs in the *Eocene* beds of Belgium (Ghent) and of France.

7. CANDONA ‡ RICHARDSONI, Jones. PL. III. fig. 13.

Valves smooth, thin, oblong; rounded at the extremities, depressed towards the anterior extremity, most convex just posteriorly to the centre; ventral border straight; dorsal border gently curved. This species approaches in shape to the recent *Candona reptans*: in size it is much inferior. It also closely resembles a species found in the Upper Eocene of the Isle of Wight.

C. Richardsoni was found by Mr. Baily, in the thin band with *Hydrobia*, *Planorbis*, and *Cyrena* in the Woolwich pit. The individuals are numerous, compressed between the laminæ of the clay. The specimens which we have been kindly permitted to use in figuring and describing this little fossil are now in the Museum of the Geological Survey, Jermyn Street.

Casts of a species perhaps identical with *C. Richardsoni* have been found by the Rev. Mr. De la Condamine in the Planorbis-bed at Counter Hill.

This species has been named after Mr. W. Richardson, F.G.S., to whom geologists and palæontologists are much indebted for facts and fossils from the Tertiary deposits.

* A generic term wrongly applied by this palæontologist in the memoir referred to and elsewhere.

† Cythereis (*Jones*) is a subgenus of Cythere (*Müller*).

‡ Candona (*Baird*) is another genus of the small bivalved Crustaceans, and is closely allied to the common Cypris. Like the latter genus, it is often found abundantly in fresh water.

Note on the Fossil Plants *from* Reading.

By J. D. Hooker, M.D., F.R.S., G.S. &c.

The fossils collected by Mr. Prestwich may be all safely assumed to represent a vegetation differing in no important respect from that at present inhabiting the north temperate zone; but none of them afford sufficient data for approximating to the generic affinities of the plants to which they belonged*. After a careful collation of the specimens with many existing plants comprised in the present floras of Europe, Northern Asia, and North America, I find no characters by which they may be allied to those of one of these countries more than another. Indeed I feel satisfied that similar forms of existing plants might be associated by natural causes in any of these countries, but that they would not necessarily belong to the same species, or even genera, in all.

The total absence of any remains indicative of a tropical vegetation is important; for although forms of foliage precisely similar to these leaves from Reading are even more abundant in some tropical countries than in temperate ones, it is legitimate to suppose that had the association resulted from a tropical vegetation, some more direct evidences of their origin would have been forthcoming.

I do not see that any objection can be urged to the assumption that the climate of the epoch during which these plants flourished was a temperate one, experiencing summer heat and winter cold, and that it was not colder than that which now prevails in England; for the large size and membranous appearance of many of the leaves, which, like those of the maple, lime, poplar, &c., are annual, indicate some duration of summer warmth; and the leaf-buds (figured 24, 25, and 26) are similar to those of various trees which lie dormant for a considerable period of the year. It may also be remarked that there are no appearances of articulations at the base of the leaves, such as would suggest the probability of any of them belonging to Leguminous or other plants with compound foliage, which in the present distribution of vegetation in the north temperate zone indicate a warmer mean temperature than England now enjoys.

The absence of any traces of Coniferous† or other gymnospermous vegetation, and of ferns, is a point of considerable interest; for in all

* These important observations by Dr. Hooker on the probable temperature of this period were made perfectly independently of my own, for, when they were written, he had not read the previous part of this paper, published in the last Part of the Journal, p. 136, nor have I, until after the printing of the above, had any communication with him on the subject of these plants. The conclusions, therefore, to which we have both arrived, upon independent evidence, respecting the apparently moderate climate prevailing here at this old Eocene period, and the absence of those tropical forms which abound in the succeeding London Clay period, furnish strong corroborative proof of the truth of this singular fact. In my former paper on the Thanet Sands I had arrived at the same conclusion respecting the temperature of the sea in which this oldest of our Tertiary deposits was accumulated (Quart. Journ. vol. viii. p. 260).—[J. P., Jun., April 15, 1854.]

† Coniferous wood, however, is present in the Woolwich series of East Kent, and a Fern at Counter Hill.—[J. P., Jun.]

beds of an earlier epoch presenting as many species as are preserved in this, ferns especially predominate. It must, however, be borne in mind, that in the temperate floras of many parts of the northern hemisphere, neither ferns nor gymnosperms are usually associated in any great numbers with large-leaved dicotyledonous trees. In Japan, I believe that Coniferæ and large-leaved Dicotyledons are associated, as also in some parts of America; in England ferns generally accompany similar forms of foliage to the Reading fossils; whereas in Siberia, where broad-leaved dicotyledonous trees are abundant, ferns are extremely rare; as is also the case, I believe, in many parts of North America.

There is no foliage resembling that of grasses, sedges, or rushes, among the Reading specimens, nor any appearance of organs of fructification.

With regard to the individual fossils of these beds; all, except figs. 22 and 23, are decidedly Dicotyledonous and Exogenous, and none present structural or physiological characters of importance, either in texture, form, or nervation. Figs. 22 and 23, from having parallel veins, may be assumed to be monocotyledons; of these, 22 is too anomalous-looking for me to hazard even a conjecture as to the appearance or nature of the plant to which it belonged; while there are few natural orders amongst Monocotyledons to which 23 might not be referred.

Though the leaves preserved in the Reading beds are all of the very commonest forms in the vegetable kingdom (of Dicotyledonous plants), I do not find that they exactly resemble those of any living English species; and indeed even were the resemblance so close that I could not distinguish them from existing forms, I should not consider myself warranted in drawing any conclusions therefrom; because, in the first place, the normal or typical form of leaf in any species can seldom be decided by one specimen or at one epoch of growth; secondly, because very similar leaves may belong to very different species; thirdly, because the top, base, margin, and stalk of a leaf are all absolutely essential for identification of the species to which it belongs, and these are not all present in any of the Reading specimens; and fourthly, because in these, as in all fossil leaves, the important characters of texture, pubescence, and colour are necessarily obliterated.

It would be very easy to produce from an herbarium leaves so similar to 1, 2, 6, 12, 13, 14, 18, &c., as to deceive the inexperienced into instituting crude affinities; but after a very careful comparison of these fossil leaves with those of willows, poplars, oaks, maples, Myricæ, Rhamni, and such familiar genera as must suggest themselves to every one, I find that while I cannot advance beyond plausible suggestions, nor give better reasons for such affinities than those presented by outline, I can adduce a copious list of far less familiar genera belonging to widely different natural orders, to which there are as good grounds to refer these leaves, as to the genera I have enumerated. It must indeed be evident to any one acquainted with the real value, in a systematic point of view, of characters derived from foliage, that it merely requires a *leading idea* to suggest affinities when imperfect remains of foliage are alone at the naturalist's disposal. I have no hesitation in saying, that were I assured from collateral evidence of the flora of the Reading beds being intimately allied to that of India, I should find no difficulty in producing the allied living representatives; and the same may be said of the vegetation of many other parts of the globe: it requires, however, some general acquaintance with the plants inhabiting different parts of the world, to appreciate the fallacious nature of the evidence afforded by leaves; these being of all organs the least important for the higher purposes of classification: a fact rendered familiar to the botanist by the habitual practice of naming a species of one genus from the similarity of its foliage to that of some other plant often in a totally different natural order.

There are two points to which I may allude, as being of practical importance to be borne in mind in examining questions of this nature. One is the extreme difficulty found in identifying the imperfect remains of existing plants, although we may be familiar with the flora to which they belong; and the other is, that when the clue to specific identity is lost, and a false identification is made, it is generally very wide indeed of the truth. My attention has been particularly drawn to these facts in foreign countries, when examining recent deposits in silt; and, though I am quite ready to admit that the power of identification in such cases depends as much upon a degree of skill or tact, which differs in amount with every individual, as upon absolute botanical knowledge, still I think that no one who has not resorted to an *experimentum crucis* of this sort can form a just idea of the real difficulties of the task, of the number of species he may make of different leaves of the same plant, of the false affinities he may draw, and the false conclusions to which he may be led.

Had the fossils of the Reading beds been presented to me in a recent state, and without my knowing their native place, I do not believe I should have been able to approximate with any tolerable degree of certainty to their affinities one with another, or to their position in the vegetable kingdom; and as I further do not think that they are even generically recognizable, I cannot deem it advisable to give them generic and specific names. The excellent plate which accompanies Mr. Prestwich's memoir serves all the purposes of a description, as the fossils possess no botanical characters of importance not represented in the lithograph (Pl. IV.).

It will not, I hope, be inferred, that, in refraining from naming and defining these vegetable remains, I am undervaluing their importance in a geological or botanical point of view. On the contrary, I think that giving them a fictitious value of this kind (which requires neither skill nor knowledge) is not only a perversion of the true aim and object of botanical science, but is calculated to mislead both geologists and botanists, besides swelling those already unmanageable catalogues of names for unintelligible fragments of vegetables, miscalled systems of fossil plants. Both in a geological and botanical point of view the Reading fossils are of first-rate interest and importance, as presenting us with an association of forms so entirely analogous to those now existing, as to leave no grounds for assuming that the now prevalent forms of foliage amongst Dicotyledonous plants did not predominate before the glacial epoch, posterior to which all the existing British plants, except the alpines, were introduced into our island, as has been shown by Professor E. Forbes in his Essay on the Flora and Fauna of the British Islands. I need hardly add, that the vegetation of the Reading beds presents no affinities whatever with that of the London clay.

Observations on the Specimens.—Fig. 1. is a very common form of leaf amongst various classes of Dicotyledonous plants, but does not exactly resemble any living plant with which I am acquainted. I assume that the scar at its cordate base represents the point of insertion on the stem, and that the leaf was therefore sessile.

Fig. 2. resembles the foliage of many species of European, North American, or North Asiatic Maples, but may be compared with equal propriety to the foliage of so very many other genera and natural orders that I cannot attach the smallest importance to the resemblance.

Figs. 3–8. I can suggest no resemblances for them that are worth recording. Figs. 3 and 15 possibly belong to the same species.

Fig. 11. resembles a fragment of fern-frond, but equally well represents a portion of the pinnatifid leaf of a composite or umbelliferous plant, and may indeed be referred to very many other natural orders.

Figs. 12, 13, 14. are very common forms of Dicotyledonous leaves that do not suggest any particular analogies to me.

Figs. 16–21. are quite unsuggestive to me. Of them, 18 may be a portion of a pinnatifid leaf, or may be a fragment of the midrib, &c. of a large entire leaf.

Fig. 23. I have alluded to as probably indicative of a Monocotyledonous vegetation.

Figs. 24–26. are finely-preserved buds of a Dicotyledonous shrub or tree, but of what natural family it is impossible to say. Poplars, Ericeæ, and many other orders have similar ones.

Fig. 27. I can make nothing of.

Fig. 28. I am equally at a loss to understand. Seeds have been suggested by one friend, and an insect's gall by another.

Fig. 22. Were I assured that this was what it appears, a petiole with two leaflets or lobes of a fan-shaped leaf, it would be curious; but I have been so often deceived on the one hand by appearances assumed by fragments of foliage, &c. thrown into accidental juxtaposition, and on the other by the false analogies that imperfect specimens suggest, that I cannot venture to give any opinion about it.

EXPLANATION OF PLATES I. II. III. IV.

Plate I.

I. General Section. Gives a general view of the Tertiary series in their range from the Isle of Wight to the Isle of Thanet, chiefly for the purpose of showing the correlation of the Middle and Lower Eocene deposits of the Hampshire district with those of the London district, and also to give the position and relation of the Lower London Tertiaries, of which latter beds the succeeding diagrams give enlarged representations.

II. Diagrams. These give the structure as determined from a number of actual (local) sections of the Lower London Tertiaries, and more particularly of the middle division thereof, or the Woolwich and Reading Series. This latter, in Diagram A, is divided horizontally into three areas—the western one (W.) unfossiliferous, the central one (C.) fluviatile and estuarine, and the eastern one (E.) marine. In terming the first unfossiliferous, this is used as a comparative term; for a few rare fossiliferous beds do occur, as the one containing the *Ostrea Bellovacina*, which is not unfrequently found at the base of the series, but in no other part of it; whilst a few feet higher in the series the rich but local bed of fossil plants at Reading is placed. Apart from these exceptions, the great mass spread through this area contains no trace of organic remains. The horizontal extent of the fluviatile beds is well-marked by the lenticular dark-coloured mass in the central area. The marine character of C in the eastern area is apparent at a few localities only; a large portion of the mass contains no fossils. The numbers refer to sections actually observed; of these the following are described or mentioned in the text of this or of preceding volumes:—

Diagram A.

	Loc. Sect.	*Page*		*Loc. Sect.*	*Page*
Hungerford	1	85	Royal Mint	21	149
Pebble Hill	2	85	Whitechapel	22	150
Newbury	3	87	Bromley, nr. Stratford	23	151
Red Hill	4	87	Charlton	24	103
Reading (Bath road)	5	88	Woolwich	25	102
Sonning Hill	7	89	E. of Bexley	29	107
Twyford, Berks	8	89	E. of Green St. Green	31	107
Starveall	11	90	Gravesend	32	107
Penlands	12	90	Shorne	33	107
Hedgerley	13	vi. 268	Upnor	34	107
Uxbridge	14	91	Otterham Wharf	35	109
Hanwell	15	94	Near Faversham	36–7	109
Castlebear Hill	16	94	N.W. of Boughton	38–9	109
Twyford, Middlesex	17	95	Boughton	40	109
Bayswater	18	96	N.W. of Canterbury	42	110
Trafalgar Square	19	148	E. of Herne Bay	43	111
Bank of England	20	143			

In addition to the foregoing sections there are the following, which are not described in the previous pages, and of which explanations are hardly necessary, as they are either described elsewhere, or else the dotted lines show the beds they traverse and the relative thickness thereof:—

Loc. Sect.

6 ...... Katesgrove pit, Reading. Dr. Buckland in Trans. Geol. Soc. ser. 2. vol. iv. p. 276.

10 ...... Section at the brick-field on the hill between Maidenhead and Marlow.

26 ...... Experimental pit sunk on the S. side of Plumstead Heath.

27 ...... Well on Bexley Heath.

28 ...... Old pit on the hill W. of Crayford. (This is drawn too near 29.)

30 ...... Section on the sides of the lane leading into Darent Wood from Darent.

41 ...... Well-section on Boughton Hill.

DIAGRAM B.

	Loc. Sect.	Page		Loc. Sect.	Page
Chesham	1	90	Chobham	5	vol. iii. pl. 14. f. 10.
Hedgerley	3	vol. vi. 268	Guildford	6	vol. vi. 260

To these we have to add the following—

Loc. Sect.

2 .... Brick-field at Oak End near Chalfont.

4 .... Well-section.

DIAGRAM C.

	Loc. Sect.	Page		Loc. Sect.	Page
4 miles N. of Ware	1	92	Royal Mint	7	149
1 mile E.S.E. of Hertford	2	92	New Cross, Naval School*	8	105
Chalk pits near Northaw	3	92	New Cross, Railway	9	104
Winchmore Hill	4	145	Sundridge Park	13	100
Colney Hatch	5	145	Hayes Common	18	99
Shoreditch	6	143	Keston Common	19	99

The following are the additional sections not described in the text:—

Loc. Sect.

10 ...... Lewisham (see Buckland in Trans. Geol. Soc. ser. 2. vol. iv. p. 287).

11 ...... Belmont near Chiselhurst.

12 ...... Section in brick-field on the hill half a mile N.W. of Chiselhurst Common.

14 ...... Section of the shaft at the chalk-pits on the S. side of Chiselhurst Common.

15 ...... Several small sections near Widmore and Leaves Green.

16 ...... Small cuttings on the road-side between Bromley and Hayes.

17 ...... Pits on the N. side of Hayes Common.

In these diagrams the local sections are not always taken on an exact straight line of section; where no sections offered on those lines, sections at short distances to the right or left of them have been taken. In looking at the diagrams, it is necessary to imagine that the unfossiliferous portion of A should be a mottled dark red, blue, and greenish colour, with subordinate beds of light yellow, which colours gradually pass, in the fluviatile area, into green at base, with grey, blue, red, and yellow above, which again give way in the marine area to a nearly uniform mass of very light green, assimilating greatly to the general tone of the underlying Thanet sands. The prevailing colour of the Basement-bed of the London clay should be ochreous of different depths of colouring, from very light yellow to deep ferruginous. It was intended originally to have coloured these Diagrams.

[*Erratum*, p. 142, in column of figures line 15 from bottom, *for* 100 feet *read* 164 feet.]

PLATE II.

Fossil Shells from the Woolwich Beds.

Fig. 1. Inside. 2. Outside.	}	Cardium Laytoni, *Morris*. Richborough.
3 *a*. Nat. size. 3 *b*. Enlarged.	}	Siliceous cast of Corbula Arnouldii, *Nyst*. Oakwells.
4. Perfect. 5. Outside.	}	Corbula Regulbiensis, *Morris*. Reculvers.
6. Outside	......	Corbula Regulbiensis, var. β, *Morris*. New Cross.
7. Outside. 8. Inside. 9. End view.	}	Cyrena cordata, *Morris*. Deptford.

* *Local Sections* 8 and 9 should be placed near together in the Diagram.

Fig. 10. Exterior. } Cyrena intermedia, *Melleville*. Woolwich.
11. Interior. }
12. Exterior. } Modiola Mitchelli, *Morris*. New Cross.
13. Profile. }
14. Cast (imperfect) of Modiola dorsata, *Morris*. Sundridge.
15. Exterior of Psammobia Condamini, *Morris*. Counter Hill.
16. Side view of Ampullaria subdepressa, *Morris*. Woolwich.
17 *a*. Nat. size. } Auricula pygmæa, *Morris*. Woolwich.
17 *b*. Enlarged. }
18. Cerithium Bowerbanki, *Morris*. Woolwich.
19. —— gracile, *Morris*. Woolwich.
20. —— Lunnii, *Morris*. Woolwich.
21 *a*. Nat. size. } Hydrobia Parkinsoni, *Morris*. Woolwich.
21 *b*. Enlarged. }
22 *a*. Nat. size. } Hydrobia Websteri, *Morris*. Woolwich.
22 *b*. Enlarged. }
23. Paludina lenta (*Sow.*), var. β, *Morris*. New Cross.
24. Patella. Sundridge Park.
25. Dentalium. Herne Bay.
26. Serpula. Sundridge Park.

Plate III.

Remains of Fishes.

Fig. 1 *a*. Posterior } aspect of an abdominal Vertebra of Lepidosteus. Upnor.
1 *b*. Anterior }
1 *c*. Lateral }
2 *a*. Inferior } aspect of a Vertebra of a Fish. Woolwich.
2 *b*. Terminal }
2*. } Cycloid? scales (imperfect). Woolwich.
2**. }

Remains of Plants.

3. Impression, in sandstone nodule, of the Cone of an Abies. Reculver Cliffs.
4. Seed-vessel. Counter Hill.
5. Vegetable remains;—possibly compressed seed-vessels. Counter Hill.
6. Leaflet of a Fern, like Asplenium. Counter Hill.

Entomostraca, from Woolwich.

7. Cytheridea Mulleri, *Münster*, sp.: left carapace-valve.
8. Cytheridea Mulleri, var. torosa, *Jones*: right carapace-valve.
9 *a*. } Cythere Wetherelli, *Jones*. Left valve and the dorsal edge of the
9 *b*. } right valve.
10 *a*. } Cythere Kostelensis, *Reuss*, sp. Perfect specimen, showing its left
10 *b*. } valve and the dorsal aspect of both valves.
11. Cythereis plicata, *Rœmer*, sp. Left valve.
12. Cythereis angulatopora, *Reuss*, sp. Left valve (imperfect).
13 *a*. } Candona Richardsoni, *Jones*. Left valve, and the dorsal edge of the
13 *b*. } right valve.

Plate IV.

Impressions of Fossil Leaves from a Bed of Clay in the Railway Cutting near Reading (*vide supra*, p. 88, Plate I. Diagram A. Local Section 5; and p. 163).

			[Notes on the relative abundance of the several forms in the specimens of the clay in Mr. Prestwich's collection.]
Fig. 1	Phyllites	(*a.*)	Single specimen, occurring with "*s*" in a group of "*b.*"
2	Phyllites	(*b.*)	Abundant: occurs in groups; together with "*a*," "*c*," "*d*," "*e*," "*f*," "*g*," "*j*," large specimens of "*p*," "*r*," "*s*," "*u*," and large stem-like bodies.
3	Phyllites	(*c.*)	Rare. Single specimens of "*c*," "*d*," and "*e*" occur on a small piece of clay, with leaves of "*b.*" A leaf similar to "*d*" occurs also with "*l*"; and another, but with a long peduncle, occurs with "*p.*"
4	Phyllites	(*d.*)	
5	Phyllites	(*e.*)	
6, 7, 8	Phyllites	(*f.*)	Abundant. In groups; together with "*b*," "*g*," "*k*," "*p*," "*q*," "*s*," and stem-like bodies.
9, 9*, 9**, 10.	Phyllites	(*g.*)	Abundant. In a compressed mass; and with "*b*," "*f*," "*j*," and "*s.*" Nearly allied to "*b.*"
11	Phyllites	(*h.*)	Rare (unique). With "*p*" and small stem-like markings.
12	Phyllites	(*i.*)	Single specimen, in very sandy clay.
13	Phyllites	(*j.*)	Abundant: in groups, with "*b*," "*g*," "*k*," "*p*," and stem-like bodies.
14	Phyllites	(*k.*)	Rare. Occurs with "*f*," "*j*," "*p*," and stem-like impressions.
15	Phyllites	(*l.*)	Rare. With a leaf resembling "*d*," large specimen of "*p*," and obscure grass-like impressions.
16, 16*	Phyllites	(*m.*)	Rare (two specimens): with "*p.*"
17	Phyllites	(*n.*)	Single specimen: with "*p.*"
18	Phyllites	(*o.*)	Single specimen; with traces of stem-markings similar to itself.
19, 20, 20*	Phyllites	(*p.*)	Abundant. Occurs scattered through very many portions of the clay; several leaflets often retaining their relative positions, as in fig. 20. A form similar to fig. 19, but larger, is also very common. Leaves of "*p*" occur with "*b*," "*d*," "*f*," "*h*," "*j*," "*k*," "*l*," "*m*," "*r*," "*s*," with a leaf like "*n*," and with obscure grass-like markings.
21	Phyllites	(*q.*)	Single specimen: with "*f.*"
22, 23	Phyllites	(*r.*)	Abundant in some pieces of the clay. (The relation of the leaf to the stem in fig. 22 is very obscure.)
24, 25, 26	(Buds)	(*s.*)	Common; occurring with "*a*," "*b*," "*f*," "*g*," "*p*" and large "*p*," "*v*," and with leaves like "*e*" and "*j*"; but most commonly associated with "*b*" and "*g.*" (The stem in fig. 24 is not connected with the bud.)
27	(Stem)	(*t.*)	A ferruginous body in sandy clay.
28	(Seeds ?)	(*u.*)	Two specimens occur; with "*b*" and stem-like impressions.
29	Phyllites	(*v.*)	Single specimen, occurring with "*s.*"

[*Note.*—The most abundant leaves are "*b*," "*g*," and "*p*"; less abundant, but also found in groups, are "*f*" and "*j.*" Fragments of "*r*," and the buds "*s*," are not uncommon. Ferruginous relics of pieces of wood are also met with in these clays.]

Series.

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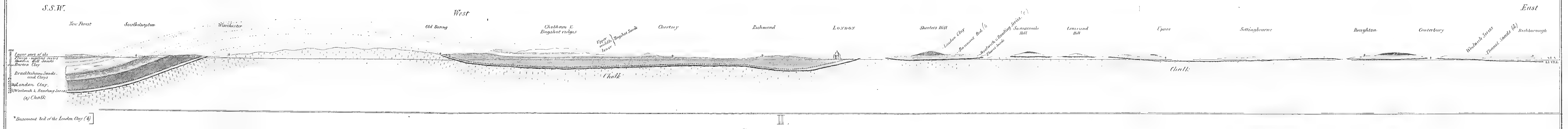
I.

General Section

showing the correlation of the London and Hampshire Tertiary Systems, and the relative Dimensions & Range of the several Deposits.

Length about 150 Miles.

(The faults are omitted.)



*Basement bed of the London Clay (b)

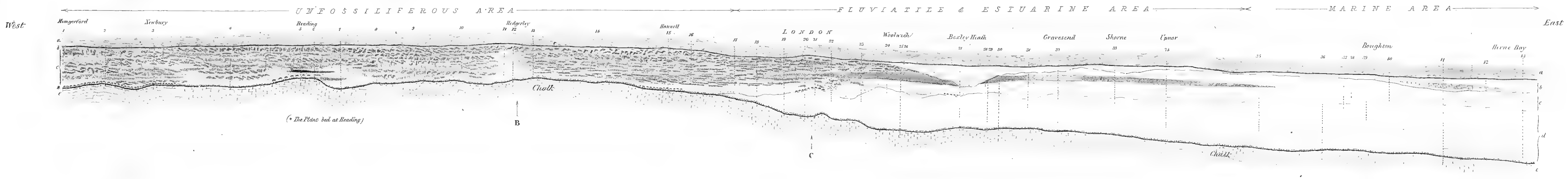
II.

Diagrams

on an enlarged vertical scale in illustration of the Structure of the "Lower London Tertiaries," being Theoretical Restorations of the strata b, c, d of the above section as they were previous to their disturbance.

(The superincumbent strata are omitted.)

A. From the neighbourhood of Hungerford to the Isle of Thanet. Longitudinal 120 Miles.

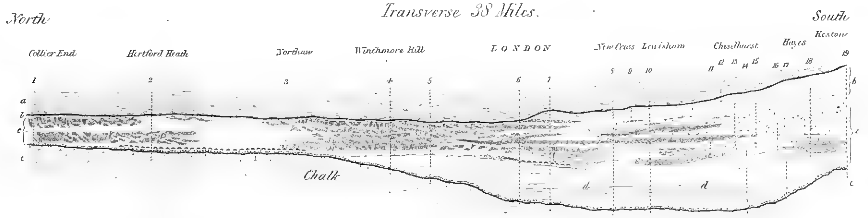


(* Band of Ostrea Bellovacina.)

(* The Plant bed at Reading)

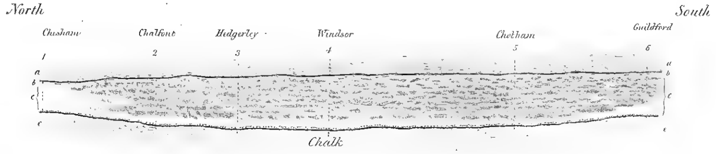
C. From the North of Ware, Herts, to Keston, Kent.

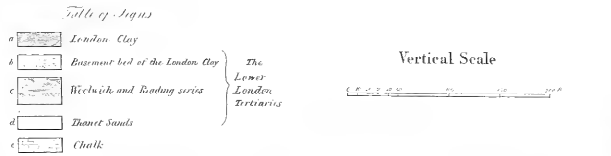
Transverse 38 Miles.



B. From Chesham, Bucks to Guildford, Surrey.

Transverse 33 Miles.





The Numbers in the Diagrams refer to Local Sections where Actual Measurements have been made. See Text.

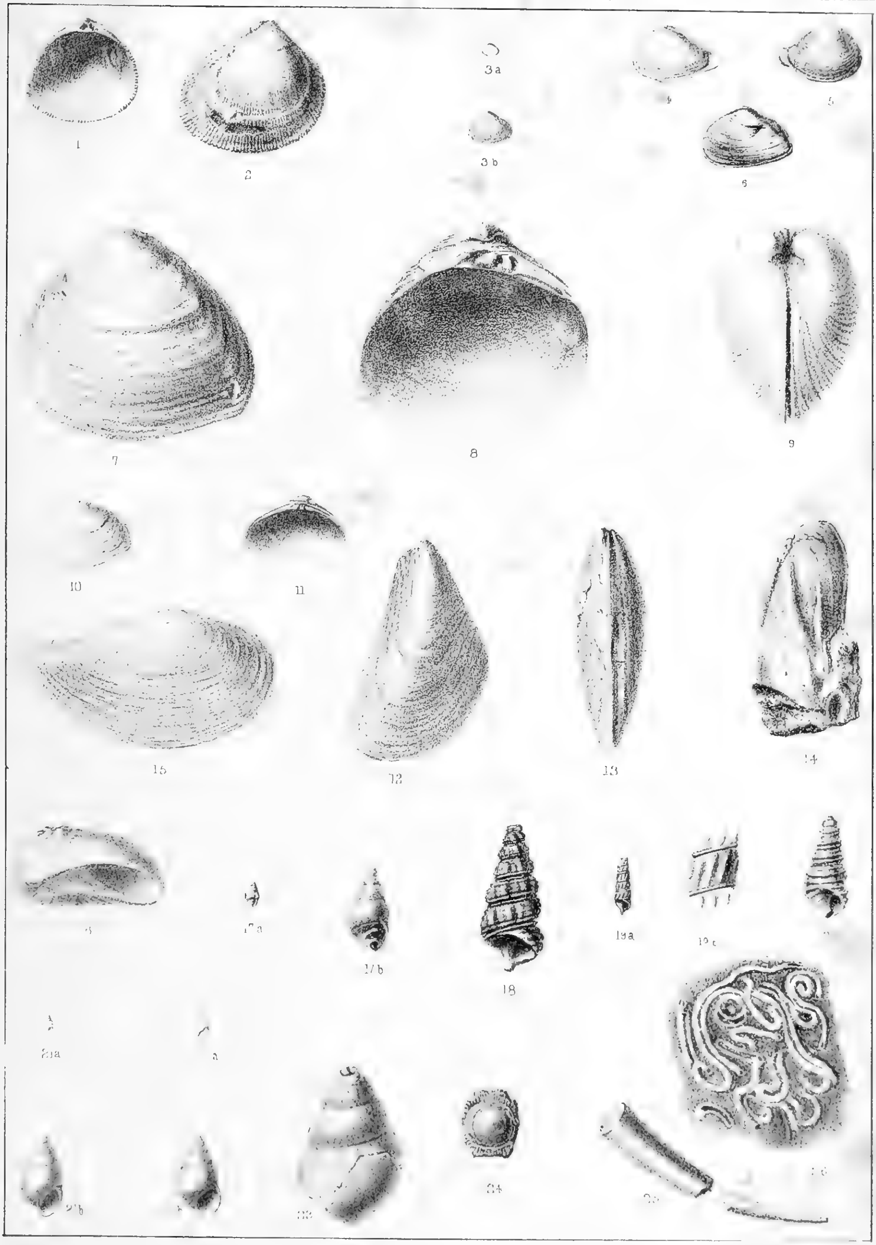
ACTUAL AND THEORETICAL SECTIONS OF THE LONDON TERTIARIES,

in illustration of Mr. Prestwich's Paper on the

Woolwich and Reading Series.

Chs. Achilles lith.

Printed by Maclure & Co.



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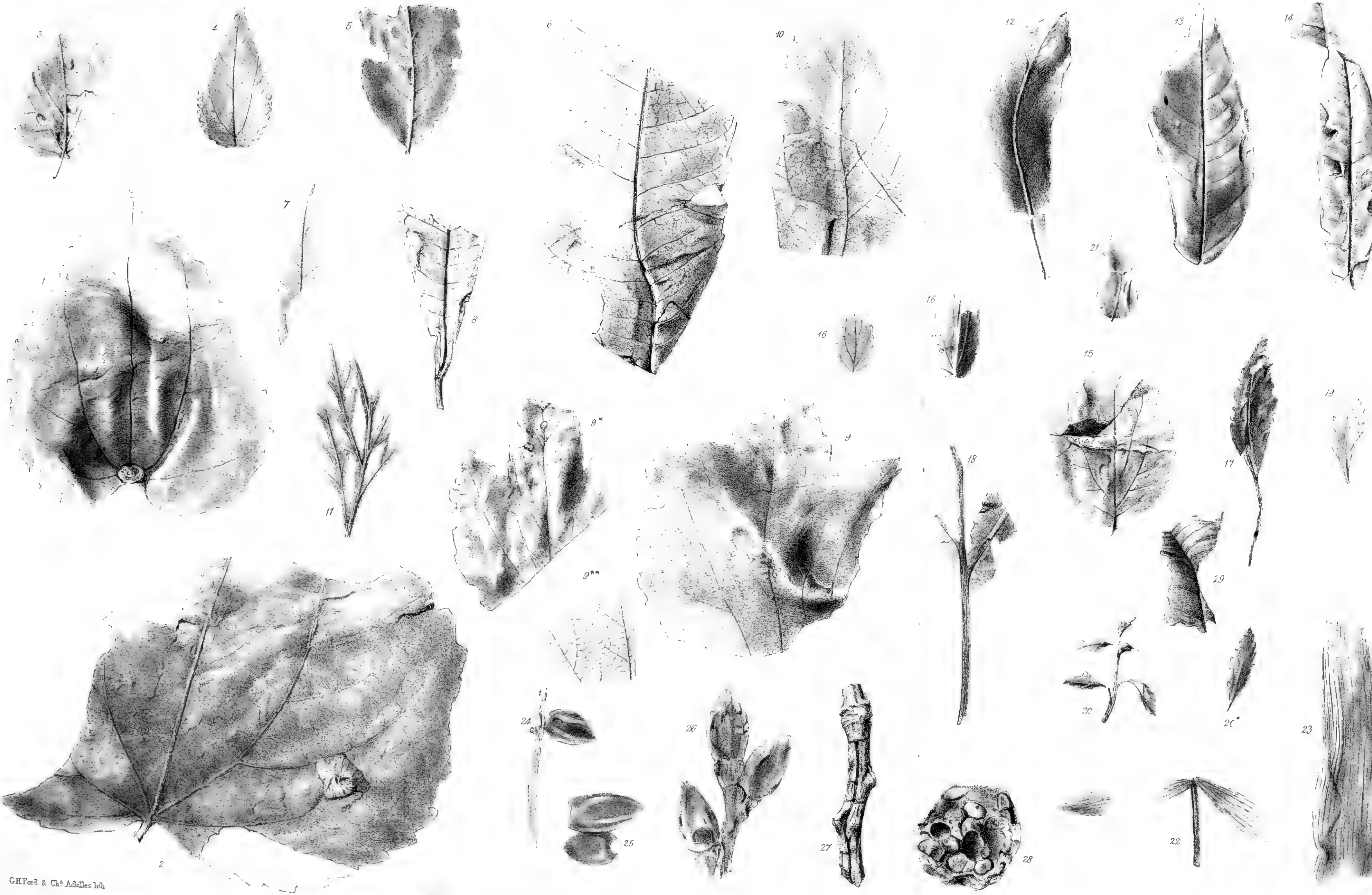


G.H. Ford & Chs Achilles lith. Ford & West Imp.

FOSSIL PLANTS FROM THE LOWER EOCENE CLAYS OF READING

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 30, 1853.

Dr. John Lister, the Rev. W. L. Symonds, A.M., David Page, Esq., and A. Robinson, Esq., were elected Fellows.

The following communications were read:—

1. *On the Occurrence of* Fossil Insects *in the* Wealden Strata *of the* Sussex Coast. By Messrs. William R. and Henry Binfield.

[Communicated by Prof. J. Morris, F.G.S.]

The specimens which we have the honour to present to the Geological Society are, we believe, the first remains of Insects from the Wealden of Hastings which have been brought before the notice of the Society*; the details we have been able to collect respecting the position and character of the beds containing them may, therefore,

* The discovery of Insect-remains in the Hastings Sands series of the Isle of Wight, by Prof. E. Forbes, is briefly referred to in Quart. Journ. Geol. Soc. No. 34. p. 52, note; and the occurrence of a few fragments of Coleopterous elytra in the Wealden marlstone, from between Tunbridge and Maidstone, was noticed by the late Dr. Mantell, *ibid.* vol. ii. p. 96; and again, vol. v. p. 39.

perhaps be interesting, although offered merely as addenda to the memoirs already published on these strata. A sketch of the Hastings Cliffs, including many localities where the insect-beds occur, will be found in the 'Geological Transactions,' 2nd ser. vol. ii. Part 1. pl. 5, appended to Professor Webster's memoir "On the Strata near Hastings" (p. 31, &c. of the same vol.), to which we shall frequently refer, as well as to Dr. Fitton's memoir "On the Strata below the Chalk," Geol. Trans. 2nd ser. vol. iv. Part 2.

The lowest beds in which we obtained traces of Insect-remains are the courses of ironstone (Webster, *loc. cit.* p. 34,—No. 1 of our General Section, *infra*, p. 175) exposed, near low-water mark, at the Govers (or Covehurst), Ecclesbourne, East Cliff, and Bulverhythe (near the place where Tower No. 42 formerly stood); and which cover a bed of light blue clay, darker downwards, with red stains. The lower courses are very carbonaceous, as described by Webster, but the two highest are much less so, afford fewer traces of Plants, are very compact, and exhibit the peculiar mineral structure shown by the specimens * No. 40 and No. 90 : the highest bed is conspicuous on the shore from its smooth pavement-like appearance, with the surface traversed by numerous vertical cracks; it separates, by the action of the waves, into very smooth square blocks. In these beds we have found a few minute *elytra* and fragments of *Neuropterous wings*; but our imperfect opportunities of examination, on account of neap-tides and limited time, render it probable that a more thorough research would be rewarded by the discovery of a very extensive series of insects in this group of strata; and more especially from the beds Nos. 3 *b*, 6 *c*, 10, and 12 of General Section (p. 175), in which traces of insects are very abundant. The ironstone at Bulverhythe yielded *Sphenopteris Mantelli*, several small undescribed Ferns, a seed-like body, and other interesting plant-remains: in similar beds at Fairlight the same *Sphenopteris* is also abundant, together with *Cyclopteris* ?, seed-like bodies, and a small fish.

Above the courses of ironstone just described, the next Insect-bed (3 *b* of Section at p. 175) is a portion of the "dark-coloured shale, which is seen at the Govers and Cliff End, and contains small roundish masses of sandstone" (Webster, *loc. cit.* p. 34), and stated by Dr. Fitton, in his 'Geology of Hastings,' p. 37, "H," to be part of the "Ashburnham Group" of Dr. Mantell ('Geol. S.E. of England,' p. 192, &c.). The ironstone beds, previously described, may be seen below this shale (with from 15 to 20 feet of sandstone and clay intervening) near the Coast-Guard-house at Ecclesbourne, and also, less distinctly, at East Cliff. In the upper part of this shale many *elytra* occur; also traces of wings, abdominal plates, &c. of *Coleoptera*, *Neuroptera*, *Diptera* ?, &c. occasionally well preserved. Many of the *elytra* were obtained at East Cliff, where the "dark-coloured shale" of Webster is divisible into the beds marked No. 3 *a*, 3 *b*, and 3 *c*, of our General Section (at p. 175); 3 *b* containing the Insects. Above this, after the courses of sandstone and shale, Nos. 4 to 6 *b*, a second bed of brown, sandy shale occurs (No. 6 *c*);

* The specimens referred to are in the Society's Museum.

very like the lower shale (3 *b*) containing Insects, but affording, with Insect-remains, *Estheria* in abundance, which we have not found in the beds below this. Masses of this shale are seen on the shore between East Cliff and Ecclesbourne, attached to sandstone blocks which have fallen from the cliffs; this sandstone immediately succeeds the "Estheria shale," and is, with its shaly partings, about 33 feet in thickness.

A bed of ironstone (No. 8) occurs in the shale immediately above this, and is the lowest bed in which we have found the *Cypris Valdensis*; it also afforded scattered Fish-scales (like those found with *Cyprides* in the beds Nos. 10 and 12; in fact, in all the strata containing *Cyprides*), *Paludinæ*, &c., with an obscure trace of the body of an insect.

The opercula of some species of *Paludina* occasionally occur in the lower Insect-shales, but we have not found either the *Cypris* or *Estheria* below this Ironstone (No. 8), which is the lowest stratum in the shale separating the beds No. 7 from the thick light-coloured sandstone No. 9 ("Worth sandstone," Mantell, 'S.E. England,' p. 14, and No. 1 of p. 197?). Above this we found the strata inaccessible at East Cliff and Ecclesbourne, but among the masses on the beach were a few blocks of ironstone having many of the characters of the St. Leonard's ironstones.

The position and character of the strata surrounding that town being minutely described by Dr. Fitton (Geol. Trans. 2nd ser. vol. iv. Part 2. p. 169, &c.), we shall only add, that from the courses of ironstone (10 of Section at p. 174), No. 5 of Group III. *c*. p. 169 of that memoir, and from the "tabular ironstone" (*γ*. of Group III. *b*. p. 167), we obtained numerous fragments, wings, and elytra of *Coleoptera*, *Neuroptera*, &c., with *Cypris Valdensis* and *C. spinigera*, *Paludina fluviorum*, *P. carinifera*, *Cyclas media*, and a few fragments of Plants too imperfect to be determined.

We obtained a few imperfect specimens of *Unionidæ* in the more friable sandstone associated with the grit (No. 1 of Dr. Fitton's Group III. *c*. on the shore below St. Leonard's), which Dr. Fitton states to have afforded him "some large *Uniones*," also in the sandy shale containing *Lonchopteris Mantelli*, at Bexhill.

The increased building at St. Leonard's and Hastings has obscured many of the sections described by Dr. Fitton; but beds apparently equivalent to his Group III. *a*, or between Groups II. and III. *loc. cit.* p. 166, were exposed in a quarry opened, near the Black Horse Inn, on the high road between Battle and Hastings, to obtain calciferous grit for the roads.

We have subjoined a section of this quarry, as the workmen have abandoned it, and the banks will probably soon have fallen in: the lower strata exposed in it appear to correspond with those seen in the highest part of the cutting close to the west end of Bo-peep Tunnel. A *neuropterous wing* was obtained from the fourth layer of indurated shale in the bed No. 1 *a* (of the Quarry section, p. 175), of which at least three courses contain *Insect-remains*; and both the indurated and softer shales afford, in abundance, *Cypris Valdensis*, *C. tuber-*

culata, *C. spinigera*, *Cyclas media*, *Cyrena*, *Paludina fluviorum*, *P. carinifera*, with Lignite and imperfect Plants. The rich ironstones (No. 1 *b* of the Quarry section) also contain numerous casts of *Paludinæ*.

We have placed, provisionally, the beds Nos. 13, 14, and 15 of the General Section (see *infra*) above those of the Black Horse Quarry, the thin bed of sandstone at the top of the quarry appearing to correspond with a part of the lowest of Mantell's "Horsted beds."

The ironstone No. 14 of the General Section occurs on the shore, at Bexhill, near the site of Tower No. 45: during a brief visit, it afforded us a few imperfect *elytra*, two or three? small varieties of *Equisetum*, and numerous other plants.

The small *elytra* No. 60 were also found at Bexhill, associated with *Lonchopteris Mantelli*, in abundance, in the bed No. 15 *b* of the General Section.

The appended General Section is merely intended as an *approximative* tabular view (in descending order) of the general relations of the beds from which we have obtained Insects, until these, and the relations of the whole group, shall have been more completely determined.

General Section. 1853.

	ft.	in.
Bexhill Beds ("Horsted beds" of Mantell).		
No. 15 *c*. Sandstone and blue clay with ironstone-nodules.		
15 *b*. Sandy shale or soft sandstone, with minute *elytra*?, *Lonchopteris Mantelli*, and *Unionidæ*.		
15 *a*. Sandstone and whitish clay with Lignite (Mantell, S.E. E. p. 190). Altogether estimated at about	25	0
14. Ironstone in large nodular blocks, containing *elytra*, and *Equisetaceæ* and other Plants, about	1	3
13. Sand-rock and thick shales..................................	?	
Black Horse Quarry and St. Leonard's Beds ("Tilgate beds" of Mantell?).		
12. Shales of the Quarry-section (see p. 175), with an *elytron*, wings of *Coleoptera*? and *Neuroptera*, *Cypris Valdensis*, *C. tuberculata*, and *C. spinigera* in abundance, with *Cyclas media*, *Cyrena*, *Paludina carinifera* and *P. fluviorum*, Fish-scales, and traces of Plants............20 to	25	0
11. Thin calciferous grit. *Unionidæ*	?	
10 *b*. Dark-coloured shales containing courses of ironstone, with numerous *Insect-remains*; *Cypris Valdensis* and *C. spinigera*, Fish-scales, *Cyclas*, *Paludina*, and Plants.		
10 *a*. Lower calciferous grit, with shale, ironstone, and thin sand-rock (at St. Leonard's).		
Top of East Cliff.		
(The above are regarded as Group III. of Fitton, estimated by him at ....50 to	60	0)

East Cliff Beds ("Worth beds" of Mantell).

No.	Bed			ft.	in.
9.	Whitish sand-rock:—(according to Dr. Fitton) about			100	0
8.	Shale, including ironstone with *Cypris Valdensis*, Fish-scales, and remains of an Insect			1	3
7.	Four beds of brown sandstone, with shaly partings, about			33	0
6 *c*.	Brown, laminar, sandy shale with *Estheria* and *Insects*	2	0		
6 *b*.	Yellowish, sandy clay (variable), about	1	0		
6 *a*.	Bluish-grey shaly clay, about	4	6		
				7	6
5 *b*.	Two beds of ferruginous brown sandstone parted by 1 inch of bluish clay			2	1
5 *a*.	Variously coloured shales with Lignite ... 3 to			4	0
4 *b*.	Light brown sandstone			2	3
4 *a*.	Grey sandy clay with yellowish partings (Passing into 3 *c*.)			4	6

East Cliff and Ecclesbourne Beds. "Ashburnham beds" of Mantell? (Fitton, Geology of Hastings, p. 37).

No.	Bed			ft.	in.
3 *c*.	Hard sandy shale, with pisolitic ferruginous grains and concretions (the highest part of Mr. Webster's "dark-coloured shale"?)			1	0
3 *b*.	Dark brown sandy shale (conspicuous above the beach at East Cliff), with Lignite, *Thuyites, Sphenopteris, Pecopteris, Pterophyllum*, a Cone, &c.; opercula of *Paludinæ*; many elytra of *Coleoptera*, and traces of *wings* ... 2 to	3	0		
	Passing into				
3 *a*.	Bluish-grey shale, about	3	0		
				6	0
2.	Bluish-grey sandstone, with alternations of light blue, Fuller's-earth-like clay, estimated at about ... 15 to			20	0
1.	Courses of compact, argillaceous, sandy ironstone with *Insect-remains* (see p. 172), resting upon bluish clay with red stains in the lower part, under which is seen, at low-water, the lowest sand-rock we have observed on the coast.				

Section (in descending order) of the strata exposed in the Quarry near the Black Horse Inn, between Battle and Hastings (see p. 173).

		ft.	in.
	Earth and sand	2	0
	Ferruginous sandstone, with whitish exterior, in thin layers, alternating with brown ferruginous shale	2	7
	Brown ferruginous shale with ironstone nodules, about	1	10
1 *b*.	Rich ironstone nodules with *Paludina*, &c.	0	2
	Dark blue and brown shale	1	2
	Lighter do. do. do.	1	10
	Dark greenish-brown shale with ferruginous layers	4	0
	Ironstone nodules	0	3
	Greenish-brown shale, like the above	1	0

	ft.	in.
1 *a*. Stiff laminated light blue shale (with 7 or 8 cream-coloured indurated veins; the lower courses nodular and from $1\frac{1}{2}$ to $4\frac{1}{2}$ inches thick, containing *Insects*), with layers of *Cyprides*, also *Cyclades* and a few *Paludinæ*	3	$9\frac{1}{2}$
Blue and light brown, stiff, sandy shale, occasionally much indurated, containing *Cyclades*?—in masses	4	0
Bluish-grey shale, less compact than the above (12 to 15 inches)	1	0
Layers of yellowish-brown shale, very irregular in thickness, perhaps from 8 to 12 inches	0	9
Compact sandy ferruginous rock (the "ironstone" of the workmen) stated to be 3 feet thick, but not well exposed during our visit: the Grit for which the quarry was worked, and of which a large quantity was collected in stacks, was said also by them to be immediately below this.		

2. *On the* Age *of the* Fossiliferous Sands *and* Gravels *of* Farringdon *and its* Neighbourhood. By Daniel Sharpe, Esq., F.R.S., F.G.S. &c.

[Plates V. and VI.]

Although the various maps and memoirs hitherto published, which have included the neighbourhood of Farringdon, have all agreed in classing with the Lower green sand the fossiliferous gravel full of the remains of sponges, which lies on the south of that town, there has been a suspicion in the minds of several palæontologists that this classification had been adopted on imperfect evidence, and that a more careful examination might lead to a different result. As the correct determination of this point seemed likely to throw light upon other localities, I determined to spare no pains in collecting and examining the organic remains upon which the decision must ultimately rest.

In justice to those whose views I am about to combat, I must confess that I returned from my first visit to Farringdon, in the spring of 1850, convinced that the Sponge-gravels belonged to the upper part of the Lower green sand, the *Terrain Aptien* of M. d'Orbigny. My first doubts on the subject arose from Mr. Morris pointing out to me how many of the Farringdon fossils agreed with those of the Upper green sand of England, and of the *Tourtia* of Belgium: this led to a closer examination of the matter, which at last brought me to the conclusion that the deposit, though belonging strictly to the cretaceous series, is a more modern member of that series than the Chalk.

The Lower green sand is the only member of our cretaceous series of marine origin, yet recognized, containing any large accumulation of ferruginous sand or gravel. Ferruginous beds are very rare in the Upper green sand, and are never found in the Gault or Chalk, hence all ferruginous deposits containing any cretaceous fossils have been called

Lower green sand. Another cause has contributed to the difficulty of fixing correctly the age of the deposits near Farringdon; there are in that neighbourhood several patches of ferruginous sand and gravel, which though really distinct, have been assumed to be of one formation: their organic remains, thrown together in our lists, have produced a sort of *olla podrida*, which may serve to warn geologists that palæontological evidence, badly marshalled, becomes a most treacherous guide.

In Mr. Austen's memoir "On the Age and Position of the Fossiliferous Sands and Gravels of Farringdon*," the various deposits above alluded to are well pointed out, and I refer to his memoir for local descriptions, to some of which I have nothing to add, while I am forced to dissent from many of the conclusions accompanying them.

The deposits in question fall naturally into three classes, differing materially in their mineral character; they all rest upon the Kimmeridge clay, except near Farringdon, where the Sponge-gravel covers the junction of the Kimmeridge clay and Coral rag, and extends over the latter bed also; they are independent of each other, and each uncovered by any other deposit; therefore their position gives very little indication of their age, only informing us that they are all more modern than the Kimmeridge clay: for closer identification, we have only the internal evidence each may afford, which must principally rest on their organic contents; and where these fail us, the point must be left in doubt. Commencing on the north, these deposits are as follows:—

1. The sands and sandstone of Badbury Hill and Farringdon Clump.
2. The gravels containing an abundance of sponges, &c. at Little Coxwell and Fernham.
3. The dark brown sand and sandy ironstone of the Furze Hill and Cole's Pits.
4. The yellow sand and sandstone of Alfred's Hill.

I can add little to Mr. Austen's account of the sands of Badbury Hill and Farringdon Clump; they clearly belong to one formation; the mineral character both of the yellow sands and cherty sandstone of both places being exactly the same, and their position being such that if the hollow between them, produced by denudation, were filled up, the beds would about meet. The only traces of fossils which I met with were impressions of *Exogyræ* and *Terebratulæ* in the sandstones of both localities. Mr. Austen mentions some small *Bryozoa*, and Mr. Cunnington informs me that he has found *Terebratula oblonga* in the sand-pit near the top of Badbury Hill. We may conclude that the deposit belongs to the cretaceous series; but its place in that series must be left for the present in doubt, since the species just named is found both in the Sponge-gravels of Little Coxwell, in the Upper green sand near Warminster, and in the Lower green sand of Hythe and Lockswell Heath.

The sand and sandstone of Alfred's Hill probably belong to the

* Quart. Journ. Geol. Soc. vol. vi. p. 464.

same formation as the beds last mentioned, to which they have a general resemblance. At the time the railroad was formed, a large quarry was opened on Alfred's Hill, which has been since ploughed over; but there is a sand-pit remaining near the railroad, with about 15 feet of fine ash-coloured and yellow sand, horizontally stratified, containing a few fragments of small Oysters and Exogyræ, too imperfect to be identified; in the upper part are some thin beds of cherty sandstone, which are now very little exposed, but for which the quarry was formerly worked.

The same deposit probably extends to the farm called "The Sands"; and it must come in contact with the Sponge-gravel of Fernham; but the junction of the two deposits is concealed by alluvial soil and vegetation.

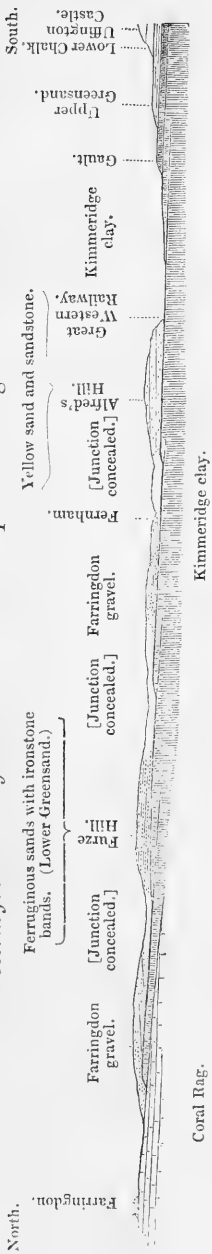
The dark brown sands and ironstones of the Furze Hill and Cole's Pits belong unquestionably to the Lower green sand. In mineral character they agree exactly with the well-determined Lower green sand of Lockswell Heath, and of the neighbourhood of Devizes, and the organic remains enumerated by Mr. Austen from this locality (*l. c.* p. 476 and 477), are all Lower green sand shells, without the admixture of a single species which can raise a doubt upon the subject*. This mass has no resemblance whatever to either of the other deposits described in this paper, and as far as I am aware, it has hardly a single species in common with the adjoining spongiferous deposit of Little Coxwell, and its organic remains are merely hollow impressions and casts, quite different from the well-preserved fossils of Little Coxwell.

I now come to my principal object, the deposit of fossiliferous sand and gravel abounding in Sponges, Terebratulæ, &c. of Little Coxwell. In Mr. Austen's section, *l. c.* p. 463, these beds are represented as continuous with the iron-sands of the Furze Hills. This view of their relation is not admissible; the two deposits rest on the Kimmeridge clay, and form adjoining hills, distinguished by only a slight depression; but between the southern point at which the Sponge-gravels are seen in the Little Coxwell pit, and the northernmost spot where the ironstone and sands are visible in a small pit by the road-side above the Ringtail Farm, there is an interval of about a quarter of a mile in which the strata are entirely concealed, and in the middle of this interval is the depression separating the two hills. Both deposits dip northward: the Sponge-gravel between 10° and 15°, and the Lower green sand at a very slight angle. They must be regarded as two deposits on the same level, abutting against one another, where, the actual junction being concealed, we cannot see which rests upon the flank of the other, and must therefore resort to internal evidence for their relative ages.

Immediately to the south of the Furze Hills another small patch

* Mr. Austen names the following species:—

Arca, undetermined.	Venus parva, *Sow.*
Cardium subhillanum, *Leym.*	—— fenestrata, *Forbes.*
Nucula scapha, *d'Orb.*	Pecten atavus, *Ræm.*
Opis Neocomiensis, *Leym.*	Emarginula Neocomiensis, *d'Orb.*



Section from Farringdon to the Chalk Escarpment. Length 5 miles.

of the Sponge-gravels is seen in the village of Fernham, where it has been quarried in a pit now abandoned. Although ill-exposed, enough may be seen of it to show that it agrees in mineral character and organic contents with the deposit at Little Coxwell. The junction of this mass with the Lower green sands of the Furze Hills is not visible. The Lower green sand being thus flanked both to the north and south by a mass of the Sponge-gravels, it hardly admits a doubt that it is the older deposit of the two, for there is no difficulty in supposing the Sponge-gravel thrown up against the sides of the pre-existing hill of Lower green sand; but it would have required a most complicated process of denudation and deposition to have lodged the Lower green sand in the hollow between the two masses of the Sponge-gravel.

The annexed section, altered from that published by Mr. Austen*, explains the views above stated.

Having thus exhausted the assistance to be derived from their position, we are necessarily reduced to internal evidence as the only means of fixing the age of the gravels of Little Coxwell. The pebbles found in them are mostly of two classes; either lumps of an earthy limestone, frequently pierced by boring shells, derived no doubt from one of the oolite formations; or small, well-rounded, siliceous pebbles of various kinds, as quartz, jasper, hornstone, and some closely resembling chalk-flints; but notwithstanding a good deal of search, I was unable to find any pebble which could be pronounced with certainty to be formed of flint from the Chalk. We are thus thrown entirely on the organic remains for assistance. In examining these, we must first separate all those which appear to have been washed out of older rocks, and brought to the spot already mineralized; these are very numerous, and for the most part they are readily recognized by their appearance and mineral condition: they are derived principally from the Coral rag and Kim-

* Quart. Journ. Geol. Soc. vol. vi. p. 463.

meridge clay: none were observed from the Portland stone, which had been denuded from this neighbourhood before the deposit of the Gault; some fragments may have been derived from the middle oolites, but they are hardly in a condition to be determined.

The following is a list of the oolitic fossils detected in the gravel of Little Coxwell:—

Exogyra nana, of the Coral rag and Kimmeridge clay.
Gryphæa virgula, of the Kimmeridge clay.
Ostræa deltoidea, of the Kimmeridge clay.
Pecten vimineus, of the Coral rag.
Belemnites, two or more species, much worn.
Ammonites, fragments of many species.
Cidaris coronata, of the Coral rag.
Diadema.
Sphærodus gigas, of the Kimmeridge clay.
Ichthyosaurus; teeth and vertebræ.
Crocodile; teeth.

Of the above list, the specimens of *Exogyra nana* and *Gryphæa virgula* are nearly in the same mineral condition as the shells which are supposed to belong properly to the deposit, being little worn, of a yellowish colour, and not filled up with stone; nevertheless I regard them as strangers brought in the fossil state to the locality. All the others differ in condition from the native species of the deposit.

At the end of this paper will be found a list of all the species yet identified, which are thought to belong to the Sponge-gravels, with an indication of the beds in which they have been observed elsewhere; the general results of which are shown in the following table:—

	Sponges.	Bryozoa.	Brachiopoda.	Lamellibranchiata.	Echinoderms.	Sundries.	Total.
Species peculiar to the deposit	4	1	1?	3	4	1	14
Maestricht sands	2	3	4	3	...	...	12
Upper chalk	1	20	3	5	...	3	32
Lower chalk	1?	2	3	2	...	4	12
Upper green sand, including Tourtia	11	17	11	8	...	3	50
Gault	...	1	1?	2	...	1	5
Lower green sand	...	4	2	3	3	1	13
Total number of species examined	16	44	19	18	7	7	111

The number of species occurring in more than one formation is shown by the following table:—

Common to Maestricht sand and chalk	...	...	3	2	...	...	5
Common to Maestricht sand and Upper green sand	2	1	2	2	...	...	7
Common to Chalk and Upper green sand	1	1	1	2	...	3	8
Common to Upper green sand and Gault, or Lower green sand	...	1	1	2	...	1	5

Besides the new species which are enumerated farther on, I have found fragments of many others, too imperfect for me to venture to describe. It is probable that most of these are new species, and that farther search will show a long list of species peculiar to this deposit. The principal additions will be to the families of Bryozoa and Monomyaria.

The following are the principal results of an examination of the stratigraphical affinities of the Farringdon fossils, considered in families; as is done in the above list.

Sponges: 16 species; many of them so abundant as to make up a large part of the solid matter of the deposit; most of these have been found elsewhere in beds between the Upper green sand and the Maestricht sand, both inclusive, those of the former bed largely predominating; but several species appear peculiar to the deposit.

Bryozoa: 44 have been identified with published descriptions of species belonging to various beds from the Lower green sand to the Maestricht sands; but of these the larger part agree with those of the Upper green sand and Upper chalk. There still remains a large number of Bryozoa to be collected and worked out by more diligent observers, many of which will probably prove to be undescribed.

Corals: I have only met with two specimens of corals, one a fragment of a Caryophyllia? too imperfect to determine, the other an Astræa, which may perhaps prove to be *A. reticulata*, Goldf.

Brachiopoda: 19 species, all published; the deposits, in which the same species have been found, range from the Lower green sand to the sands of Maestricht; the two Lower green sand species, *T. oblonga* and *T. tamarindus*, are very rare at Little Coxwell, while those of the Upper green sand and Tourtia are both very numerous and very abundant.

Lamellibranchiata: the Dimyaria are very rare, and I met with no specimen which I could name. Monomyaria numerous, and referable to species known in deposits ranging from the Lower green sand to the Maestricht sands.

Gasteropoda are very rare; the only perfect specimen is of one found in the Lower chalk? of Germany.

Cephalopoda: there are two species of Nautilus found in Boutcher's pit near Farringdon; *N. lævigatus*, which ranges all through the Chalk, is abundant; the other is more rare, and is a new species, which I have named *N. Farringdonensis*.

The only Belemnites or Ammonites found are worn specimens which have been washed out of the oolitic beds.

Serpulæ are abundant and belong to several species, which correspond with those from the Lower green sand to the Chalk.

Echinodermata: Professor Forbes has kindly examined my specimens, and refers 3 species to the Lower green sand; besides which there are fragments of 2 or 3 undetermined species of *Cidaris*, and 2 *Nucleolites*, probably of new species.

The comparison of the families making up the fauna of the Farringdon gravels with the organic contents of the various members of the cretaceous series shows that their strongest affinity is to the

Upper chalk, in which Amorphozoa, Bryozoa, Monomyaria, and Brachiopoda abound in the greatest proportion, while Dimyaria, Gasteropoda, and Cephalopoda are proportionally rare: in the Upper green sand, Amorphozoa, Monomyaria, and Brachiopoda are also abundant, but Bryozoa are more rare, and Cephalopoda numerous; in which two latter points that formation differs from the bed under consideration: the strongest contrast is to the Gault and Lower green sand, especially the latter, in which the Amorphozoa and Bryozoa are few; and the prevailing families are those of the Dimyaria, Gasteropoda, and Cephalopoda, in which the Farringdon deposit is particularly deficient. Thus the first general view of its fauna would lead us to place the Farringdon gravels near the top of the cretaceous series*.

But it is necessary to examine the matter in closer detail, and to compare our species with those of the several cretaceous formations separately, which we will commence at the lowest.

Lower green sand: the species common to this formation and to the Farringdon gravels are the following:—

Reptomulticava micropora.
—— collis, also found in the White chalk.
Heteropora cryptopora, also found in the Maestricht sand.
Proboscina marginata.
Terebratula tamarindus.
—— oblonga, also found in the Upper green sand.
Ostræa macroptera, also in the Gault and Upper green sand, and perhaps in the Chalk.
Pecten Dutemplii, also in the Upper green sand.
—— interstriatus, perhaps identical with T. Dutemplii.
Serpula quinque-angulata.
Salenia punctata, of Atherfield.
Goniopygus peltatus, of Switzerland.
Diadema dubium, do.

The number of species hitherto known only in the Lower green sand is so small compared with the total number found at Farringdon, as to send us higher up in the series for the synchronism sought.

Gault: this formation offers fewer points of comparison than even the preceding; the only Farringdon species also known in the Gault being the following:—

Multicrescis mammillata.
Rhynconella antidichotoma?
Ostræa macroptera, also in Upper green sand.
Pecten Raulinianus.
Serpula plexus, also in Upper green sand, and Upper and Lower chalk.

The shortness of this list, and the absence of all the characteristic gault shells, remove the deposit from any connection with the Gault.

Upper green sand: we find here, for the first time, materials for a serious comparison with the Farringdon fossils; and this comparison is strengthened if we add the *Tourtia* of Belgium to the Upper green sand, as has been done by M. d'Archiac, whose excellent memoir on

* Compare the list of organic remains of Farringdon with the "Tableau de la Faune Crétacée d'Angleterre." d'Archiac, Histoire, vol. iv. p. 109.

that curious deposit* has been of the greatest assistance to me. The Tourtia appears to be a gravel beach of the age of the Upper green sand, yet it contains some species common to the Upper Chalk; and the grey marly chalk which covers it also contains some mixture of species of the Upper with those of the Lower chalk. It is probably owing to the littoral origin of both deposits, that we find so strong a connection between the Tourtia and the Farringdon gravels.

Throwing together the Upper green sand and the Tourtia, and adding thereto the species indicated in the 'Paléontologie Française' from the *Craie Chloritée*, all of which, for convenience, we will call *Upper green sand*, we have 50 species common to these and the Farringdon gravels, of which 13 species are also found in beds above the Upper green sand, 3 in beds below it, and 1 in beds both above and below it; leaving 33 species hitherto thought peculiar to the Upper green sand, and now found at Farringdon. These belong principally to the Amorphozoa, Bryozoa, Monomyaria, and Brachiopoda; but the most striking resemblance is of the Sponges of Farringdon with those of the Upper green sand of Essen on the Ruhr, and of the Brachiopoda with those of the Tourtia of Belgium.

But if instead of comparing the fauna of Farringdon with that of foreign localities, we look to the Upper green sand of its immediate neighbourhood, we shall find very little resemblance. The Upper green sand of Berkshire contains few fossils, and of these very few are found at Farringdon: a few more Farringdon species are found in the uppermost bed of the Upper green sand at Warminster, but there is no spot in England where the Upper green sand affords an assemblage of species at all similar to those of Farringdon.

The *Lower chalk* bears very little comparison with the Farringdon gravels in its organic contents: only 11 of the Farringdon species are known in that deposit, and of these 3 are also found below the Lower chalk, and 4 both above and below it.

The *Upper chalk*, on the contrary, contains 32 Farringdon species, of which 4 are also found in lower formations, 2 also in the Maestricht sands, and 2 both in the Maestricht sands and beds below the white chalk. More than half of the Chalk species found at Farringdon are Bryozoa.

The *Maestricht sands* contain 12 species found at Farringdon, of which 10 are also found in lower beds; of these latter 5 are in the Upper green sand, but not in the Chalk. Unfortunately there is no good list of the mollusca of the Maestricht beds, and the collections in this country of Maestricht fossils are very poor, so that I have less opportunity of comparison with the species of this bed than with those of the lower beds of the cretaceous series.

The *Terrain Danien* of M. d'Orbigny comprises several deposits, which are considered by him to belong to a place in the cretaceous series above the Chalk; these are the coralline limestone of Faxoe and various deposits of pisolitic limestone near Paris. This has led to some controversy among the French geologists, many of whom regard the pisolitic limestone as a Tertiary formation. Without entering at

* d'Archiac, Memoirs of the Geol. Soc. of France, 2nd Series, vol. ii.

length into this subject, it may be taken as proved that the pisolitic limestones of Laversine, near Beauvais, and Vigny belong to an upper member of the cretaceous series; as they are stated by M. d'Orbigny to contain *Nautilus Danicus* and *Cidaris Forchhammeri* in common with the Faxoe beds, and their cretaceous origin is confirmed by other authorities. The other masses of pisolitic limestone, in the departments of the Seine and of the Seine et Oise, may perhaps be of the tertiary period. Without giving any opinion on that point, it is sufficient for me to call attention to the existence of certain cretaceous deposits near Paris above the Chalk containing peculiar species of fossils, and for these we may use the term *Terrain Danien*, without affirming that all the beds mentioned by M. d'Orbigny in the Prodrome, 23rd Etage, really fall into this category*. There are at present very scanty means of comparing the fossils of the Terrain Danien with those of Farringdon; but when M. Hébert has published the account of the pisolitic limestone, on which he is understood to be engaged, that difficulty will be much diminished.

Thus the examination of the whole list of species, or that of the families separately, gives the result, that the Farringdon gravels contain species hitherto thought characteristic of every bed from the Lower green sand to the Maestricht sand inclusive; but that those referable to species found elsewhere above the Gault preponderate nearly 10 to 1 in the number of species, and still more so in that of individuals; so that we need only consider to what part of the cretaceous series above the Gault this deposit belongs. This conclusion limits our choice to the Upper green sand, or to a place altogether above the Chalk; for no one could seriously propose to place it on a level with the Chalk.

The outcrop of the Upper green sand through the counties of Wiltshire, Berkshire, Oxfordshire, and Buckinghamshire is too well known to need description, except for the purpose of contrasting it with the gravel of Farringdon: at Devizes its thickness is above 100 feet; from thence it gradually diminishes in thickness as we follow it to the eastward; but through all those counties the mineral characters of the formation only vary between a fine sand, more or less calcareous, with green particles occasionally hardening into beds of stone, and a chalk marl. Nowhere is there any trace of gravel, nor any ferruginous bed, in the Upper green sand of this part of England. Very few of the organic remains of Farringdon which are referable to the Upper green sand, are found in that deposit in this neighbourhood. Warminster is the nearest spot which affords any large number of these species, and then only in the uppermost bed of the formation; but for the counterparts of the greater number we must travel to the Tourtia of Belgium or to Essen in Westphalia.

It might lead to erroneous results if we drew our conclusions from the Bryozoa, which though now admirably described in France by

* In a recent communication to the Académie Royale de Belgique, M. Hébert asserts his conviction that the whole of the pisolitic limestone of the neighbourhood of Paris is synchronous with the Upper chalk of Maestricht. Bull. de l'Acad. t. xx. N. 3.

M. d'Orbigny, have been much neglected in this country, and their geological range is little known; but the remaining classes furnish safe grounds of comparison: of these the Farringdon gravel contains 33 species, found either in the Upper green sand, the Tourtia of Belgium, or the Craie Chloritée of France. But of these 33 species only the following 13 are known in the Upper green sand of England, and most of these range upwards into higher strata, viz.—

Manon peziza, also in the Maestricht sands.
—— marginatum, also in the Upper chalk.
Jerea pyriformis.
Terebratula biplicata.
—— Menardi, also in the Maestricht sands.
Rhynchonella latissima, also in the Chalk and Maestricht sands.
Ostræa vesicularis, also in the Upper chalk and Maestricht sands.
Exogyra conica, also in the Maestricht sands.
Pecten Dutemplii.
Dianchora striata, also in the Chalk.
—— radiata, also in the Chalk.
Serpula plexus, also in the Chalk.

leaving only 3 species peculiar to the Upper green sand of England.

Out of above 70 species enumerated by Dr. Fitton from the Upper green sand of the counties here referred to, only 9 are found in the Farringdon gravel, and these do not include the most characteristic species of that formation.

The southern extremity of the Farringdon gravel at Fernham is only two miles from the escarpment of Chalk and Upper green sand, and there are no indications of any barrier having ever intervened, so that, if the Farringdon beds are to be classed with the Upper green sand, we must suppose the same sea to have been forming two totally different deposits, and to have been inhabited by two different groups of inhabitants at the distance of only two miles; a supposition which, when clearly explained, is sure to be unanimously rejected.

We are thus driven step by step, by the exhaustion of all other alternatives, to class the Farringdon Sponge-gravels as more modern than the Chalk; but I do not by this mean to include them in the Tertiary series, with which their fauna has nothing in common, but to regard them as a remaining fragment of one of the upper members of the Cretaceous formation, of which the rest were destroyed by denudation before the commencement of the Tertiary period. Other relics of the upper cretaceous deposits are found in the limestone of Faxoe, the calcareous sands and sandstones of Maestricht and Ciply, and the pisolitic limestone of Laversine and Vigny; and I hope on some future occasion to succeed in convincing the Society that there are also other deposits of the same period in England*.

* The ferruginous sandstone which caps the hill of Seende, near Devizes, described by Mr. Cunnington in the 6th volume of our Journal, p. 453, is undoubtedly contemporaneous with the Farringdon Sponge-gravel. I believe also that the ferruginous sand and gravel of Nuneham Park and Clifton Hampden, in Oxfordshire, with outlying patches at Broom Hill, Boars' Hill, and Cumner Hurst, near Oxford, belong to the same period. Probably some of the ferruginous deposits of Buckinghamshire and Bedfordshire, now attributed to the Lower green sand, may also prove to be of the Danian formation.

The long interval which intervened between the formation of the uppermost chalk and the first tertiary bed was a period of denudation, in which the chalk was entirely removed from some places, and its upper portion washed away from others; the deposits formed during this period were likely to contain coarse and water-worn materials, like that under consideration; and it is surprising that we find so few traces of such deposits.

The organic remains of the Chalk are in a great degree peculiar to that formation; but there are many species common to the Upper green sand, the Tourtia, the Maestricht sand, and the Farringdon gravels which are not found in the Chalk itself*: all of those deposits were formed in comparatively shallow water not far from a coast, and their fossil species naturally differ from those of the Chalk which lived in a deep open sea. The following hypothesis will explain our finding the same species above and below the Chalk, but not in the Chalk itself: during the formation of the Chalk the land was gradually sinking, and the ocean consequently extending itself; as long as this process continued the deep-sea deposit of the Chalk would be gradually spread over the littoral deposit of Upper green sand previously accumulated round its shore; but when at a later period a rise of the land took place, reducing the ocean to narrower limits, littoral deposits would be accumulated above the Chalk, as has taken place at Maestricht. In this view the Upper green sand and the Maestricht sands appear to be continuous deposits formed round the edge of the same ocean, at periods when its limits were different; and an explanation is afforded of the large number of species common to those two formations which are usually regarded as entirely distinct, because they are separated by the whole thickness of the Chalk.

The organic remains of the Sponge-gravels of Farringdon have much less in common with the fauna of the Blackdown sands than with that of the Upper green sand proper; for no species characteristic of Blackdown has been found at Little Coxwell; and the only species common to the two localities are such as had a long range through the cretaceous series. The Blackdown sand, as is well known, contains many Gault species not found elsewhere in the Upper green sand. Mr. Austen suggested (*l. c.* p. 472) that the Gault was a deep-sea deposit synchronous as a whole with the Upper green sand. The observations here recorded lead me to modify that view, and to suggest that the Blackdown sand was the littoral deposit of the

* The proof of this will be found, not only in the list appended to this paper, but by reference to Goldfuss, whose work contains descriptions of 14 species common to Maestricht and the Upper green sand, only 3 of which occur in the Chalk. In a note upon *Manon peziza*, vol. i. p. 243, Goldfuss remarks, "Es ist übrigens merkwürdig, dass mehrere Petrefacten des St. Petersberges auch hier (Essen an der Ruhr) jedoch gewöhnlich mit einem etwas abweichenden Habitus, vorkommen." The *Calcaire pisolitique* of Laversine, near Beauvais, is in the same case; M. d'Archiac says of it, "Il est remarquable qu'on y ait trouvé si peu d'espèces de la craie blanche, avec laquelle ce lambeau est en contact, tandis qu'il y a un assez grand nombre qui sont identiques avec celles de pays fort éloignées et avec celles de la craie tufeau."

ocean at the time that the Gault was formed at its lower depths, and the Upper green sand the littoral deposit of the sea in which the Chalk was formed*. The deep-sea formation of Gault was ended by a rising of the earth's surface, which narrowed the area and reduced the depth of the sea, and then the first beds of the Upper green sand were deposited on the Gault in the same manner as we afterwards find the Maestricht sands deposited on the Chalk. Thus the Upper green sand bears the same relation to the Blackdown sand as the Maestricht sand bears to the Upper green sand itself; and we can understand the continuance of certain littoral species of mollusca from the period of the Blackdown to that of the Maestricht sand, while the inhabitants of the deep seas of the Gault and Chalk were entirely distinct, if we admit that the earlier Gault ocean became too shallow to be a suitable habitation for the animals requiring deep water; but that shallow waters continued in some part or other of the area in question, either near the coast of a greater sea, or at the bottom of a smaller one, from the commencement of the deposit of the Gault to the termination of that of the Danian formation above the Chalk.

In this country we know of no *littoral* deposit similar to that of Maestricht lying above the Chalk: the uppermost chalk of Norfolk contains many of the Maestricht species, and is no doubt of nearly the same age, and somewhat higher in the series than the chalk of other parts of England; but it is still a deep sea bed. Before the Sponge-gravels were deposited at Farringdon, the great mass of the chalk hills must have been too much raised up to be covered by new matter, and the only accumulations we now find of the period of the *Terrain Danien* are at a lower level along the northern base of the chalk escarpment.

M. d'Orbigny would have made a better classification had he included the Maestricht sands in his *Terrain Danien*, which would then have embraced all the littoral and sublittoral cretaceous deposits, which though not strictly synchronous, are of more modern date than the Chalk: these various deposits are so widely separated from each other, and formed under such different circumstances, that it is not easy to decide upon their relative ages.

The limestone of Faxoe and the sands of Maestricht seem nearly synchronous, and appear to be the earliest beds of this series, both being deposited conformably on the white chalk; and both containing many Upper chalk species, especially *Baculites Faujasii* and *Belemnitella mucronata*, which are not found in the other localities. The large number of gasteropods found at Faxoe show that to have been most strictly a littoral deposit.

The pisolitic limestone of Laversine and Vigny, and the Sponge-gravels of Farringdon are unconformable to the Chalk, and were deposited somewhat later, after a great denudation of the Chalk had

* Near le Mans, in the department of the Loire, a bed of micaceous marl, containing many shells of species found at Blackdown, lies below the Upper green sand of that district, which has supplied the abundance of well-known fossils (d'Archiac, Histoire, vol. iv. p. 360). This fact confirms my opinion that the Blackdown sands are older than the Upper green sand.

taken place, and after the Baculites, Belemnites, and Ammonites had disappeared*. The Laversine and Vigny beds seem to have preceded the Farringdon gravels, inasmuch as the Chalk was less elevated and less denuded when those beds were deposited than when the gravel in question was accumulated; although this difference might be due to local causes.

Throughout this memoir, I have taken it for granted that all the fossiliferous beds usually referred to the Upper green sand really belong to that formation. If future examination should show that the sands of Essen on the Ruhr, or of any of the other localities here quoted, belong to a later period than the Upper green sand, the argument in favour of the *Danien* date of the Farringdon gravel will be so much strengthened. But no such change of classification is necessary for my argument, as the more extended vertical range here claimed for many species is in harmony with all later observations, which show that the duration of species at all geological periods has been longer than was formerly suspected; and that the same species reappear at various levels in beds of similar character, notwithstanding that those beds may be separated by others deposited under conditions unfit for the habitation of the species in question. The most mischievous heresy which has grown up in modern geology, is that which attempts to limit the existence of species to individual beds or deposits. The definitions of species, which ought to rest on zoological grounds only, are marred by warping them to fit geological views; and geological divisions are established or strengthened on lists of species, many of which are only founded on the evidence of those very divisions, by the ingenious process of reasoning in a circle. Fortunately such views have found little favour with English geologists, but we suffer from them indirectly, whenever they affect foreign works on Palæontology which we have occasion to consult.

[P.S. When the preceding memoir was written I had not had an opportunity of consulting M. Graves's admirable "Essai sur la Topographie géognostique du Département de l'Oise," which contains a description of the Pisolitic limestone of Laversine.—April 22, 1854.]

* *Vide* d'Archiac, Histoire des Progrès de la Géologie, vol. iv. p. 375.

List of species found at Little Coxwell, indicating the formation and localities where they have been found elsewhere.

[N.B. The species marked * are abundant, and those marked † are rare.]

	SPONGES.		
SPONGIA.			
S. Trigeris	Michelin, Iconogr. t. 53. f. 12	Upper Green Sand.	Mans.
*S. peziza	*Manon*, sp. Goldf. t. 5. f. 1	Upper Green Sand.	Essen.
†S. Michelinii	*Porites*, sp. Reuss, Kreide, t. 48. f. 3.	Hippuritenkalk.	Bohemia.
MANON.			
*M. peziza	Goldf. t. 29. f. 8; *Spongia*, sp. Mich. Icon. t. 36. f. 5.	Maestricht Sand. Upper Green Sand.	Maestricht. Warminster.
M. pulvinarium	Goldf. t. 29. f. 7; Bronn, Lethæa, t. 29. f. 1.	Maestricht Sand. Upper Green Sand.	Maestricht. Essen.
*M. marginatum	*Spongia*, sp. Phillips, Yorksh. 1 t. 1. f. 5; *Chenendopora*, sp. Mich. Icon. t. 28. f. 7; *M. Phillipsii*, Reuss, Kreide. t. 19. f. 7–9; *M. seriatoporum*, Rœmer, Kreide. t. 1. f. 6; *Tragos acutimargo*, Rœmer, Oolite t. 17. f. 26; *Tragos peziza*, Mantell, Wond. Geol. p. 636. f. 1.	Upper Chalk... Upper Green Sand.	Danes' Dyke. Warminster, France, and Germany.
*M. macropora	Sharpe, Pl. V. figs. 3 and 4.		
*M. porcatum	Sharpe, Pl. V. fig. 2.		
*M. Farringdonense	Sharpe, Pl. V. figs. 5 and 6.		
CHENENDOPORA.			
C. fungiformis?	Lamouroux, Polyp. t. 79. f. 1; Blainville, Actinol. t. 64. f. 1; Michelin, Iconogr. t. 34. f. 3; Mantell, Wond. Geol. p. 637. f. 140.	Upper Green Sand.	Near Havre.
SCYPHIA.			
*S. foraminosa	Goldf. t. 31. f. 4; Mantell, Medals, p. 256. f. 6; S. intermedia, Mantell, Medals, p. 256. f. 2.	Upper Green Sand.	Essen.
*S. mammillaris	Goldf. t. 2. f. 1; S. ramosa, Mantell, Medals, p. 256. f. 5.	Upper Green Sand.	Essen.
*S. furcata	Goldf. t. 2. f. 6; *Cnemidium astrophorum*, Mantell, Medals, p. 256. f. 7.	Upper Green Sand.	Essen.
JEREA.			
J. Desnoyersii	Michelin, Iconogr. t. 39. f. 1	Craie Chloritée.	Cap la Hève.
†J. pyriformis	Lam. Michelin, t. 36. f. 3	Upper Green Sand.	Warminster, &.
VERTICILLIPORA.			
*V. anastomosans	Mantell, Wond. Geol. p. 636. f. 3; Medals, p. 256. f. 4; Pl. V. fig. 1.		
	BRYOZOA.		
DOMOPORA.			
D. tuberculata	d'Orb. Terr. Crét. t. 648. f. 1–4; *Ceriopora stellata*? Goldf. t. 30. f. 12, not t. 11. f. 11.	Upper Green Sand.	Warminster.
†D. clavula	d'Orb. Terr. Crét. t. 647	Craie Chloritée.	Mans.

ACTINOPORA.			
†A. papyracea	d'Orb. Terr. Crét. t. 643. f. 12–14..	Upper Chalk.	
RADIOPORA.			
†R. pustulosa	d'Orb. Terr. Crét. t. 649. f. 1–3 ...	Craie Chloritée.	
DIASTOPORA.			
D. tuberosa	d'Orb. Terr. Crét. t. 639. f. 1–3 ...	Chalk.	
D. papyracea	d'Orb. Terr. Crét. t. 641. f. 4; t. 758. f. 14–16.	Upper Chalk.	
D. ramulosa	Michelin, Iconogr. t. 52. f. 3	Maestricht Sand. Upper Green Sand.	Ciply. Mans.
D. congesta ?	d'Orb. Terr. Crét. t. 640. f. 1–3 ...	Chalk.	
D. spongiosa	d'Orb. Terr. Crét. t. 637. f. 5–6 ...	Craie Chloritée.	Havre.
D. oceanica	d'Orb. Terr. Crét. t. 639. f. 6–7 ...	Upper Chalk ...	Fécamp, Dover.
REPTOMULTICAVA.			
R. mammilla	d'Orb. Terr. Crét. t. 793. f. 3–4 ...	Upper Chalk.	
R. micropora	d'Orb. Terr. Crét. t. 791. f. 10–12..	Néocomien.	
R. collis	d'Orb. Terr. Crét. t. 792. f. 1–3; *R. Cupula*, d'Orb. l. c. f. 6–11.	Néocomien. Craie Chloritée.	
MULTICAVEA.			
M. lateralis	d'Orb. Terr. Crét. t. 778. f. 7–9 ...	Upper Chalk.	
REPTOTUBIGERA.			
†R. elevata	d'Orb. Terr. Crét. t. 760. f. 1–3 ...	Upper Chalk.	
†R. marginata	d'Orb. Terr. Crét. t. 750. f. 19–21..	Upper Chalk.	
†R. ramosa	d'Orb. Terr. Crét. t. 751. f. 1–3 ...	Upper Chalk ...	Brighton.
CERIOCAVA.			
*C. ramulosa	d'Orb. Terr. Crét. t. 788. f. 11–12; *Chætetes*, sp., Michelin, Iconogr. t. 51. f. 5.	Upper Green Sand.	Mans.
C. irregularis	d'Orb. Terr. Crét. t. 788. f. 15–16..	Lower Chalk.	
SEMIMULTEA.			
S. irregularis	d'Orb. Terr. Crét. t. 741. f. 6–8 ...	Upper Chalk.	
HETEROPORA.			
H. dichotoma.........	Goldf. sp. t. 10. f. 9; Hagenow, Bryozoen, t. 5. f. 15.	Maestricht Sand.	Maestricht.
*H. cryptopora	Goldf. sp. t. 10. f. 3; Hagenow, sp. Bryozoen, t. 5. f. 6; Blainville, Actin. t. 70. f. 4; Michelin, Iconog. t. 1. f. 2; *H. tenera*, Hagenow, l. c. t. 5. f. 14; *Multicrescis Michelini*, d'Orb. Terr. Crét. t. 799. f. 14–15.	Maestricht Sand. Lower Green Sand.	Maestricht. Grandpré.
CERIOPORA.			
*C. polymorpha......	Goldf. t. 10. f. 7	Upper Green Sand.	Essen.
C. mammillosa	Rœmer, Kreidegeb. t. 5. f. 25; Michelin, Iconogr. t. 52. f. 12.	Upper Chalk Marl. Upper Green Sand.	Goslar. Mans.
C. venosa	Goldf. t. 31. f. 2	Upper Green Sand.	Essen.
PUSTULOPORA.			
P. pseudospiralis.	Michelin, Iconogr. t. 53. f. 6; Peripora, sp. d'Orb. Terr. Crét. t. 616. f. 6–8.	Upper Green Sand.	Mans.

Entalophora.			
E. Cenomana	d'Orb. Terr. Crét. t. 618. f. 11–15..	Craie Chloritée.	Mans.
E. costata	d'Orb. Terr. Crét. t. 621. f. 19–22..	Chalk.	
*E. Meudonensis ...	d'Orb. Terr. Crét. t. 623. f. 9	Upper Chalk.	
E. ramosissima	d'Orb. Terr. Crét. t. 618. f. 1–5 ...	Craie Chloritée.	Le Havre.
E. Sarthacensis	d'Orb. Terr. Cret. t. 619. f. 6–9 ...	Chalk.	
Reptocea.			
R. Cenomana.........	d'Orb. Terr. Crét. t. 788. f. 1–3 ...	Craie Chloritée.	
Multicrescis.			
M. mammillata	d'Orb. Terr. Crét. t. 800. f. 1–2 ...	Gault.	
M. variabilis	d'Orb. Terr. Crét. t. 800. f. 3–7 ...	Craie Chloritée.	
Proboscina.			
P. marginata	d'Orb. Terr. Crét. t. 759. f. 4	Terr. Aptien.	
P. subelegans.........	d'Orb. Terr. Crét. t. 759. f. 8	Craie Chloritée.	
Zonopora.			
Z. undata	d'Orb. Terr. Crét. t. 771. f. 14–15..	Upper Chalk.	
Z. variabilis	d'Orb. Terr. Crét. t. 771. f. 9–13...	Upper Chalk.	
Nodelea.			
†N. semiluna	d'Orb. Terr. Crét. t. 735. f. 9–11...	Upper Chalk.	
Alecto.			
A. reticulata	d'Orb. Terr. Crét. t. 630. f. 1–4 ...	Upper Green Sand.	Mans.
A. Calypso	d'Orb. Terr. Crét. t. 630. f. 5–8 ...	Upper Chalk ...	Fécamp.
A. ramea..............	Blainv. Actin. t. 78. f. 6; d'Orb. Terr. Crét. t. 630. f. 9–12.........	Upper Chalk ...	Meudon.
Laterocavea.			
L. punctata............	d'Orb. Terr. Crét. t. 772. f. 11–12..	Upper Chalk.	
Lopholepis.			
*L. Hagenovii	n. s. Pl. V. fig. 7	Upper Green Sand.	Warminster.
	BRACHIOPODA.		
Terebratula.			
*T. depressa	Lamarck, An. sans Vert; *T. Nerviensis*, d'Arch. Mém. Soc. Geol. Fr. 2. t. 17. f. 1–6 & 8–10; comp. also *T. longirostris*, Nilss.	Tourtia	Tournay.
*T. Nerviensis, var. E.	d'Archiac, *l. c.* t. 17. f. 7	Tourtia	Tournay.
*T. Boubei............	d'Archiac, *l. c.* t. 19. f. 11; *T. Viquesneli*, d'Arch. *l. c.* t. 18. f. 1.	Tourtia	Tournay.
*T. Rœmeri	d'Archiac, *l. c.* t. 18. f. 6; *T. Bouei*, d'Arch. *l. c.* t. 18. f. 7; *T. crassa*, d'Arch. *l. c.* t. 18. f. 8–9; *T. crassificata*, d'Arch. *l. c.* t. 19. f. 1; *T. rustica*, d'Arch. *l. c.* t. 19. f. 11.	Tourtia	Tournay.
†T. Keyserlingi	d'Archiac, *l. c.* t. 20. f. 7	Tourtia	Tournay.
†T. biplicata	Sowerby, Min. Con. t. 90, t. 437. f. 2–3.	Upper Green Sand.	Warminster.
†T. tamarindus	Sowerby, G. T. 4. t. 14. f. 8	Lower Green Sand.	Hythe.
†T. oblonga	Sowerby, M. C. t. 535. f. 4–6; Davidson, Pal. Soc. t. 2. f. 29–32.	Upper Green Sand.	Warminster.
		Lower Green Sand.	Hythe.

*T. revoluta	d'Archiac, *l. c.* t. 19. f. 3; T. Roysii, d'Arch. *l. c.* t. 19. f. 4 & 5; T. subpectoralis, d'Arch. *l. c.* t. 19. f. 9.	Tourtia	Tournay.
†T. Robertoni	d'Archiac, *l. c.* t. 18. f. 2	Tourtia	Tournay.
TEREBRATELLA.			
*T. Menardi	Lamarck, sp. An. sans Vert. von Buch; d'Orb. T. Crét. t. 517. f. 1–15; Davidson, Pal. Soc. t. 3. f. 34–42; *T. truncata*, Min. Con. t. 537. f. 3; var. *oblongata*, Leymérie, Mém. Soc. G. Fr. 5. t. 15. f. 12; *T. Astieriana*, d'Orb. T. Crét. t. 516. f. 6–12.	Maestricht Sand. Upper Green Sand.	Ciply. Mans.
RHYNCONELLA.			
*R. latissima	Sowerby, M. C. t. 502. f. 1; *R. Scaldisensis*, d'Arch. *l. c.* t. 21. f. 11; *R. convexa*, Sow. G. T. 4. t. 14. f. 12.	Maestricht Sand. Lower Chalk ... Upper Green Sand. Tourtia	Ciply. Chardstock. Warminster. Tournay.
*R. depressa	Sow. Min. Con. t. 502. f. 2.		
*R. nuciformis	Sow. Min. Con. t. 502. f. 3	Lower Chalk ...	Chardstock.
†R. triangularis	Wahl, sp. Hisinger, Leth. t. 23. f. 1; Geinitz, Kreidegeb. t. 19. f. 1–3.	Upper Chalk ... Maestricht Sand. Lower Quader and Pläner.	Sweden. Ciply. Bohemia.
R. antidichotoma? ...	Buvignier, sp. d'Orb. T. Crét. t. 500. f. 1–4.	Gault	Grandpré.
CRANIA.			
†C. Cenomanensis ...	d'Orb. Terr. Crét. t. 524. f. 1–4 ...	Upper Green Sand.	Mans.
†C. Parisiensis?	Defrance, d'Orb. Terr. Crét. t. 524. f. 8; Davidson, Pal. Soc. t. 1. f. 1.	Maestricht Sand. Upper Chalk ...	Ciply. *Passim.*
THECIDEA.			
T. Wetherellii	Morris. Ann. Nat. Hist. 1851, t. 4. f. 1–3; Davidson, Pal. Soc. t. 1. f. 15–26.	Upper Chalk ...	Kent.
	LAMELLIBRANCHIATA.		
OSTRÆA.			
*O. macroptera	Sowerby, Min. Con. t. 468. f. 2–3; *O. prionota*, Goldf. t. 74. f. 8.	Upper Green Sand. Gault .... Lower Green Sand.	Warminster. Essen. Folkstone. Hythe, &c.
*O. vesicularis	Lam. Brongn. Env. Paris, t. 3. f. 5; Goldf. t. 82. f. 1; *Gryphæa globosa*, Min. Con. 392.	Maestricht Sand. Upper Chalk ... Upper Green Sand.	Ciply. Norwich. Brighton. Warminster. Essen.
†O. semiplana	Mantell, Foss. S. D. t. 25. f. 4; Sowerby, Min. Con. t. 489. f. 3; *O. alæformis* and *O. inæquicostata*, Woodw.	Upper Chalk ...	Norwich. Brighton
EXOGYRA.			
*E. conica	Sowerby, Min. Con. t. 26. f. 2–4. t. 605. f. 1–3.	Maestricht Sand. Upper Green Sand.	Maestricht. *Passim.*

PECTEN.			
P. Dutemplii	d'Orb. Terr. Crét. t. 433. f. 10–13...	Upper Green Sand.	Warminster.
		Lower Green Sand.	Lockswell Heath.
P. interstriatus	Leymérie, Mém. Soc. G. Fr. 5. t. 13. f. 1; d'Orb. Terr. Crét. t. 433. f. 1–5.	Lower Green Sand.	Chilworth, &c.
†P. elongatus.........	Lam. d'Orb. Terr. Crét. t. 436. f. 1–4.	Upper Green Sand.	Warminster.
†P. Raulinianus......	d'Orb. Terr. Crét. t. 433. f. 6–9 ...	Gault	Grandpré.
†P. striato-costatus..	Goldf. t. 93. f. 2; *a* and *b*, not *c* and *d*; d'Orb. Terr. Crét. t. 449. f. 5–9.	Maestricht Sand.	Ciply.
		Upper Chalk ...	Cognac, &c.
DIANCHORA.			
†D. striata	Sow. Min. Con. t. 80. f. 1; Goldf. 106. f. 5.	Upper Green Sand.	Warminster.
†D. radiata...........	Goldf. sp. t. 106. f. 6.................	Upper & Lower Chalk.	*Passim.*
		Upper Green Sand.	
D. guttata	n. s. Pl. VI. fig. 4.		
LIMA.			
L. multicostata	Reuss, Kreide. t. 38. f. 18	Plänersandstein..	Bohemia.
L. consobrina.........	d'Orb. Terr. Crét. t. 422. f. 4	Upper Green Sand.	Mans.
L. dichotoma	Reuss, Kreide. t. 38. f. 10	Upper Chalk ...	Bohemia.
L. Farringdonensis...	n. s. Pl. VI. fig. 2.		
AVICULA.			
†A. lineata	Rœmer, Kreide. t. 8. f. 15	Lower Chalk ...	Hanover.
PLICATULA.			
†P. inequidens	n. s. Pl. VI. fig. 3.		
TEREDO?			
GASTROCHÆNA?			
	ANNELIDA.		
SERPULA.			
*S. gordialis	Schloth. Reuss, Kreide. t. 43. f. 3...	Lower Chalk.	
		Upper Green Sand.	Bohemia.
*S. plexus	Sowerby, Min. Con. t. 598. f. 1......	Upper Chalk ...	Norwich.
		Lower Chalk ...	Dover.
		Upper Green Sand.	Warminster.
		Gault	Folkestone.
S. obtusa	Sowerby, Min. Con. t. 608. f. 8 ...	Upper Chalk ...	Norfolk.
S. quinqueangulata...	Rœmer, Kreide, t. 16. f. 6............	Lower Green Sand.	Scöppenstedt.
	GASTEROPODA.		
NATICA.			
†N. nodosa...........	Geinitz, Kreide. t. 15. f. 27–28; Reuss, Kreide. t. 11. f. 2.	Hippuritenkalk.	Kutschlin.

	CEPHALOPODA.		
NAUTILUS.			
*N. lævigatus.........	d'Orb. Terr. Crét. t. 17; Sharpe, Pal. Soc. t. 2. f. 1.	Upper & Lower Chalk.	*Passim.*
		Upper Green Sand.	France.
N. Farringdonensis...	n. s. Pl. VI. fig. 1.		
	ECHINODERMATA.		
DIADEMA.			
†D. dubium...........	Gras	Lower Green Sand.	Switzerland.
SALENIA.			
*S. punctata	Agassiz	Lower Green Sand.	Atherfield.
GONIOPYGUS.			
†G. peltatus, var. ...	Agassiz, Mon. des Salen. t. 3. f. 9–18;	Néocomien......	Neufchatel.
NUCLEOLITES.	2 species.		
*CIDARIS.	Plates and Spines of more than one species.		

Notes on some of the FARRINGDON FOSSILS, *and Descriptions of some* NEW SPECIES *of the* ZOOPHYTES *and* MOLLUSCS.

MANON PEZIZA.

Goldfuss has described several different sponges under this name, which do not all possess the distinctive character of the genus of having the mouths of the canals circumscribed; of these the sponges (pl. 1. fig. 7 & 8) do not now concern us as they are not found at Farringdon. The cup-shaped sponge (pl. 5. fig. 1) is very common at Farringdon; its inner surface is covered by a tolerably compact integument without distinct openings, and its outer surface consists of loose spongy tissue, in which the canal openings are distinguished by larger irregular openings. As this should not be called a Manon, I have called it *Spongia peziza*; in its structure it is closely allied to the *Spongia Trigeris.* Its form is always a very regular cup. *Manon peziza,* Goldf. pl. 29. f. 8, is a good Manon, with small, well-defined round openings to the canals; it is found either lobate and spreading, or irregularly cup-shaped.

CHENENDOPORA FUNGIFORMIS.

Dr. Mantell has figured this species in the 'Wonders of Geology' as found at Farringdon; but his figure is obviously copied from Blainville. Lamouroux's figure has a general resemblance to several of the Farringdon sponges, but is not in sufficient detail for me to identify it with either of them. Mr. Lonsdale is quoted in Mr. Morris's Catalogue as the authority for its occurrence at Warminster. The identification must remain in doubt till we can compare our specimens with the original of Lamouroux, as his figure and description would apply equally well to several of the Farringdon sponges, viz. *Manon peziza, M. marginatum, M. macropora,* or *M. Farringdonense.*

VERTICILLIPORA ANASTOMOSANS, Mantell. PL. V. fig. 1.

V. sessilis, ramosa, e fibris densè reticulatis composita: ramis tubulosis, cylindricis, liberis vel coalescentibus, subæqualibus; intus tubo centrali septisque horizontalibus numerosis munitis: tubo supernè aperto, intus poris concentricis perforato.

An attached branching sponge; with cylindrical branches of nearly equal diameter, formed of a thin external wall connected to a small central tube by numerous horizontal diaphragms; the whole consisting of uniform, closely reticulated, fibrous tissue; the central tube is open at the top of the branch, and is furnished at irregular intervals with a circle of openings into the outer chambers. The branches are marked by numerous slight constrictions, and coalesce when growing in contact.

Forms irregular clusters of 2 or 3 inches across; the branches vary from $\frac{1}{6}$th to $\frac{1}{2}$ an inch in diameter, but are usually of about $\frac{1}{4}$ of an inch. The diameter of the central tube is very nearly a quarter of the diameter of the branch.

I venture to offer a description and figures of this curious sponge, which is the most interesting of all the organic remains found at Farringdon; as Dr. Mantell's woodcuts hardly do justice to its complicated structure. It is one of the most abundant species found at Farringdon, but has not yet been recognized elsewhere.

PLATE V. fig. 1 *a*. A branching specimen, with two of the branches coalescing.

Fig. 1 *b*. Exterior of a branch.

Fig. 1 *c*. Top of the same.

Fig. 1 *d*. Horizontal section.

Fig. 1 *e* & 1 *f*. Perpendicular sections: *a a*, the openings from the tube into the chamber.

Fig. 1 *g*. Portion of the surface magnified.

MANON MACROPORA, Sharpe. PL. V. figs. 3 & 4.

M. sessile, expansum vel cyathiforme; extus fibrosum, intus membranaceum; osculis majiusculis, inæqualibus, concentricis, sub-stellatis; canalibus sex vel octo ab osculis divergentibus.

A sponge attached at its base, and either irregularly cup-shaped or expanded, consisting of a loose fibrous network, which is covered on the inner side by a membrane pierced by large round openings arranged in concentric rings, and varying in size and distance from each other; six or eight canals diverge from each of the openings into the sponge, forming an ill-defined star within each of the openings.

Diameter 1 to 2 inches; thickness $\frac{1}{4}$ of an inch; openings 2 to 3 lines in diameter.

Moderately common in all the gravel-pits at Little Coxwell.

This species is easily recognized by the large size of its canal-openings, and by the stellate arrangement of the canals within each opening.

Plate V. fig. 3. A cup-shaped variety.

Fig. 4. Expanded variety.

Fig. 4 *a*. A canal-opening magnified. N.B. The artist has drawn the star of too regular a form.

Manon porcatum, Sharpe. Pl. V. fig. 2.

M. sessile, cyathiforme vel expansum; fibris laxis, reticulatis; extus nudum, rugosissimum; intus membranaceum, osculis parvis, numerosis, irregularibus.

A sponge attached at its base, either irregularly cup-shaped or expanded, consisting of a loose fibrous network covered on the inner side by a slight membrane, which is pierced by very numerous, small, ill-defined openings; the outer surface is ornamented with highly projecting branching wrinkles, which divide and re-unite irregularly.

This species is nearly related to *Manon peziza*, from which it differs not only in the peculiar wrinkling of the surface, but also in a looser texture, and less regularly defined and more numerous canal-openings. In its external wrinkling it resembles *Spongia sulcataria* of Michelin, which belongs to a different genus.

Height 1 to 3 inches.

From the gravel of Little Coxwell near Farringdon.

Plate V. fig. 2. External view.

Fig. 2 *a*. Inner surface magnified.

Manon Farringdonense. Pl. V. figs. 5 & 6.

M. sessile, cyathiforme; extus nudum, tuberosum; intus supernè porosum, infrà membranaceum.

A cup-shaped sponge, attached at the base, formed of coarse and loosely netted fibres; the inner side of the cup is lined, nearly to the top, with a thick membrane, without any openings; above this the upper part and the edge of the cup are uncovered and are pierced by the numerous irregular openings of large canals, which descend nearly perpendicularly and open downward on the outer surface. The exterior is fibrous, and irregularly and variously wrinkled.

Height and diameter 2 to 3 inches.

Found in the Sponge-gravel of Little Coxwell near Farringdon.

This species differs from all those with which it is associated in having the lower part of the cup entirely lined by a thick membrane, leaving only the upper portion of the interior porous.

Plate V. fig. 5. Exterior of a wrinkled variety.

Fig. 6. Interior of another specimen.

Lopholepis Hagenovii, Sharpe. Pl. V. fig. 7.

L. expansa, parasitica; cristis elongatis, sub-ramosis, disjunctis, utrinque 3- vel 4-seriatim porosis; poris lineas obliquas describentibus.

An incrusting coralline with long, narrow, porous ridges rising out of a smooth crust; the ridges are detached, but are usually arranged with some resemblance to branches on each side of a stem; the crust is cellular, but as few of these cells have openings, it is probable that the pores in its surface were gradually filled up; the ridges are formed of oblique tubular cells with small rounded openings, arranged in oblique lines, forming three or four rows on each side of the ridges; and these rows are continued beyond the ridges in the flat crust.

Common at Little Coxwell near Farringdon, and also found in the Upper green sand of Chute Farm near Warminster.

Plate V. fig. 7 *a*. A well-preserved specimen covering a branch of *Verticillipora anastomosans*.

Fig. 7 *b*. Portion of 7 *a* magnified.

Fig. 7 *c*. A worn specimen on a pebble; the cells are laid open by the wearing of the tops of the ridge.

Fig. 7 *d*. A portion magnified.

This pretty Coralline probably belongs to Dr. Hagenow's genus *Lopholepis*, but it is larger and has the pores more regularly disposed than either of his species. It has much resemblance also to *Repto-clausa Neocomiensis* and *R. obliqua* of M. d'Orbigny. It is named after Dr. Hagenow, author of the 'Bryozoen der Maastrichter Kreidebildung.'

PLICATULA INÆQUIDENS, Sharpe. PL. VI. fig. 3.

P. testâ oblongâ; valvâ inferiore omnino affixâ; cardinis dentibus valde inæqualibus, transversè rugosis.

Shell oblong, attached by the whole surface of the lower valve, and adapting itself to the form of the body on which it grows; hinge-teeth very unequal and transversely furrowed.

Length 1 inch, breadth $\frac{6}{10}$ths of an inch.

In the gravel of Little Coxwell, attached to *Ostræa macroptera*.

The form of this shell and of its hinge is so peculiar that I have figured it, although I have only seen one valve.

PLATE VI. fig. 3 *a*. Interior of lower valve.

Fig. 3 *b*. Hinge-teeth of the same, enlarged.

DIANCHORA? GUTTATA, Sharpe. PL. VI. fig. 4.

P. testâ oblongâ; valvâ inferiore affixâ; superiore tenuissimâ, longitudinaliter striatâ; striis inæqualibus, guttatim nodosis.

Shell oblong, flat, very irregular; fixed by nearly the whole surface of the lower valve, and taking the form of the bodies upon which it grows; upper valve very thin, ornamented with numerous, close set, radiating ribs, very unevenly covered with guttate, spinous projections.

Length 1 inch, breadth $\frac{6}{10}$ths of an inch.

Common in the gravel of Little Coxwell, adhering to Oysters, Sponges, &c.

Although this species is abundant in the Farringdon gravel, it is generally so much broken that it has been necessary to frame the above description from a number of fragments, none of which show the hinge distinctly: the shell was apparently very thin at the hinge. Not being satisfied with the reasons which have led many authors to class such shells with *Spondylus*, I place it provisionally in Sowerby's genus *Dianchora*, which forms a convenient receptacle for them till their true characters are better known.

Plate VI. fig. 4 *a*. Inside of under valve.

Fig. 4 *b*. Side view of fig. 4 *a*.

Fig. 4 *c*. Fragment of upper valve.

Fig. 4 *d*. Fragment of upper valve of a variety with finer granulations.

Lima Farringdonensis, Sharpe. Pl. VI. fig. 2.

L. testâ ovatâ, compressâ, undique radiatim costatâ; costis inæqualibus, angulatis, longitudinaliter striatis; anterioribus subobsoletis.

Shell transversely ovate, ornamented throughout with unequal ribs radiating from the beak, which are sharply angular or slightly rounded at top, and covered at their sides with fine radiating lines, becoming gradually stronger towards the posterior side of the shell; anterior ribs faint, middle ribs sharp and large, with a small sharp rib between each; posterior ribs less elevated; ears unequal.

Length $\frac{1}{2}$, breadth $\frac{3}{4}$ of an inch.

Found in the Sponge-gravel of Little Coxwell near Farringdon, and in the ferruginous sandstone of Seende near Devizes.

This shell is very closely related to *L. Cottaldina* and *L. parallela*, d'Orb., and combines the small intermediate rib of the former with the longitudinal radiation of the latter; it differs from both in having the anterior side ribbed.

Plate VI. fig. 2 *a* & 2 *b*. Natural size.

Fig. 2 *c*. The same, magnified.

Nautilus Farringdonensis, Sharpe. Pl. VI. fig. 1.

N. testâ inflatâ, lateraliter compressâ, latè umbilicatâ; juniore lævi, adultâ undato-subcostatâ; aperturâ truncato-ovatâ, profundè sinuatâ; septorum marginibus paululum sinuatis; siphunculo?

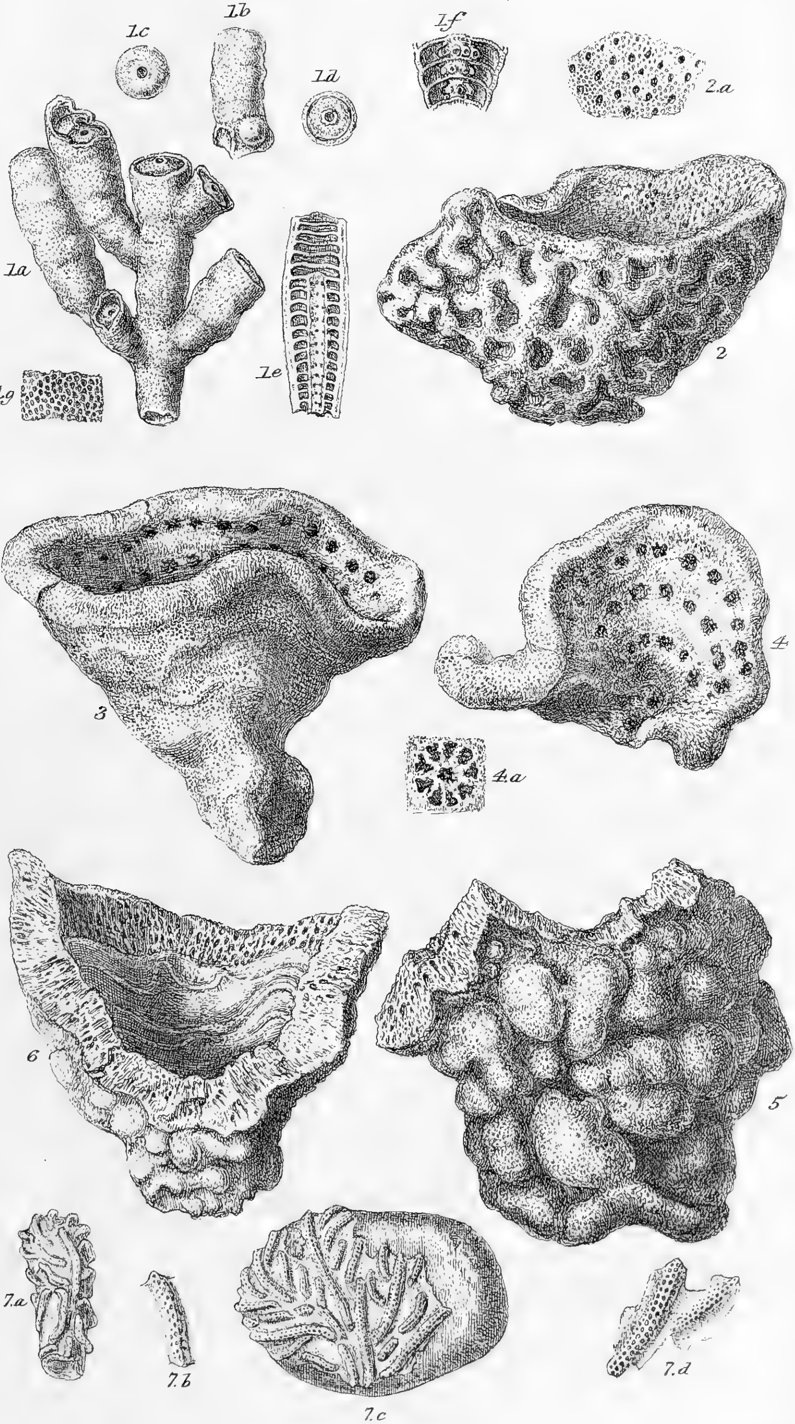
Shell gibbous, with flattened sides, at first smooth, then crossed by broad shallow undulations, which advance in a bold curve at each side of the whorl and recede at the back, marking the deep sinus of the mouth; edges of the septa nearly straight; umbilicus large, with a rounded edge. Mouth broadly ovate.

Diameter $4\frac{1}{2}$ inches; width of mouth $2\frac{1}{4}$ inches; height of mouth 2 inches.

From Boutcher's pit, Farringdon, where it is rare.

This Nautilus has a flatter and more regular form and fainter undulations than *N. undulatus*, from which it is distinguished by its large umbilicus; the undulations are very faint, and in the largest part of the specimen are half an inch wide each. There is no other species for which it can be mistaken. The position of the siphuncle has not yet been seen.

Plate VI. fig. 1 *a* & 1 *b*, reduced to $\frac{2}{3}$rds of the natural size.


1c
1b
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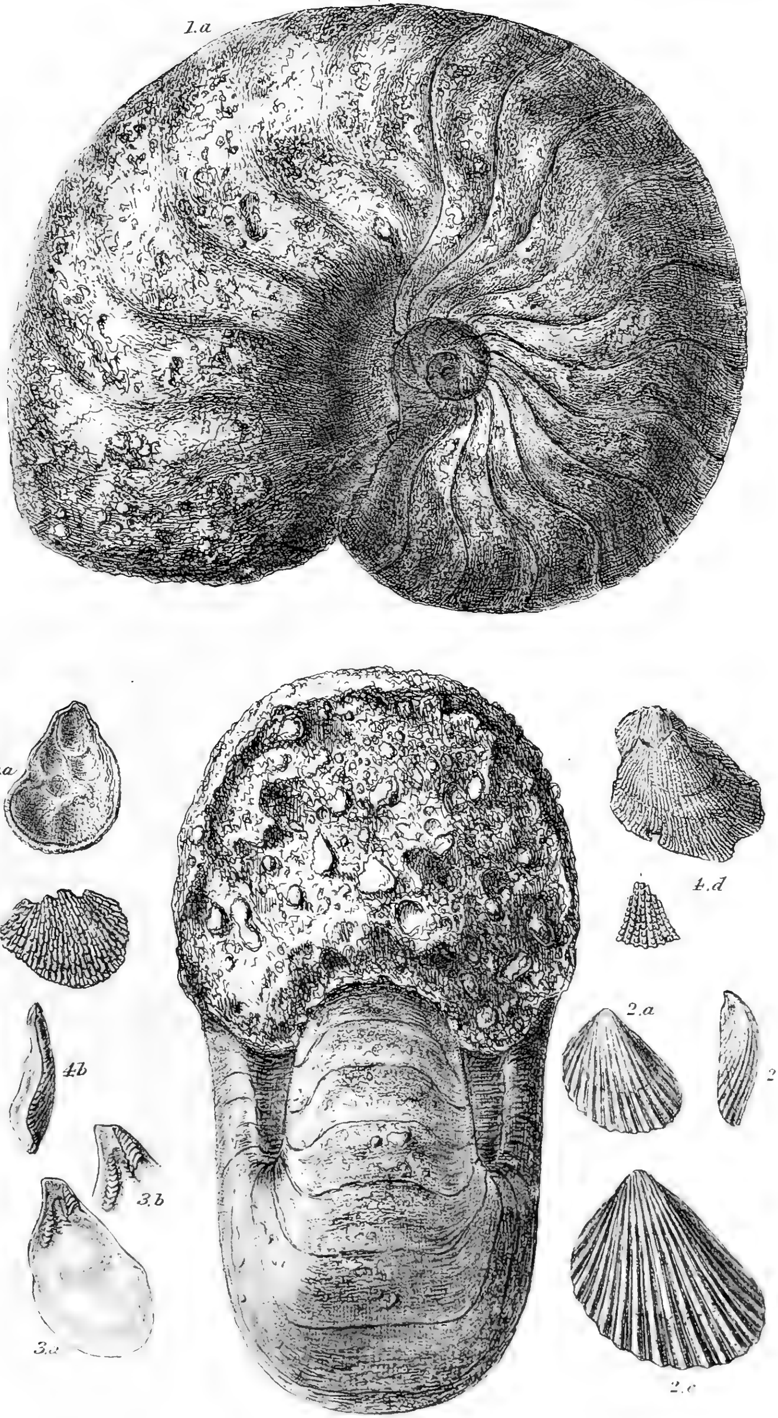
1.a
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2.a
4b
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3.b
3.a
2.c
1b

December 14, 1853.

The Rev. Prof. S. Haughton, A.M., M.R.I.A., Prof. Isaac Newton Loomis, M.D., the Rev. F. F. Statham, A.M., and S. Highley, Jun., Esq., were elected Fellows.

The following communications were read:—

1. *On a* NEW SPECIES *of* VOLKMANNIA. By J. D. HOOKER, M.D., F.R.S., F.G.S.

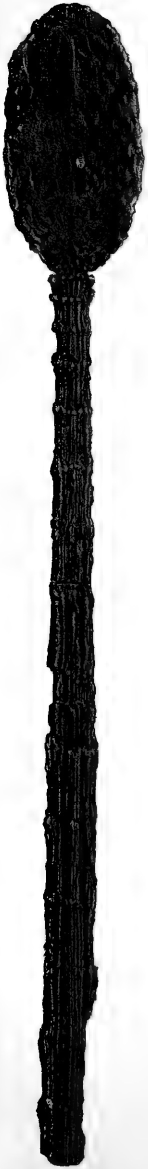
[Plate VII.]

THE subject of the present communication is one of the most remarkable of the many botanical puzzles presented in such abundance by the shales of the Carboniferous period. It was procured by my friend Mr. W. Gourlie*, of Glasgow, and forwarded to me with the request that I would lay some account of it before the Geological Society. As the specimen presented no characters by which its botanical affinities could be determined positively, and as our fossil flora is rapidly advancing towards the state of a chaos of synonymy, I felt that my most prudent course was to exhibit the drawing and specimen for several successive evenings at the Geological Society, in the hope that some amongst our Fellows, more familiar with the nomenclature of fossil botany than circumstances have, of late, allowed of my becoming, might be able to point out the genus to which it should be referred. Nor have I been disappointed; for I am indebted to Mr. Morris for indicating to me its very considerable similarity to the genus *Volkmannia*† of Sternberg, and its probable identity with it. Mr. R. Jones, also, has referred me to a drawing of a fragment of a fossil, apparently belonging to the same genus, made under his own eye, for Dr. Johnston's 'Natural History of the Eastern Borders,' and which is there given as *Coniferites? verticillatus*, Tate.

The general appearance of the Carluke fossil is accurately represented in the accompanying drawing (Pl. VII.): it consists of a straight, undivided, apparently nearly cylindrical stem or termination of a branch, 9 inches long, gradually tapering from $\frac{1}{2}$ to $\frac{1}{3}$rd of an inch in diameter (as compressed), interrupted by seventeen nodes or joints, which bear each a series of tubercles. The internodes are grooved, and diminish in length upwards; the grooves alternate with the tubercles, which appear to be placed on the intervening ridges: the number of striæ and tubercles is from ten to fifteen on each surface. The lower transverse series of tubercles crosses obliquely the diameter of the stem, as though indicating a spiral arrangement; this, however, I do not doubt, is the effect of unequal pressure during fossili-

* The fossil was discovered, Mr. Gourlie informs me, by Mr. William Grossart, of Carluke, near that town, in the ironstone working, midway between the Cannel-coal and Main-lime, and consequently at no great distance from the Old Red Sandstone.

† A Bohemian genus of fossils, which, to the best of my belief, has not hitherto been recorded as British.



M & N Hanhart, Del^t et Lith

VOLKMANNIA MORRISII _ *Hooker*.

From the Carluke Coal Shale

zation, it not being apparent in the seven upper nodes, which are nearly horizontal. The upper node appears to bear a whorl of subulate suberect leaves, half an inch long, pressed against a large terminal, erect, oblong body, resembling a cone. This is no doubt an organ of fructification, but whether of male, female, or hermaphrodite flowers, there are no means even of assuming: it is $2\frac{1}{3}$ inches long and $1\frac{1}{3}$ inch in diameter, blunt at both ends, and appears to have been in a state of decomposition when imbedded.

There is an appearance of what is usually (but often very erroneously) termed a bark, extending along the circumference, and for some distance towards the axis of the cone, all round; and this, as well as the surface from which it has been removed, presents obscure traces of hexagonal areolæ: this appearance, however, varies so much according to the light in which the fossil is held, that I cannot place much dependence upon it. I have not myself, nor has any botanist to whom I have shown the specimen, been able to detect any character of importance in this terminal organ; though it is doubtless one of very complex organization, and, were it capable of analysis, would form a most important addition to the scanty knowledge we possess of the affinities of the plants composing the Coal-flora.

After a very careful examination of Sternberg's description and plates of *Volkmannia*, I have no hesitation in assenting to Mr. Morris's opinion as to the genus in which it is expedient that this fossil should be placed; and I propose that it bear the name of that excellent palæontologist, *V. Morrisii*. The *Coniferites? verticillatus* of Tate must also be placed in the same genus, until more perfect specimens shall be found, or some characters detected, by which it may be separated from it.

Several species have been described of *Volkmannia*; they are verticillately branching plants, with subulate leaves, and they probably attained a considerable stature: as they have hitherto been met with in the German coal-fields but rarely, it is the more remarkable that several of them should have been found with organs of fructification; as is also the case with this British specimen.

Among Sternberg's species a very singular one has been figured (Flor. Vorwelt, tab. 15) under the name of *V. gracilis*, which bears a terminal cylindrical cone, as long as that of *V. Morrisii*, but not half its diameter. This cone presents no appearance of articulations, beyond numerous whorls of short subulate leaves. The whorl of leaves at the base of the cone of the Carluke fossil resembles one of these, and it is very possible that as the cone of *V. gracilis* advanced to maturity, the majority of its leaves (or rather bracts) might fall off; leaving an areolated surface. This is, however, a mere hypothesis.

In existing plants, the arrangement of the male or female flowers into cones or catkins prevails throughout so many natural orders, that from this character alone no conclusion can be drawn as to the possible affinities of *Volkmannia*: a combination, however, of this and the fluted and articulated stem almost restricts us to two natural orders of dicotyledonous living plants; viz. *Casuarineæ* and *Gnetaceæ*. Of these, *Casuarineæ* have the male flowers in catkins very similar to that of *V. gracilis*, as figured by Sternberg, in which the supposed subulate leaves resemble the exserted filaments of the jointed catkin in the modern plant; and in another species of *Volkmannia* we have the so-called leaves or bracts of the cone terminated by swellings like the anthers of *Casuarina*. But the *Casuarineæ* have sheaths like those of *Equisetum* at the nodes; and, no known allies of this natural order having hitherto been met with in the coal formation, it would be rash to depend too much on the evidence I have detailed. Amongst *Gnetaceæ*, the genus *Ephedra*, though differing much in some respects, and especially in the small size of the catkins of male flowers, presents in its sheathless joints and verticillate ramification much analogy to *Volkmannia*, while it sometimes also bears foliaceous organs at the nodes; and the presence in the Carboniferous flora of Coniferous plants (which are allied to *Ephedra*) is presumptive evidence of their possible affinity. Again, much may be said in favour of *Lycopodiaceæ* and *Equisetaceæ*; for while in the former order the leaves are sometimes distant and whorled, on the other hand the general resemblance of *V. Morrisii* to a gigantic *Equisetum* without sheaths is obvious. It is, perhaps, not improbable that the genus may prove to be allied to *Lepidodendron*, but there is no species amongst either recent or fossil *Lycopodiaceæ* at all resembling Sternberg's figure in structure or in ramification; which latter character probably led Unger to class it with his artificial group *Asterophylliteæ*.

I cannot but regret that such a remarkable and unique fossil should pass through my hands unaccompanied by any more definite information regarding its botanical affinities than that I have hazarded; but it must be borne in mind that the botanist can only bring an experience matured by errors and disappointments to bear upon incomplete specimens, especially of fossil plants. No progress in systematic botany can be made without an extensive study of the structure and morphology of plants,—of their comparative anatomy, in short; and the materials for these researches are seldom preserved in fossil specimens. The familiar characters of plants are easily acquired; but when once lost sight of, the botanist must have recourse to dissection, and in the first instance, to the dissection of the reproductive organs, however minute; and these, even when present in the fossil, are almost invariably irretrievably injured. In the Coal-flora we have but one familiar feature, the *Polypodiaceæ*; and we recognise these at once by their habit, and approximate to their affinities by their venation. I know of no other genus of coal-plants, of which it can be said that it is known to be at all closely allied to any existing genus. To appreciate these difficulties, a very extensive knowledge of recent plants is necessary; and when this is brought to bear upon fossils, the results are very barren of geological conclusions.

Plants are much more protean than animals in habit, and in the form and characters of their external organs of support, assimilation, and respiration; and there is also another and a greater difficulty not sufficiently understood, namely, that the habit and functions of a plant are not indicated by its structure to the extent which is commonly supposed. The prevalent tendency to infer from the lax and compressible tissue of so many of the plants of the Carboniferous flora, that the vegetation of that epoch was a swamp one, is one instance of this amongst many. Amongst the marsh-trees of our own era, whether of fresh water or salt, of the tropic or of the temperate zones, the botanist perceives hard and compact woods to prevail: this is shown in the Swamp-pines of the north and south temperate hemispheres on the one hand, and in the *Avicennia, Rhizophora*, and other mangroves, and a host of dicotyledonous trees of the deltas and salt-water creeks of the tropics, on the other. And if we turn to the driest regions of the globe, the Baobab, one of the most bulky known trees, an inhabitant of Senegal and of the arid Cape de Verd, may almost be sliced with a knife, like a carrot*. The gigantic *Cacti* of America and the *Euphorbiæ* of the African deserts are other cases in point, of succulence indicating drought. That the plants which contributed most materially to the formation of coal, had unusually lax tissue, is, I think, proven; but this, of itself, is no argument for their being evidences of a swamp-flora; whilst the prevalence of ferns throughout the coal-formations is rather against such an hypothesis, than in its favour. On the other hand I think that the geological evidence in favour of the coal-plants having grown in swamps is of itself conclusive, and opposed to no botanical considerations of importance.

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2. Observations *on the* Chonetes comoides (*Sowerby*). By Thomas Davidson, Esq., F.G.S. &c.

[Plate VIII.]

The external characters of *Chonetes comoides* have been carefully described by several authors†, but little or nothing appears to have been written on its internal arrangements. Sowerby's figure does not convey a correct idea of the double area, fissure, and cardinal process belonging to this species; he simply represents a bivalve shell

* Yet Adanson, arguing from their gigantic dimensions, pronounced some specimens of this tree to be upwards of 3750 years old!

† Described as "*Productus comoides*" by Sowerby in the 4th vol. of the 'Min. Con.' (p. 31, pl. 329, 1823); but it is not *P. comoides*, Phill. ('Mount. Limestone,' p. 213, pl. 7, fig. 4 which represents the *Prod. Cora*). This mistake was hinted at by Prof. M'Coy in p. 107 of his 'Synopsis of the Carb. Foss. of Ireland,' 1844; but the authors who have more particularly described the exterior of this remarkable species are M. de Verneuil, 'Russia and the Ural Mountains,' vol. ii. p. 241, 1845,—Count Keyserling, 'Reise in das Petschora-land,' p. 214, pl. 6. figs. 1 *a, b, c*, 1846,—M. de Koninck, 'Monographie des Genres Productus et Chonetes,' p. 189, pl. 19. fig. 1, 1 *a, b, c*, 1847; this excellent description of the exterior is accompanied by a list of synonyms.

possessing a convex and concave valve, finely striated, with a flat parallel space between the beaks. Better illustrations were, however, subsequently published by Count Keyserling, and reproduced by M. de Koninck: therein the characters of the double area, cardinal process, and fissure are faithfully delineated; but the recent discovery of several more perfect examples has made it desirable to publish a few observations and illustrations additional to those we already possess.

The *Chonetes comoides* may be described as a large semicircular, inequivalve shell, with a straight hinge-line, generally (but not always) as long as the greatest width of the shell, and articulated by means of teeth and sockets. *The ventral or dental* valve is exteriorly more or less convex, with ear-shaped expansions. *The dorsal or socket* valve concave, following the curves of the other. The beak of the ventral valve is variably developed in different examples,—a circumstance due to the lesser or greater convexity of the shell: thus in specimens with a moderately convex valve the beak is rarely produced or visible above the cardinal edge, while in more convex individuals (as in the typical examples figured in the 'Min. Con.') the beak is more or less inflated, incurved, and produced beyond the level of the cardinal edge. Each valve is provided with a subparallel area, rather narrower in the smaller valve. In the middle of this last exists a produced trilobed cardinal process (*not tooth*), which enters and almost fills a corresponding triangular cavity or fissure in the *ventral area**. The external surface of the shell is finely striated. Of the interior of the *dorsal* and characteristic valve unfortunately no example has been hitherto obtained, and all we may observe is, that it was provided with a well-developed cardinal process, and sockets for the reception and articulation of the strong teeth of the ventral valve; but I have little doubt that the interior of this valve was not only provided with the muscular impressions of *Chonetes*, but likewise with the reniform impressions common to *all the genera* or *subgenera* composing the family PRODUCTIDÆ†; but of the inte-

* This portion of the area in Mr. Sowerby's specimen was concealed by matrix. The cardinal process does not concur in the articulation of the valves, which last function is entirely performed by the means of special teeth and sockets; the fissure in this and other similar cases serving simply to afford space for the cardinal process. This fact was clearly demonstrated by Prof. King and others; but often very erroneously termed *a tooth* by various authors. To this process were, no doubt, fixed powerful cardinal muscles; a point anatomically proved by the examination of the same process in genera and species still alive (see General Introduction to my work on British Fossil Brachiopoda, Palæontograph. Soc. 1853).

† Prof. M'Coy considers *Chonetes* to be simply a subgenus of *Leptæna*, removing it, as well as *Strophalosia* (King) and *Aulosteges* (Helmersen), from the family PRODUCTIDÆ (British Pal. Foss. Cambridge Museum, p. 387, 1852), and placing them among his *Leptænidæ* or ORTHISIDÆ; but that is far from being the case, as I have endeavoured to demonstrate in p. 112 of my 'General Introduction,' when showing that the reniform impressions (supposed to be vascular) are the same both in *Chonetes* and *Productus* (see the annexed Plate VIII. figs. 11 and 13), while a completely different arrangement in the vascular system seems to have prevailed among the STROPHOMENIDÆ, of which *Leptæna* constitutes simply a section.

rior of the *ventral or dental valve* we are at present in a condition to offer a detailed description and exact illustrations*.

Under the extremity of the more or less produced and incurved beak, and between the projecting teeth, is seen a depression of moderate depth, which was almost entirely occupied by the *cardinal process* of the dorsal valve. At the base of the fissure above described, originates a large deep pyriform muscular cavity extending to beyond half the length of the valve, and occupying upwards of a third of its inner surface, its greatest breadth being towards the centre of the shell. In this depression are situated four elongated muscular impressions; and these are separated to a greater or lesser extent by three longitudinal ridges, the central one of which is shorter than the others, and assumes the character of a mesial septum; the two smaller scars situated on either side near the central ridge are due to the *adductor*, the outer and larger ones to the *cardinal muscles*; but no traces of peduncular muscular impressions could be traced on any of the specimens placed at my disposal for examination, nor are the muscular scars equally deep in all examples; the separating ridges are often but faintly developed, especially in those cases in which the valve is shallow.

Sowerby stated that the *Chonetes comoides* is "very thick and rough within;" the same was noticed by M. de Koninck and others; but these authors do not seem to have observed the very great disproportion in the relative thickness of the valves so beautifully exemplified in the fragment (Pl. VIII. fig. 5)†. The considerable weight of the *ventral valve* precludes all possibility of the animal having lived attached by its short and delicate cardinal spines‡, as some have imagined, and renders more probable the idea expressed by M. d'Orbigny (when describing *Productus*), that the animal lived on muddy bottoms with its smaller (*dorsal*) valve uppermost, because no aperture exists large enough to have afforded passage to muscular fibres of sufficient strength to have supported so ponderous a shell, nor could the physical power of the animal have sufficed to have opened its valves, had the weighty and often gibbose *ventral valve* been the upper one; but, on the contrary, by supposing this to have been the lower one, not much exertion would have been required to slightly raise its *dorsal valve*, which was comparatively thin.

* Some months ago, while examining the carboniferous Brachiopoda, preserved in the Museum of the Geological Society, my attention rested upon two imperfect but remarkably massive circular valves of a Brachiopod labelled "*Productus* ?," and stated to have been discovered at Llanymynech by Mr. J. Yates. These valves differed so materially from all those with which I was then acquainted, that I was tempted to refer them, with doubt, to some species of *Orthis* bearing outward resemblance to the *O. resupinata* (see a note, p. 103 of my 'Introduction'); but shortly after, having received from Mr. G. W. Ormerod the loan of several perfect examples similar to those in the Society's Collection, I at once discovered my mistake, since they belong to a variety of the *C. comoides* of Sowerby, an opinion previously expressed by Mr. Salter on inspecting Mr. Ormerod's specimens at Manchester.

† I do not quite understand Count Keyserling's section of *Chonetes*, as no free space seems to exist for the animal.

‡ Their presence in this species has not as yet been satisfactorily demonstrated.

None of the examples I have been able to examine were provided with cardinal spines, nor do the figures published either by Sowerby or Count Keyserling exhibit any ; but, from various indications along the cardinal edge of one or two of Mr. Ormerod's specimens, it seems probable that they originally existed, and were (as observed by M. de Koninck) numerous, short, and slender.

In dimensions, as well as in external shape, this species varies to a considerable extent,—a circumstance common to almost every species composing the class. Thus some examples are of a broad semicircular form, with their greatest width at or near the hinge-line; while others are almost circular, the greatest width being found towards the middle of the shell*. Thus two extreme individuals have presented the following measurements :—

Length	3 inches.	Width......	6 inches.
Ditto	2 inches 9 lines.	Ditto	3 do.

The *Chonetes comoides* does not appear to be a very common species, and occurs only in the Mountain-limestone. The following British localities have been recorded. Llangaveni in Anglesea, by Sowerby; Llanymynech, by Mr. Yates; Tidenham Chase (Gloucestershire), near Chepstow, Treflach Wood, S.W. of Oswestry, and Beaumaris, Anglesea, by Mr. G. W. Ormerod; Bundoran, County Donegal; and Lough Erne, Fermanagh, &c.

* Since communicating the above observations to the Geological Society, Mr. D. Sharpe has obtained the loan of the original specimens of *C. comoides*, figured in the 'Min. Con.,' and, having removed the matrix which encumbered some portions of the *area*, has found that fig. 1 in Plate VIII. exactly agrees with the *typical specimen*, but that, in his opinion, the other examples illustrated in Plate VIII. figs. 2 to 8, may, perhaps, belong to another species, as they seem externally more globose, and have a smaller area, on which he was unable to discover the diagonal lines observable in the types of *Chonetes comoides*; Mr. Sharpe considers also that in the interior of the *ventral valve* there is a perceptible difference in the shape of the muscular impressions as well as in the development of the mesial septum. But, having since had the opportunity of examining along with Mr. Sharpe and Mr. Salter the specimens above alluded to, I did not feel convinced that sufficient grounds existed for the establishment of two distinct species (an opinion in which I am supported both by Mr. Salter and Mr. Woodward). The original type of *C. comoides* does not appear to me to differ materially in its convexity from several of those figured in my Plate. The area, I am ready to admit, is certainly wider in both of Mr. Sowerby's specimens, than in those belonging to Mr. Ormerod (figs. 2 to 8). Mr. Sowerby's second example (not figured in the 'Min. Con.') is an incomplete interior of the *ventral valve*, in which from the shell being both young and shallow, the muscular impressions could not be as deep or as indented as in the adult, very convex, and thickened valves, such as the original specimen figured in the 'Min. Con.,' or those illustrated in my Plate, figs. 6 to 8; nor could I perceive that the interior of Mr. Sowerby's specimen varied in any *essential* particular from those more perfect specimens I had examined, and all I feel at present disposed to admit is, that those more circular shapes with a narrow area may be varieties of the *C. comoides*. No difference in external striation appears to exist, nor are all the examples circular, which is proved by my figs. 2 and 6. I need hardly recall to the reader's memory how much some individuals of *one species* vary in shape, some being wide, others elongated, depressed, or gibbose, with a large or narrow area,—circumstances often due to habitat or other physical conditions, forming innumerable varieties of a single species; but, since a difference of opinion to that advocated in this paper has been expressed, the subject may be considered unsettled and worthy of the notice of palæontologists.—[Jan. 6, 1854.]

On the Continent it was found at Visé, by M. de Koninck; on the banks of l'Ylytsch in the Ural, by Count Keyserling; it also occurs near Switschei, and at Sablé in France.

EXPLANATION OF PLATE VIII.

Illustrative of the Structure of the Shell-Valves of Chonetes *and* Productus.

Fig. 1. *Chonetes comoides* (Exterior), from a very remarkable and typical specimen belonging to the Bristol Institution Museum. In this example the *double area, trilobed cardinal process,* and *fissure* are largely developed: on the *ventral area* may be observed a series of narrow diagonal concave striæ, which diminish both in size and distance as they approach the beak, and are similar to those already noticed by Count Keyserling in his Russian examples.

Fig. 2. Exterior of another individual, showing the concave *dorsal valve.* The double area in this example is much less developed than in fig. 1, but exhibits a similar cardinal process and fissures (the margin has been slightly restored on one side). From the limestone quarries under Treflach Wood at Trefonen, S.W. of Oswestry, Salop. This, as well as figs. 3, 4, 5, 6, 7, and 8, are drawn from specimens discovered by and belonging to the Collection of Mr. G. W. Ormerod of Manchester, and are regarded by Mr. D. Sharpe as specifically distinct from fig. 1; but I feel disposed to consider them as only varieties of *C. comoides.*

Fig. 3. Exterior of the *ventral valve.* Same specimen as fig. 2.

Fig. 4. A vertical section of the *Chonetes,* supposed to have been cut longitudinally through the middle, exhibiting the comparative thickness of the valves, as well as the remaining free space occupied by the animal.

Fig. 5. A fragment, exemplifying the great disproportional thickness of the valves; along the weathered section of the *ventral valve* may be distinctly traced successive layers of shell. This specimen is from Tidenham Chase (Gloucestershire), near Chepstow.

Fig. 6. Interior of the *ventral valve* of a broad specimen: (T) teeth; (A) *adductor* muscle; (C) cardinal muscles. This beautiful specimen was discovered on the beach at Beaumaris by Mr. Henry Ormerod. (The margin has been slightly restored.)

Fig. 7. A small, almost circular, example of the *ventral valve,* showing the interior. This is figured to show an unusual development of the central septum. From the same locality as figs. 2, 3. (The specimen is much damaged at the beak.)

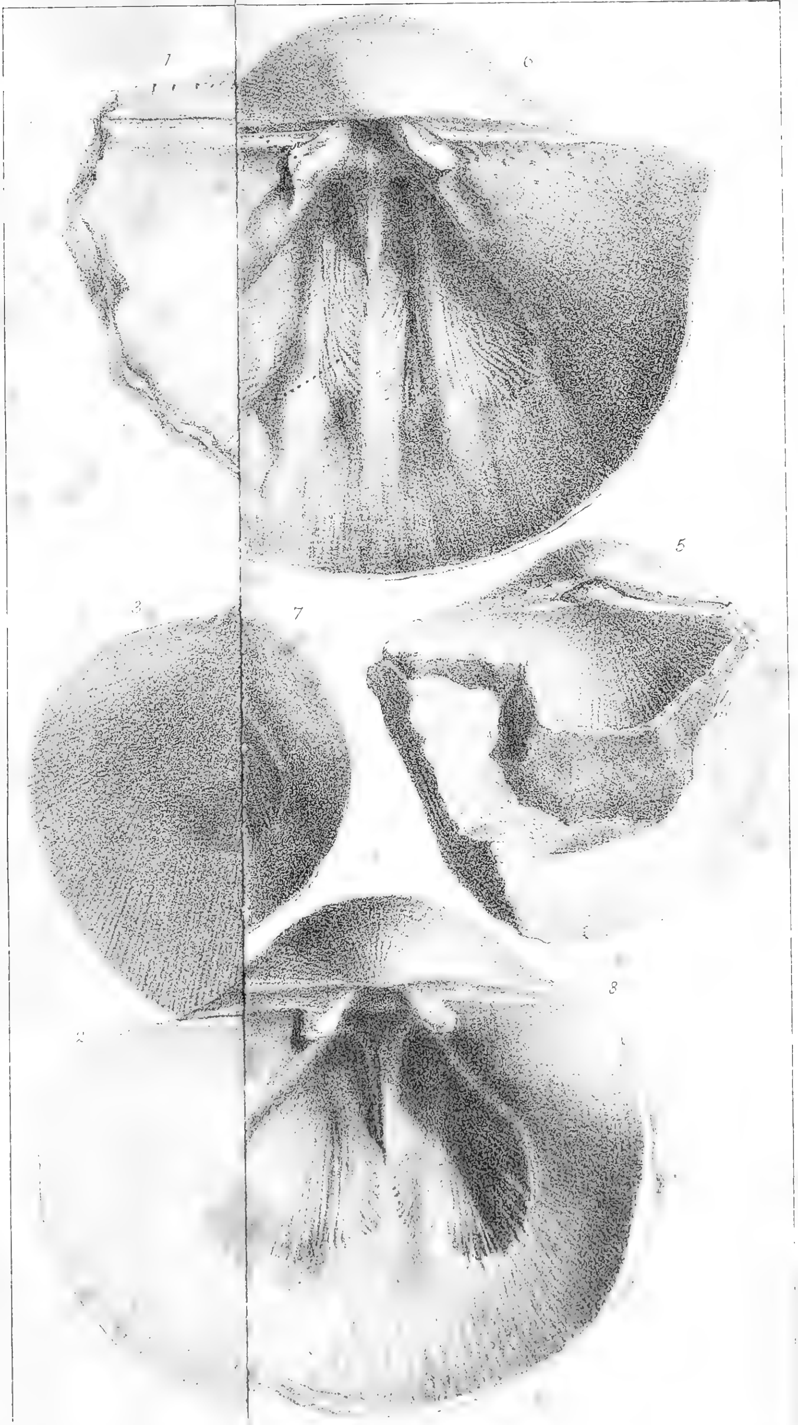
Fig. 8. A circular example of the *ventral valve.* This specimen is similar (although more perfect) to those from Llanymynech in the Society's Museum. It is from the same locality as figs. 2, 3.

Fig. 9. Interior of the *ventral valve* of a *Productus,* perhaps *giganteus,* from a remarkably beautiful and perfect example belonging to the Bristol Institution Museum, and figured here to show the difference in the shape of the muscular scars compared with those of *Chonetes.*

Fig. 10. Interior of the *ventral valve* of *Productus horridus.*

Fig. 11. Interior of the *dorsal valve* of *Productus longispinus,* to serve for comparison with fig. 13, in which the same characteristic reniform impressions (V), supposed to be vascular, may be noticed.

Fig. 12. Interior of the *ventral valve* of a new species of *Chonetes* from the Devonian beds of Néhou, in France; exhibiting cardinal spines



Thos. Davidson del. et lith.

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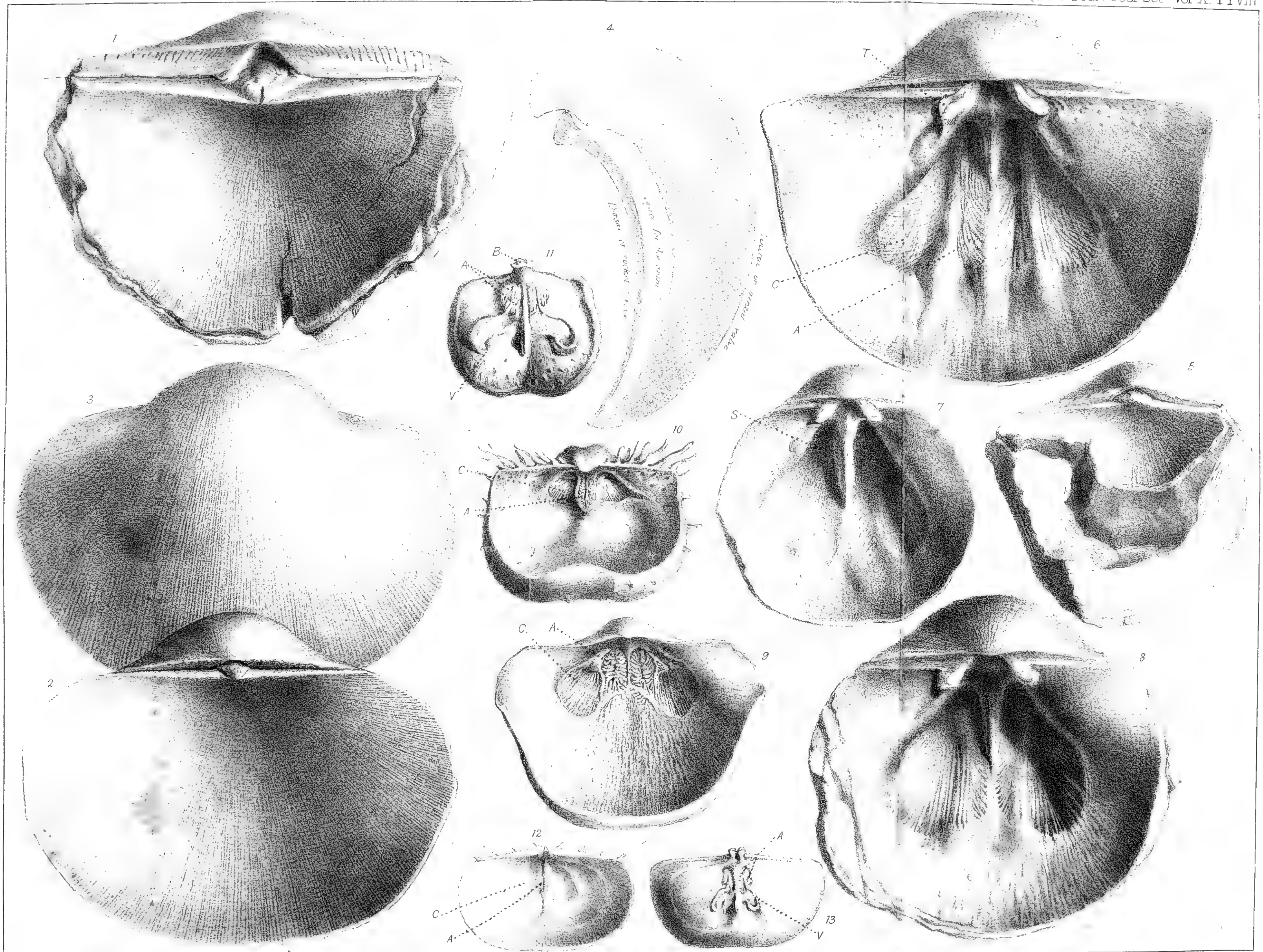

Thos Davidson del. et lith.

Ford & West Imp.

CHONETES AND PRODUCTUS.

21

and muscular impressions somewhat similar in shape and position to those observable in the same valve of *C. comoides*.

Fig. 13. Interior of the *dorsal valve* of the same *Chonetes* (fig. 12). Reniform impressions (V) similar in character to those of *Productus*, but not to those of *Leptæna*.

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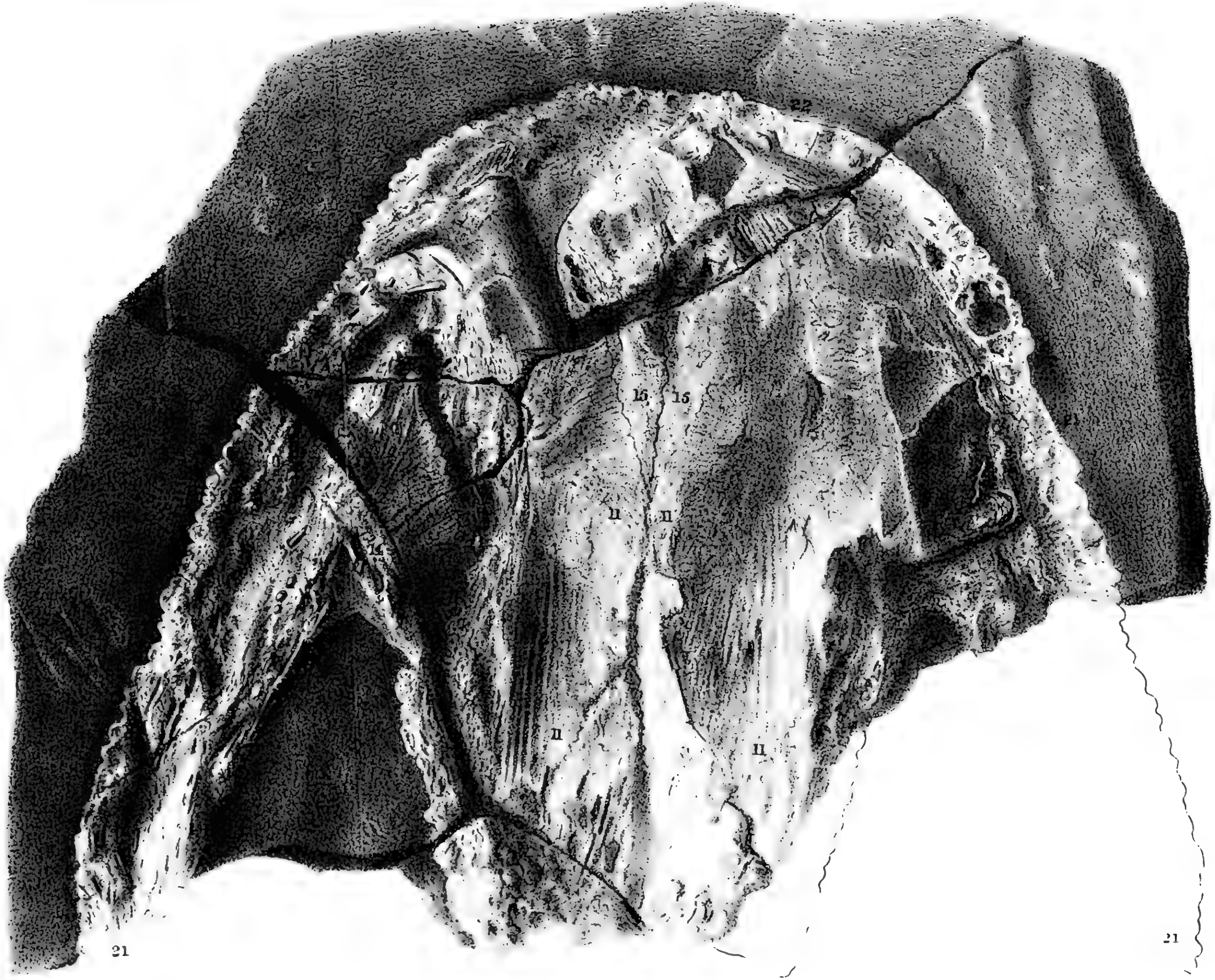
3. *On a* Fossil *imbedded in a mass of* Pictou Coal, *from* Nova Scotia. By Professor Owen, F.R.S., V.P.G.S. &c.

[Plate IX.]

The fossil imbedded in the mass of Pictou Coal, from Nova Scotia, submitted to my inspection by the President of the Geological Society, consists of the anterior extremity of the cranium and upper jaw, with the exterior of the bone imbedded in the matrix, and its substance, for the most part, reduced to a thin layer by abrasion of the exposed inner surface (see Plate IX.). It displays accurately the contour of the fore-part of the upper jaw, which was broad, obtuse, and rounded: and some portions of the bone, with the inner surface entire, prove this part of the cranium to have been broad, flat, and of very little depth or vertical diameter.

The parts preserved include the premaxillaries, 22, nasals, 15, and portions of the frontal, 11, prefrontal, 14, and maxillary, 21, bones, the proportions and connexions of which best agree with those in the skull of the *Capitosaurus*,—a Labyrinthodont Batrachian, from the Bunter sandstone of Bernburg.

The premaxillaries, which show some obscure traces of a symphysial suture at the median line, anterior to the nasal or naso-palatine vacuities, extend outwards, on each side, for an extent of $2\frac{1}{2}$ inches, and there join the maxillaries. Traces of round alveoli for teeth, some of which are 2 lines in diameter, are visible on the alveolar border of the premaxillaries. The alveolar border is continued, by the maxillary bone, for an extent of $4\frac{1}{2}$ inches beyond the premaxillaries; and this border shows still more distinct traces of alveoli, of a circular form, about a line in diameter, and rather closely set in a single series. The fore-part of the orbit is very unequivocally displayed, the smooth under or inner surface of the bone forming that part being entire; and this shows the fore-part of the orbit to be formed, partly by the maxillary, partly by a lacrymal or prefrontal bone in close sutural union therewith,—a structure which does not exist, to my knowledge, in any recent or fossil fish with a dentigerous superior maxillary bone. Where the substance of the bone has been detached so far as to expose the exterior layer in contact with the coal, as *e.g.* on the frontal and part of the prefrontal bones, the exterior surface of those bones is shown to have been impressed by subhemispheric, or elliptical pits, from 1 line to $1\frac{1}{2}$ line in diameter, and with intervals of half that extent: and this coarsely pitted character agrees with that presented by the outer surface of the similarly broad and flat crania of the



BAPHETES PLANICEPS.

Reptilian Remains in Pictou Coal.

Labyrinthodont Batrachia, e. g. *Trematosaurus, Capitosaurus,* and *Labyrinthodon* proper. The evidence of this structure presented by the tubercles of carbonaceous matter that filled the depressions in the bone, is at the same time evidence of the pulpy or plastic state of the carbonaceous matter when it made the cast of the sculptured outer surface of the cranium, which surface it now shows in relief.

A small microscopic section of the osseous tissue, which Mr. Quekett has had the kindness to prepare, shows very distinct and well-defined bone-corpuscles or cells, of an elliptic or oval figure, scattered throughout the tissue, at distances of from one to two or three of their own long diameters: without any appearance, in the section prepared, of vascular canals. The size of these bone-cells is less than those in the Batrachian reptile discovered by Sir Charles Lyell and Mr. Dawson in the South Joggins coal-field of Nova Scotia*, and corresponds with those in some of the larger Sauria, as *e. g.* the *Megalosaurus.* Neither Mr. Quekett nor I have yet met with any fish-bone recent or fossil, which shows a microscopic structure like that of the fossil in question from Pictou coal.

From the characters above specified, therefore, I conclude that this fossil is the fore-part of the skull of a Sauroid Batrachian, of the extinct family of the Labyrinthodonts. It agrees with them in the number, size, and disposition of the teeth; in the proportions and mode of connexion of the premaxillaries, maxillaries, nasals, prefrontals, and frontals; and in the resultant peculiarly broad and depressed character of the skull. The traces of the nostrils are less definite and satisfactory than the remains of the orbits; but the latter appear to me to be decisive against the piscine nature of the fossil. The fossil also presents the same well-marked external sculpturing as in the Labyrinthodonts; and amongst the genera that have been established in that family, the form of the end of the muzzle, or upper jaw, in the Pictou coal specimen best accords with that in the *Capitosaurus* and *Metopias* of Von Meyer and Burmeister. [The orbits have been evidently larger and of a different form than in the reptiles so called; and, for the convenience of distinction and reference, I propose to name the present fossil *Baphetes planiceps* (*βάπτω*, I dip or dive), in reference to the depth of its position, its probable diving habits, and the shape of its head.—Feb. 25, 1854.]

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4. *On the* TRACKS *of a* CRUSTACEAN *in the* "LINGULA FLAGS." By J. W. SALTER, F.G.S., A.L.S., *of the Geological Survey of Great Britain.*

WHILE investigating in the past autumn the fossil contents of the lowest fossiliferous zone in Wales—the "Lingula flags"—my atten-

* See Quart. Journ. Geol. Soc. vol. ix. pl. 3. fig. 8.

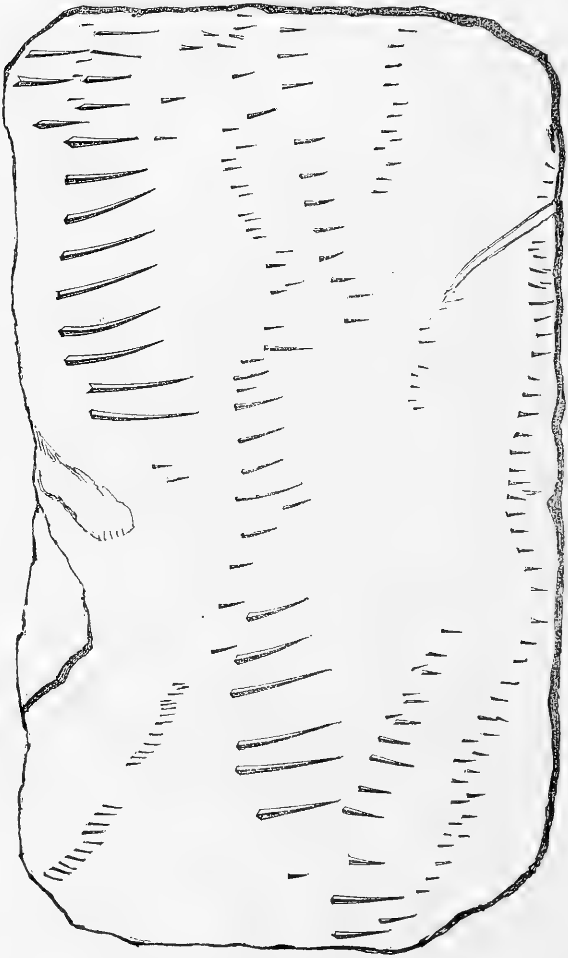
tion was frequently directed to very numerous evidences of the existence of marine worms during the formation of these ancient deposits.

Nearly all the sandy and ripple-marked surfaces present worm-tracks, whether in the higher or lower division of these strata, and in all the localities visited: viz. the elevated country between Arenig and Ffestiniog, the vale of Ffestiniog itself, and the valley of Tremadoc in Caernarvonshire.

The latter locality, besides exhibiting a very complete section of the whole series of these ancient rocks, exposes particularly well the lower or lower middle portion, in which only the *Lingula Davisii* is found in any great abundance, but in which the *Hymenocaris vermicauda* also occurs. The latter fossil, a crustacean of the phyllopod tribe, was described by me in the 'Reports of the Sections of the British Association' for 1852. About a mile and a half west of Tremadoc, the Lingula beds are well exposed; and along the road to Criccieth, and on the bye-roads near Penmorfa, they are loaded with the *Lingula*;—just above Penmorfa church the beds are particularly rich in this fossil. At the village of Y-Felin-Newydd, the sandy surfaces are seen to be broadly ripple-marked; and the beds, alternately of coarse and fine materials—many different layers often occurring in the space of an inch,—have quite the appearance of having been accumulated near shore, or at least in shallow water. The sandstone is highly micaceous in parts, often very fine-grained, generally flinty and of a flag-like character, and, though not at all cleaved, it exhibits everywhere proofs of movements which have compressed the beds laterally and plaited their surfaces in a remarkable manner. On one of the sandy surfaces, obscurely and broadly ripple-marked, were a number of short parallel linear impressions, arranged in several transverse curved series, and of such a uniform size and character that it was plain they were the marks made in succession by the same animal. (See figure, p. 210.)

The space on the slab which these impressions occupy is more than a foot in length; and there are five or six distinct sets of indentations, each set 3 or 4 inches in extent, and with a curved outline, the broadest end of each impression being towards the outer side of the curve. The indentations themselves are more than half an inch long, and half a line wide; abrupt and broad at their anterior end, and tapering backwards to a point. They are almost always a little curved, and are distant from one another a quarter of an inch,—in some cases rather less, in others more. Intermixed with these, which seem to have been the successive tracks of one larger animal, are numerous similar series of much smaller size, and also many single indents not placed in the regular transverse curves before noticed.

That these are not the tracks of marine worms is at once evident from their arrangement in regular series, and from their each tapering backwards, as well as lying parallel to each other. The section of each indent is subtriangular, so that it was probably made by some sharp instrument; and their shape tapering backwards and position in parallel series indicate a rapid movement, such as would be given by the spinous feet or abdomen of some crustaceous animal. As there is every reason to believe that Trilobites had soft feet, they could not have made such indentations with these instruments, and as the only species known in these beds—the *Olenus micrurus*—had an obtuse rounded tail, it could not have made the marks with that. We must look then to the possibility of their having been made by



Tracks of a small Crustacean animal (Hymenocaris vermicauda?) *on a ripple-marked surface of the "Lingula-flags" of North Wales.* (Nat. size.)

the *Hymenocaris*, a shrimp-like animal, whose abdomen does possess the requisite sharp prongs at its extremity, having in particular one large spine which seems to be exactly the instrument fitted for the purpose. It is well known, that, when in rapid or violent movement, the crustacea can strike vigorously with the abdomen, and so gain the impetus necessary for advancing or retreating. And there is so much resemblance between these indented tracks, and those produced by the common Shrimp at ebb-tides, that the observer cannot help suspecting them to have been produced by this*,—perhaps, the oldest of crustaceans, in its movements along the bottom, or (what is more probable) over the sand at the extreme edge of the waves.

The smaller marks were of course made by younger individuals of the species, whatever that may have been. But why should the indentations be parallel and arranged in transverse curved lines?

This question leads to the consideration of the circumstances under which these beds were accumulated, because, if under a sufficient depth of water to be out of reach of the tide, there seems no reason why the *Hymenocaris* should not have advanced in a straight direction; or, if agitated, why there should be any regularity in the indentations. I have already said, that the alternating coarse and fine materials of the sandy and micaceous beds indicate shallow water, a conclusion which is, I think, borne out by the occurrence of patches of drifted sand and broken shells on the strata in some neighbouring localities (for instance, in the quarry at the entrance to Y-wern). I would now go further, and suggest that we have here probable evidence of a flat shore, and of an ebbing tide against which the creature was striving to advance, and by keeping along the water's edge as the wave retired, it would necessarily produce a series of parallel indents along the curved edge. Such an explanation would account for the accurate preservation of all these minute impressions in their original sharpness; because the surface would be dried before it was again covered by fresh sand. I may remark that these indentations are common in the neighbourhood on similar surfaces, and with annelide tracks accompanying them. But I only met with this instance of their regular arrangement.

January 4, 1854.

Charles Moore, Esq., Robert Hunt, Esq., R. Hall, Esq., Dr. J. Hobbins, and E. S. Jackson, Esq., A.M., were elected Fellows.

The following communications were read:—

1. *On the* Superior Limits *of the* Glacial Deposits *in the* Isle of Man. By the Rev. J. G. Cumming, M.A., F.G.S., Vice-Principal of King William College, Isle of Man.

In a paper, read before this Society on the 4th of February, 1846, on the Tertiary Formations of the Isle of Man†, I detailed the position and relations to each other of certain pleistocene accumulations, which

* This is rendered still more probable by the fact, that the *Hymenocaris* is found at Tremadoc, but the *Olenus* has not yet been discovered there.

† Quart. Journ. Geol. Soc. vol. ii. p. 317; with maps and sections.

I classed under the heads of,—1st. Boulder-clay, and erratic blocks; 2nd. Diluvium; 3rd. Drift-gravel; and 4th. Alluvium.

In a subsequent paper, read before this Society on January 6th, 1847, on the Geology of the Calf of Man*, I stated that I felt inclined to remove to the division of Boulder-clay a large portion of the accumulations which I had classed under the head of "diluvium," confining this term to those masses of *insular* granite and detritus which had been carried from their original position to higher localities, and, as I then presumed, by violent diluvial or cataclysmal action. I thought it impossible that any *ordinary* action of icebergs could elevate to a height of upwards of 600 feet (and that within a distance of a mile and a half from their parent source) such immense quantities of granite and other rocks which I traced to the very summits, and abundantly on the other side of our highest southern mountains. In the same paper I stated my conviction that the sea-bottom of the glacial period had in this neighbourhood been depressed and raised again to an extent of not less than 400 feet.

Mr. Darwin in his paper "On the Transportal of Erratic Boulders from a lower to a higher level, read before this Society† on April 19th, 1848, in commenting on these facts, (which I had also more fully detailed in my 'History of the Isle of Man,' published that same year,) has shown how, by presuming a slow subsidence of the land, through a lengthened period, the agency of ice could be effectual to the producing these singular phænomena without necessarily calling in aid any violent cataclysm.

A further and closer examination of the locality convinces me of the soundness of Mr. Darwin's views, and that a gradual submergence took place of the Isle of Man to an extent of not only 400, but at least 1600 feet.

I shall very briefly draw attention in this paper to some of the evidences of the great probabilities of this hypothesis as presented to us in the Isle of Man.

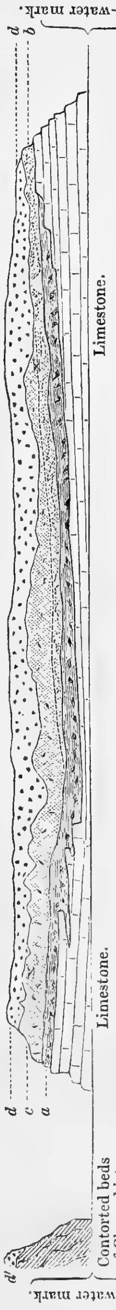
I should premise, that I consider all the appearances of the true boulder-clay (*i.e.* clay or loam imbedding *scratched* rocks and boulders *principally*,) as pointing to a *sinking* condition of the land; for, as proposed in my paper "On the Tertiaries of the Moray Firth‡," read April 18th, 1849, "the very circumstance, of the rocks *in* as well as *under* the boulder-clay being grooved and polished, is in itself a strong evidence of subsidence; the grooving must have taken place prior to the covering up of the fundamental rock; and the same must be true of each successive fragment in the superior mass."

I consider, at any rate, this hypothesis as presenting as simple a solution of the facts as the supposition of a mud-glacier sliding forward over itself through several miles of country and over every irregularity of ground.

I would observe that there was a period, prior to the subsidence and emergence of which I am about to speak, when the Isle of Man

* Quart. Journ. Geol. Soc. vol. iii. p. 179; with sections.
† Quart. Journ. Geol. Soc. vol. iv. p. 315.
‡ Quart. Journ. Geol. Soc. vol. vi. p. 10.

Cliff-section from Perwick Bay to the Lime-kilns near Port St. Mary. Length of section 450 feet: height above high-water about 32 feet.



a. Blue clay with angular and scratched blocks of limestone.
b. Grey gravel and loam much disturbed.
c. Fine yellow loam with occasional scratched pebbles.
d, d'. Coarse gravel.
x, x, indicate the places of two granite blocks.

presented (if we except the northern area consisting wholly of pleistocene deposits to the extent of 50 square miles) the general outline which it now does. At what period the great denudation took place which planed down to the same level both sides of extensive faults which took place in the older strata subsequent to the deposit of the carboniferous series, we have no distinct evidence. The boulder-clay consists, in greatest part, of materials derived from the older rocks in the immediate neighbourhood, as I have before pointed out; and it lies right across the faults which have been so denuded and planed down evenly on both sides*.

Over the whole of the southern area of the Isle of Man, wherever the limestone is uncovered, glacial groovings and scratches are distinct; their general direction being very nearly magnetic east and west, *i. e.* from N. 59° E. to S. 59° W. by meridian, and quite independent of the dip of the limestone-beds. The scratchings extend down to the present high-water-line; and even below it, wherever they have been protected by the stiff clay from the present action of the sea.

I would direct particular attention to the patch of limestone existing between Port St. Mary and Perwick Bay, of about 60 acres in extent. The general dip of the beds is *from* the fault which runs nearly magnetic east and west; and the *regular* groovings are in the direction of this fault; but there are frequent *minor* cross scratchings which vary several degrees from this general direction. This appears to me to be attributable to the action of *shore-ice*.

There are also appearances as if the boulder-clay had been forced violently amongst the different beds of the limestone; and fragments of the latter are torn up and carried forward; and these remain angular though much scratched, at no great distance in the mass of clay which now covers up the limestone-beds. (See section.)

A section of 400 feet in length, which I have made in a direction east and west by

* See sections and maps of the papers above referred to.

the meridian, well displays this phænomenon and the general appearance of the overlying deposits.

To the south-westward of this district the country presents to the sea a perpendicular wall, rising at Spanish Head to a height of 300 feet.

The great drift-current would pass along the face of this wall, and no doubt would originally mark it with groovings. But as the groovings would be in the strike of the bedding of the clay-schist, it would be difficult to separate them from the lines of bedding; and they would be greatly effaced by the action of the sea at the subsequent upheaval. Indeed a large portion of this cliff has fallen, and other portions annually fall into the sea.

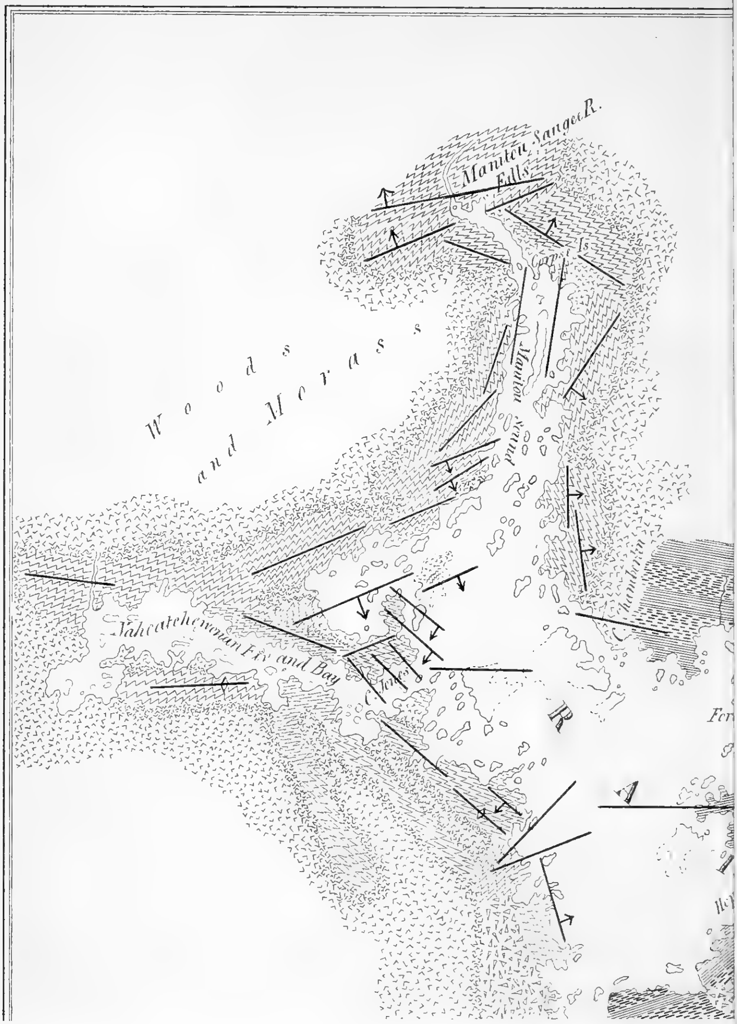
But all the way on the face of the mountain to the westward of Port of St. Mary, we have accumulations of the boulder-clay very distinctly, up to a height of 400 feet. Then, at a height of 460 feet above high water, we have, on the surface of the rock, a couple of hundred yards from the hamlet of Creggneese, by the road-side, distinct glacial groovings, having a direction a little more to the southward than those at Perwick Bay; but this direction the drifting-current would be compelled to take in passing through the slight depression which exists between the highest point of the Mull Hills and the point which lies to the eastward, in the direction of Spanish Head. The highest point of the Mull Hills is 500 feet above the level of the sea.

If we pass over northward to the mountain-range extending from Brada Head to South Barrule, we find the whole of the eastern face, to a height of 800 feet, covered with patches of the boulder-clay deposits, which remain wherever they have been protected from the action of the sea during the subsequent upheaval. These abound chiefly in boulders of the South Barrule granite, mixed with quartz and fragments of the clay-schist. Above this limit we find very little clay, but immense quantities of boulders lie both on the eastern and western side of the mountain, up to the very summit, though decreasing very fast the higher we ascend.

The summit of South Barrule is 1595 feet above the sea. To this depth, therefore, at least, the submergence would appear to have taken place.

We have few mountains on the Island whose summits are much higher than this, though Snea-fell reaches a trifle over 2000 feet. There is good reason to believe that they were all submerged, though I have not distinct proof of a similar kind to that which we find on South Barrule. The presumption arises from the character of the Insular Flora, destitute as it is of the plants of the true Scandinavian type, as compared with the flora of the opposite Cumberland Mountains.

With regard to the nature of the emergence, my impression is that it was also of a quiet and continuous character. The proofs of this seem to lie in the circumstance, to be observed here (as in the case of the parallel roads of Glen Roy and the neighbouring Caledonian Valleys), of terraces being found at the same level as contiguous mountain-passes.


Manitou Sanger R.
Falls
Woods and Morass
Manitou
Nahcatcheywan Riv. and Bay
R
A

This may be particularly noted in passing into Fleshwick Bay from Rushen Church, and in the terrace extending between Port St. Mary and Port Erin. Another argument in favour of this hypothesis is found in the entire absence of any water-worn caves at any great height above the present level of the sea.

I believe that the re-elevation was of such an extent as to lay dry the whole area of the Irish sea, and thus to connect the Isle of Man with the surrounding countries, and these countries with each other.

Over the plain, so formed, the *Megaceros Hibernicus* immigrated into these regions, as we find its remains buried in freshwater deposits which were formed in depressions of the drift-gravel terrace.

There was, however, a subsequent period of subsidence to a partial extent, and then a stationary period, which is indicated both by the great excavations in the drift-gravel made by the sea at a higher level than at present, and also by the presence of deep water-worn caves at the height of about 12 feet above the present sea-level.

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2. *On the* Geology *of* Rainy Lake, South Hudson Bay.

By Dr. J. J. Bigsby, F.G.S., &c.

[Plate X.]

Geographical position, &c.—Rainy Lake, or Lake Lapluie, is placed on the great commercial route from Canada to Prince Rupert's Land and the north-west fur countries.

It is 225 miles west of Lake Superior, and 85 miles south-east of the Lake of the Woods*, from the head of Rainy River; but at Nahcatchewonan River it is only 37 miles distant from that lake.

This lake, 50 miles long by 38½ miles broad, is 294 miles round by canoe-route. Its form, like that of most bodies of water resting on plutonic rocks, is extremely irregular, being in three great troughs (with deep lateral indents), one of these running easterly, and the other two in a northerly direction. See Map, Plate X.

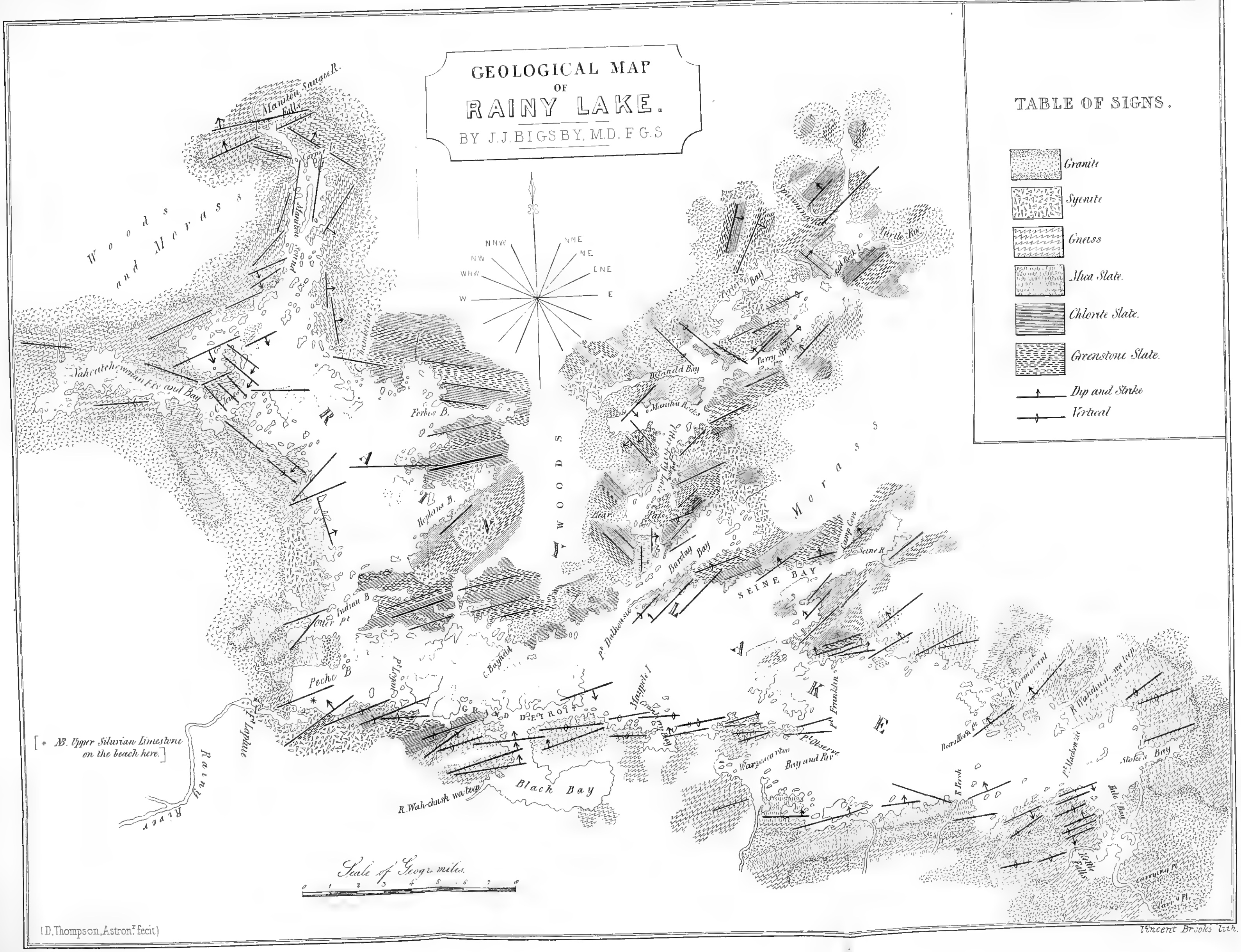
The immediate shores are usually low, rarely cliffs or earthy banks; but they rise in shapeless masses of rock, often naked, with broad marshy intervals; or in ridges, which become hills 300–500 feet high at distances from the lake varying from half a mile to four miles.

The low grounds are well covered with small trees, such as are common in these regions, and the higher abound in *Vaccineæ* and other useful fruit-bearing bushes.

Rainy Lake is 1160 feet above the level of the sea, according to Capt. Lefroy. Its water is pure and clear, but seldom deep, and the spring-freshets rise to the height of from 3 to 5 feet. Its magnetic variation is 10°–12° E.

We counted 516 islands; but there are more. They are mostly small and marshy; and never exceed four miles in length.

* Quart. Journ. Geol. Soc. vol. viii. p. 400, and pl. xxii.


GEOLOGICAL MAP OF RAINY LAKE.
BY J.J. BIGSBY, M.D. F.G.S.
TABLE OF SIGNS.
Granite
Syenite
Gneiss
Mica Slate.
Chlorite Slate.
Greenstone Slate.
Dip and Strike
Vertical
NNW
NNE
NW
NE
WNW
ENE
W
E
Woods and Morass
WOODS
Morass
R A I N Y L A K E
Manitou Sauges R.
Falls
Nahcatchewenan Riv and Bay
Forbes B.
Hopkins B.
Indian B
Otter Pt
Peche B
Black Bay
R. Wah-chush wa-teep
GRAND DETROIT
Maypole I
Pt. Dalhousie
Barclay Bay
SEINE BAY
Seine R.
Camp Cove
Pt. Franklin
Pt. Observe
Warpiscarton Bay and Riv.
Parry Strait
Delamere Bay
Manitou Rocks
Porter's Bay
Turtle Riv
Stokes Bay
Kettle Falls
Carrying Pl.
R. Cormorant
Rainy River
Ft. Lapluie
[* N.B. Upper Silurian Limestone on the beach here.]
Scale of Geogr. miles.
0 1 2 3 4 5 6 7 8
(D.Thompson, Astron.r fecit)
Vincent Brooks lith.

The map (hitherto unpublished) which accompanies this paper is taken from the archives of the Canadian Boundary Commission, whose surveyors I accompanied in their circumnavigation of this lake. While they were employed on its topography, I attended to its geology.

Geological conditions.—The geology of Rainy Lake is well worth a short but careful notice, because it continues north-easterly, into a country rarely visited, the investigations of Dr. Norwood, of Dr. Dale Owen's party of geological surveyors, who worked to the north-east from the head-waters of the Mississippi. Professor Keating (Long's Expedition) and Dr. Norwood passed along the south shore only of this lake, and their observations are contained in a few lines*.

The geology of this body of water may be summed up in the following words. Chloritic and greenstone slates, gneiss and mica-slate, in proportional quantities in the order here set down, seem once to have occupied the lake-basin, with an E.N.E. strike, and a N.N.W. dip, at a high angle usually. But subsequently a very extensive outburst of granite, with some syenite, has taken place, to the great disturbance of the stratified rocks, and penetrating them both in intercalations and crosswise. These intrusive rocks occupy a very large portion of the lake; most of the western shore, nearly all the eastern trough or arm, and much of the east end of the lake about Stokes and Hale Bays; as will be best seen by referring to the Map.

Near the head of Rainy River, there are vestiges of an Upper Silurian limestone, which will be mentioned in the sequel.

The whole of Rainy Lake may (solely for the convenience of description and reference) be distributed into six parts, in the order of our voyage round it; each having its own geological characteristic.

The first includes the whole west side of the lake from Rainy River to Manitou River, and round to Cape Chamberlin. The second takes in the interval of thirty-six miles between Cape Chamberlin and Cape Bayfield.

The third embraces the whole eastern arm,—the eight miles south of Point Lyon excepted.

The fourth occupies fifty-two miles of coast by Barclay and Seine Bays, easterly to near Point Franklin.

The fifth includes the whole south-eastern end of the lake, a coast-line sixty miles long, and having Point Franklin and Maypole Island as its western limits.

The sixth portion takes in the south shore from Maypole Island to Rainy River.

First Division of the Lake Shore.—The first of these portions or divisions (west shore), with the exception of a small district of greenstone slate at the south angle of Peche Bay, running obscurely E.N.E., is mainly occupied by granite; this is coarse in grain and grey about Peche Bay, but north of Otter Point the prevailing colour, especially in Manitou Sound, is white, from that of its three

* See Dr. D. Owen's Report of a Geological Survey of Wisconsin, Iowa, and Minnesota, &c. 4to. Philadelphia, 1852.

constituents. In patches we find it of a pale salmon tint, from the colour of its felspar. In the northern parts of this shore it is finely granular and porphyritic, in equal quantities. At the River Nahcatchewonan, the granite cannot be distinguished from that of Gravel Point and other districts in the Lake of the Woods, about forty miles distant on the W.N.W. The northern half of this western shore is for the most part a perfectly naked, bleached rock.

In Peche and Otter Bays, and for five or six miles northwardly, by the admission of hornblende and other changes in its constitution, the granite becomes a syenite, which, in its turn, by patches, becomes a hornblende-greenstone, and even slaty; while over the whole western shore, in places too numerous to designate, but occasionally noted on the Map, it passes into gneiss. Whether this is effected here by gradual transition, I cannot say, but intercalations of these two rocks are frequent; and so is the occurrence of veins of porphyritic granite, traversing the gneiss in all directions without disturbance of any kind (two miles N.E. of Cape Jones, &c.).

Throughout this coast, round and lenticular masses of black hornblende occur, both in the granite and in the gneiss, from 100 to 300 yards in length, and often ramifying far and near into the containing rock;—or it may be interleaved with the gneiss, as in Nahcatchewonan Bay, four miles west of Cape Jones. Point Otter is a headland of this rock, 250 yards broad. It is penetrated from below by granite, whose main seams (4–6 yards broad) rise up perpendicularly, but which ramify and inosculate very freely in the smaller branches.

On the north side of Nahcatchewonan Bay, this black hornblende is very abundant; and near Cape Jones a mass of it occurs in layers, which open and contain a large lenticular lump of crystalline quartz. It also abounds on the east side of Manitou Sound for ten miles south of Corpse Island, and here it passes conformably into a dark gneiss.

The strikes and dips of the gneiss are so various as only to be understood from the Map, where it will be further seen that the form and direction of the Western Arm (twenty-five miles long) and its different bays and inlets are greatly governed by the stratification; a remark which must be extended to the whole of Rainy Lake.

Second Division.—The second portion, with its winding shores, commences at Cape Chamberlin. Here a total change of rock takes place; but under what circumstances, the marshy nature of the country prevents us from seeing.

This whole line of coast (thirty-six miles) is based on greenstone-slate and chlorite-slate, passing into each other insensibly. Although of several shades of green elsewhere, and very fissile, the greenstone of Hopkins and Indian Bays is black, very compact, and often in such broad strata (many yards across) as to be almost massive. In this state it changes into syenite, in and near the two bays just mentioned, in spaces of a few square miles, and is either interleaved with the two slates in broad seams, or is in intrusive masses, containing numerous and large imbedded lumps of nearly pure hornblende.

The chlorite-slate is well characterized by its glossy-green colour, unctuous feel, and wavy or even crimped lamination. At the south angle of Forbes' Bay, a few hundred yards inland, these undulations take on a singularly contorted form. It is difficult to conceive what kind of force, or combination of forces, could have created the regular succession of numerous waved zigzags, seen at this spot, all of the same size (5 inches long), and ending suddenly in gracefully recurrent sweeps of lamination on a much larger scale. At this place, the layers of the chlorite-slate open, and contain irregular deposits many tons in weight, either of hornblende, or of very white crystalline quartz. A little to the west of Point Back are veins of chlorite-earth, a foot and more thick; and there the foliations of the chlorite-slate are greatly bent and crumpled. Chlorite-slate here never passes into syenite, at least directly; but is confusedly and largely interleaved with it, as in Hopkins Bay.

At Point Back, a mound or two of grey granite protrudes above the marshes.

Both the greenstone and the chlorite-slate are strictly conformable with each other;—their *most common* strike being E.N.E. At Cape Chamberlin, and on the north side of Forbes Bay, it is a little to the south of east; the strike is to the north of east on the south side of that bay, and throughout all the coast to Cape Bayfield, with the exception of the south side of Hopkins Bay, in proximity to syenite, where it is north-east, with a southerly dip, contrary to the usual dip in Rainy Lake. The dip is often vertical, and always high.

Third Division.—The third division commences at Point Bayfield, and extends nearly over the whole eastern arm, twenty-eight miles long in a direct line. The immediate shores of the lake are usually morasses, except high up in the north of this arm, where the country ascends at once in hills of pine-forests, or in naked ridges, 500 feet high, and as white and shining as porcelain. This division is characterized by the confused state of its stratified rocks, especially on the west side of the arm.

White or pale red granite is the prevailing rock, and especially in the north, accompanied by syenite*, and flanked by mica-slate and by chlorite-slate and greenstone-slate, quite the same as those already described.

The strike of these three last-mentioned rocks is usually N. and N.W., as at Bear's Pass, Otterberry Lake, and Porter's Bay; to the N.E., at Spawning River and the Manitou Rocks; as well as to the E.N.E., two miles north of Parry Strait. On the east side of the Arm, the strike seldom deviates from the N.E. or E.N.E.

By way of a few local details, we have to state that, from Cape Bayfield to Otterberry Lake, there is a confused intermingling of granite with greenstone-slate and chlorite-slate, and with three small districts of coarse grey mica-slates; one of these being a mile south of Bear's Pass, and the other two near the foot of Otterberry Lake; the most northern having many flexures, and abounding in garnet and staurotide.

* I found apatite in the syenite of Porter's Bay.

On the east shore, for some miles north of Parry Strait, dark greenstone-slate and gneiss occupy the country conformably with each other, granite here and there emerging from their midst. The gneiss has imbedded in it large masses of hornblende such as are noticed elsewhere, which also run into it in seams, in all directions.

From the north end of Otterberry Lake to Point Dalhousie (about twelve miles), the mainland consists of dark greenstone and chloritic slates, with some syenite at the bottom of Barclay Bay.

The chloritic slate of an island two miles N.E. of Point Dalhousie, marked by a fine grove of pines, is so quartzose as to become a hornstone. It has many veins and masses of white calcspar.

Fourth Division.—The fourth district includes the fifty-two miles of coast from Point Lyon, eastwardly, to Point Franklin.

It is almost wholly occupied, as far as I could see, by both broad and narrow alternations of greenstone- and chlorite-slates, in about equal quantities, and of the kinds common on this lake. The former is often in very thick strata, and is traversed by veins of white quartz and chlorite-earth; the latter being so soft as to be carved into images by the Indians. Chlorite-slate is in particular abundance at the north angle of Seine Bay.

Both rocks are conformable; their strike being to the E.N.E. or N.E., with a northerly or perpendicular dip. They have been little affected, in trend at least, by eruptions of granite, and are in fact continuations of the same strata some miles across the lake, on its south shore.

It has yet to be stated that the bottom of Barclay Bay, three and a half or four miles broad, is based on syenite, which is in connexion with the granite region of the East Arm on the north.

Fifth Division.—At the distance of two miles W.N.W. of Point Franklin, we enter our fifth division. It comprises the S.E. end of the lake.

The greenstone-slate here begins, as we see in coasting along, to alternate with dark syenitic gneiss, and then appears no more eastwards, being replaced entirely by gneiss with a strike varying from E.N.E. to E. by N., the dip being either perpendicular or northerly at a high angle.

About two miles N.W. of Cormorant River, great seams and tortuous veins of white granular granite everywhere traverse the gneiss, without alteration of the latter; and all around the above river, the country is studded with hummocks and bosses of granite with (to my eye) confused intervals of gneiss among them.

This continues, with imbedded masses of hornblende (as seen in the west of the lake) in either of these rocks, past Wah-chusk River to Point Mackenzie (eight miles), where, southward for seven miles, to Stokes Bay, numerous broad intercalations of a beautiful silvery mica-slate are met with among the granitic and gneissoid ridges. This handsome slate is thickly spotted with small scales of black mica, and fine granular quartz and felspar, both white.

From Stokes Bay, along a low coast, through Hale Bay (almost filled up with densely wooded islands) to Perch River, granite continues very plentiful, with beds of gneiss interposed. It disappears westwards at Wapescartoo River. The Falls of the Chaudière River, close to Hale Bay, pass over gneiss striking E.N.E., and vertical; but a white porphyritic granite is frequently seen close at hand.

On the west side of Hale Bay I had an opportunity of taking strikes and dips carefully in six places. They were always E.N.E., and in one place indicated a small anticlinal (see Map, Pl. X.). Since this paper was written I have been pleased to find my notes confirmed by the observations of Dr. Norwood, both in this locality*, and in the neighbouring fine body of water, Lake Namaycan.

This granite is remarkably porphyritic one mile west of Perch River, the felspar-crystals varying from 1 to 10 inches in length, the amorphous quartz-masses from 1 to 24 inches in diameter, and the hexagonal crystals of yellowish silvery mica 1 or 2 inches broad. In some places hereabouts the granite is of the kind called "graphic,"—as was remarked by Dr. Norwood of the granite not far from the Chaudière Falls at the S.E. corner of the lake. As might have been expected from its strike, we find the mica-slate of Stokes Bay, reappearing at Perch Bay, with an interval of six miles of lake; but it is here coarser, more quartzose, often ferruginous, and in this vicinity it distinctly runs into true gneiss. The nakedness of this part of the coast permits a freer examination of its rocks than elsewhere.

From Wapescartoo River, through the Grand Detroit to Maypole Island (sixteen miles), the only rock visible among the low woods is exactly the same gneiss as that of Point Franklin on the opposite shore.

This is particularly true at Point Observe, and on the east side of Black Bay. For many square miles about Wapescartoo Bay it is traversed everywhere by string-like beadings and larger masses of transparent amber-coloured quartz in long interrupted lines, with here and there wandering veins of granite.

The gneiss and mica-slate are conformable with each other and with the slates of Seine Bay, &c. Out of thirty-eight recorded observations in this fifth division, twenty-four are to the E.N.E., eleven E. by N., two nearly N.E., and one E.S.E. Of the twenty-eight dips, fifteen are northwards, ten vertical, and three southwards; the last being near each other; and two of them, although taken three miles apart, evidently occur in continuations of the same strata. They indicate small anticlinals.

Sixth Division.—The sixth division occupies rather more than one-third (the western) of the south shore of this lake, from Maypole Island to Rainy River.

For nearly eleven miles west of Maypole Island, to Point Logan, chlorite-slate† and greenstone-slate predominate, and in precisely the same relations to each other as in Indian Bay, &c., on the opposite coasts.

* Dr. Norwood found tourmaline, actinolite, and garnet here.

† Dr. Norwood (Owen's Report, p. 319) informs us that there is much talcose slate hereabouts. It may be so, but I saw none, although I carefully went over this coast three times. I suppose him to mean fine soft chlorite-slate.

The extensive shallow indent, called Black Bay, however, is based on granular gneiss with white mica, and with small quantities of greenstone-slate interleaved; both having an E. by N. or E.N.E. strike and northerly dip.

The greater part of the interval of four miles between Point Logan and Rainy River is occupied by syenite, in districts covered up irregularly by morass. It is very dark, from the preponderance of hornblende. It frequently contains isolated sheets of very micaceous gneiss and dark greenstone-slate; both with the usual E.N.E strike and northerly dip, but not without one or two small deviations.

At the commencement of Rainy River, on both banks, and for two miles of the south shore of the lake, there is a large quantity of untravelled debris of an Upper Silurian limestone, which is always sharp-edged and slaty; and now and then is planted into the earth in such great square masses, that I am constrained to consider it living rock, split into fragments by the intense cold of these regions.

Containing the same fossils as the limestone of the lake of the woods, I believe it to be of the same age*. It is browner and coarser in texture. There is not much doubt but that it underlies most of the bed of Rainy River, and is continued into the plains about the Red River settlement.

Remarks.—Whilst vast districts to the south and west are buried under clays, sand, gravel, and boulders, to the depth occasionally of 500 feet, there is about Rainy Lake but little loose debris; the earth or gravel banks being few, and seldom exceeding a few feet in thickness†. Whenever the land rises a little we have for the most part bleached and naked rock for many square miles together. Some northern erratic blocks there are, but not in such marvellous accumulation as elsewhere encumbers the surface.

The strikes in Rainy Lake, of which that to the E.N.E. may be taken as normal or common, require a correction of 10° or 12° westerly; such being the amount of the magnetic variation easterly. This brings the strikes nearer to the N.E.

The rock-formations of this lake are a continuation of those on the south;—both towards the head-waters of the Mississippi, and the Fond du Lac of Lake Superior; the rocks themselves, their mutual relations, and their strikes being similar.

Dr. Norwood in his map of these parts of Minnesota (Atlas, Dale Owen's Survey of Minnesota, &c.) covers the country with granite and syenite, mingled with metamorphic slates, going N.E., as far as enormous quantities of coarse and fine drift have permitted him to observe.

On the west of the Fond du Lac, and between the Mississippi and Minnesota Rivers, Dr. Norwood found the strike to be N.N.E.; but whether this indicates a formation of a different era from that of Rainy Lake and other neighbouring parts, or is due to local magnetic variation, so changeable among these lakes, cannot at present be settled.

* Quart. Journ. Geol. Soc. vol. viii. p. 405.

† See Dr. Bigsby on Canadian Erratics; Quart. Journ. Geol. Soc. vol. vii. p. 215.

Dr. Norwood (Owen's Survey, p. 192) considers the great plutonic chain north of Lake Superior, and running nearly parallel with its north shore, from N.E. to S.W., to be the main axis of dislocation for wide regions in this part of North America.

This opinion is strengthened by finding in Rainy Lake, and along the chain of lakes (225 miles long) which lead to the Grand Portage of Lake Superior, that the dip of all the stratified rocks is almost invariably to the north*; while that of the kindred rocks in Wisconsin and Michigan, south of Lake Superior, is with great constancy to the south; and this over areas of many thousand square miles.

In hand-specimens the rocks of Rainy Lake are often not to be distinguished from those of Lakes Superior and Huron. Although carefully sought for, I met with no ores in Rainy Lake; while in Iron and Gunflint Lakes, on the east, indications of metalliferous rocks are numerous.

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3. *On some* Swallow Holes *on the* Chalk Hills *near* Canterbury. By J. Prestwich, Jun., Esq., F.R.S., F.G.S.

The occurrence of swallow holes on chalk and limestone hills is a phænomenon almost too well known and too general to call for any special notice; but there exists, in a locality not hitherto cited, near Canterbury, a group of these stream-absorbent cavities of so remarkable a character, that, as this question also bears so materially upon the subject of the next communication I have to make, I beg to lay before the Society a short account of them.

I came upon this spot whilst tracing, a few years since, the Thanet Sands through East Kent. Around Feversham and Canterbury the country consists essentially of chalk, but the high ground between these towns consists of tertiary strata, forming a tableland of a few square miles in extent. The area to be noticed is merely that portion of the hill which lies south of the high-road, and which is in part marked by a wood named on the Ordnance Map "Fish Pond Wood," extending over the London clay and Lower Tertiary sands down to the edge of the chalk. The drainage from this clay surface is carried off by several small brooks † having an easternly or a southerly direction. It is to the latter that I would particularly direct attention. Skirting the wood from Nick-hill Farm westward to Lower Elmsden, there are to be found within a distance of about a mile as many as six or seven of these watercourses, all of which, without exception, disappear just within the edge of the wood, in swallow holes, some of which are not more than 6 or 8 feet broad and deep, whilst others attain a diameter of 30 to 40 feet and a depth of 20 to 30. There is generally not much water in the brooks running into these funnel-shaped ‡ excavations, at the bottom of which they form a small pool, that, notwithstanding this

* The result of 120 observations in Rainy Lake, and of thirty in the other lakes, carefully made by myself.

† These brooks are not laid down on the Ordnance Map.

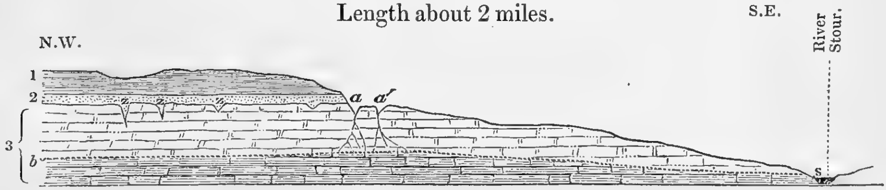
‡ On one side of which the stream forms a gap or lip.

incessant addition, remains unchanged and without rise, the water being gradually and quietly absorbed as fast as it is supplied. Only occasionally after heavy rains the water stands for a few hours some feet higher. The sides of these excavations are usually sloped with debris, grass, and bramble, and the bottom covered by a bed of sand and gravel so that the chalk surface cannot often be seen. Some of the swallow holes are situated within the boundary of the Lower Tertiary sands, whilst others are just on the edge of the chalk. Between this spot and the river Stour at Shalmford Street there is a descent probably of 200 to 300 feet, throughout which the surface of the chalk is as bare of wood as it is of water. But on the river-bank near that village a large and perennial spring bursts out. There are, I believe, several other springs in the river, but this is a very striking one, and is apparently dependent upon the brooks lost in the swallow holes a mile distant on the hills above. Not that I think that the streams are continued underground in separate and independent channels from the spot where they disappear to that at which they issue in the river-bank, but that they descend, within a short distance, through one or more channels down through the mass of the chalk, until they reach the line of permanent water-level which passes under the hills in a curve rising slightly from the river Stour and descending again towards Feversham. The additional supply made by the brooks at this spot determines a higher local level in the water-line, and consequently the springs issue in greater force, and higher above the river, along the nearest lowest level of the valley—the river channel. The bulk of the springs are probably in the bed of the river, or low on its banks, and are therefore not so apparent.

The accompanying section gives a general view of the position of these swallow holes and of the main spring.

General theoretical Section of the Hills S.E. of Boughton to the River Stour between Chilham and Canterbury.

Length about 2 miles.



1. London Clay. 2. The Lower Tertiary Sands. (These should be continued between *a* and *a′*.) 3. Chalk.
a, *a′*. Swallow-holes in the surface of the Chalk.
b. Line of water-level in the Chalk *. *s*. Spring on the river-bank.
z, *z*, *z*. Sand-pipes on the surface of the Chalk, filled with the tertiary sands.

* Assuming *b* to be placed in a central position between *s* and the river-level at Feversham, to the N.W., the line of water-level from *b* to *s* would form a nearly regular descending plane in either direction, and the point *s* would fall rather lower than in the above diagram; but the concentrated supply of water at *a*, *a′*, raises the water-level between *b* and *s*, and affects in proportion the water-level at *s*, causing it to stand higher than it would in its normal condition, and determining, therefore, at that spot a larger delivery of water than usual. The water-channels conducting from *a*, *a′*, to the dotted line *b*, *s*, may be nearly perpendicular, or may follow for some distance the line of stratification formed by the beds of flints.

On the other side of the hill, in proceeding from Hatch Green to Dinstead and Fish Pond Farm, there are several other swallow holes. Altogether the district is a very interesting one in this respect, and, although I have seen larger streams absorbed elsewhere, I know of no other locality where so many may be seen within so small an area, or where the phænomenon is more striking*.

It would appear that two conditions are essential for the formation of swallow holes: the one, that there should be streams formed at such a level that they have to pass over a surface of country higher than that of the main valleys of drainage; and the other, that the line of water level in the mass of calcareous strata in which the swallow holes are formed should be below the level at which the streams drilling the swallow holes are absorbed. The action is therefore dependent upon the tendency which the water has to seek the lowest water-level. Consequently wherever a predisposing cause†, such as a crack or fissure, may exist, the water will tend to escape through any available subterranean channels to the lower water-level and then to the river-channels, in lieu of flowing over the surface to the same ultimate point, as it would do in the case of passing over strata not acted upon by water holding, as usual with all surface waters, carbonic acid in solution.

* Amongst other places in the chalk around London where swallow holes may be observed, I would instance in particular the neighbourhood of Farnham, and the districts immediately north of Newbury, S.W. of Hungerford, and N. of Barnet.

† In this case the old Tertiary sand-pipes may have determined the formation of some of these existing swallow-holes.

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I. TRANSACTIONS AND JOURNALS.

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AMERICAN Journal of Science and Arts. Vol. xvi. no. 48. *From Prof. Silliman, M.D., For. Mem. G.S.*

Hitchcock.—Coal-field of Rhode Island.
Nicklès.—Nickel and Cobalt.
Dana.—Coral formations.
Smith and Brush.—American Minerals.
Dana.—Supposed change of Ocean temperature.
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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

January 18, 1854.

Alfred William Morant, Esq., C.E., and John Bailey Denton, Esq., C.E., were elected Fellows.

The following communications were read:—

1. *On* Pipes *and* Furrows *in* Calcareous *and* Non-calcareous Strata. By Joshua Trimmer, Esq., F.G.S.

I propose, in this communication, to give a brief summary of the evidence on which I rely for proof of the formation of those remarkable cavities in the chalk, known as pipes and sand-galls, by the mechanical action of water, before the matter which fills them was deposited. I shall describe the various forms which they assume, the different strata, besides the chalk, in which they are found, and the various deposits of the tertiary epoch with which they are filled.

1. *The Pipes are terminations of Furrows.*—In the first place, then, they are the termination of furrows, which widen and deepen as they approach the pipes. This becomes evident, when we have an opportunity of seeing a ground-plan of them, in consequence of

the removal of the matter covering the chalk, without disturbance of the surface of the rock. Until I drew attention to this fact*, they had only been studied in sections; and when seen in section, they frequently present very deceptive appearances.

It was the connexion of these furrows with pipes and other cavities in the chalk which caused me to venture to dissent from the theory of their formation by acidulated water percolating the strata above them, as promulgated by Sir Charles Lyell, and adopted by some of our most eminent geologists.

Detailed descriptions of several such cleared surfaces of chalk in Kent and Norfolk, which I had watched from day to day, during several weeks and even months, while the clearing was in progress, will be found in the Proceedings and Journal.

Shape of the Furrows and Pipes.—The result of these observations was, that the furrows are, in some cases, wider than they are deep, in others, deeper than they are wide, and that, in juxtaposition with one another, and with both kinds of furrows, we find cavities of various shapes, which all pass among geologists under the name of pipes or sand-galls. There are cylindrical cavities of various depths, some terminating abruptly, some extending below the depth of the section, even when it is as much as 20, 30, and, in extreme cases, nearly 60 feet. There are funnel-shaped cavities, or inverted cones. There are caldron-shaped cavities, wider at half their depth than at the surface, like many of the rock-basins on the sea-shore, or in the beds of rapid rivers. There are dish-shaped cavities, or circular basins, several feet in diameter, and not exceeding a foot or two in depth. Lastly, there are large irregular cavities, such as would have resulted from the breaking down of several neighbouring cavities into one.

2. *Occurrence of Pipes and Furrows in Non-calcareous Strata.*—The second argument in favour of the mechanical origin which I assign to these mysterious excavations is, that they occur in non-calcareous strata. Dr. Fitton pointed them out in the Green-sand. Before I saw them in that formation, I had observed similar pipes and furrows, of much smaller dimensions, on blocks of sandstone derived from the Lower London Tertiaries, and scattered over various parts of Kent. A considerable number of these blocks were placed as a protection to the footpath in the streets of Ospringe and Feversham in 1841, and some are still to be seen there. Some of the cylindrical cavities in these blocks terminate in a blunt point, like those in the chalk, others pass completely through the block. In a few blocks they commence from opposite sides. I attribute this to the blocks having been exposed to the breaking of the sea upon the shore, and, after having lain for some time in one position, having been turned over by a storm of unusual violence; because—

3. *Pipes and Furrows now in course of formation on Stone and Chalk*—I had seen cylinders of still smaller size, on blocks of sandstone, on the shore near the Reculvers, actually being formed by the

* Proc. Geol. Soc. vol. iii. p. 186; *ibid.* vol. iv. p. 7 and p. 482; and Quart. Journ. Geol. Soc. vol. i. p. 300.

vorticose action which the flux and reflux of the waves communicated to sand and water lodged in hollows on the face of the block :

4. I have seen cylindrical and funnel-shaped cavities connected by furrows, in the course of formation by means of similar vorticose action, on a flat shore of chalk, between high and low water, near Cromer. The cylinders were 2 inches in diameter and 4 inches deep.

5. After the heavy gale which, in 1846, carried away the jetty at Cromer, and caused great destruction of the detrital cliffs there, I found part of a ledge of chalk, which forms their base, and which had been exposed for some little time to the breaking of the sea beyond the usual tidal limits, having a surface of several square yards, covered with circular hollows, 1 to $1\frac{1}{2}$ foot in diameter. These cavities were filled with loose pebbles, on removing which, the cavities were found gradually to contract in diameter, until they assumed a cylindrical shape. A section of one, laid open by the sea, was 2 feet deep and 3 inches in diameter, terminating with a blunt point, like many larger chalk-pipes of other epochs. This is a very common depth of similar cavities on various strata which are filled with warp-drift, as I shall describe hereafter, and which rarely attain the large size so common among those in the chalk which are filled with older tertiary deposits.

6. *Conformability or Non-conformability of Deposits overlying the Mouths of the Pipes.*—On a broadly-undulating surface of chalk, covered with the crag, the ferruginous breccia, called "the pan," which forms the base of that deposit, together with the alternations of sand and clay above, conform to this undulating surface. It is the same with those large irregular cavities which have a greater width than depth. Such conformability to an irregular surface is admitted by geologists to be an original condition of deposit ; and that bending down of the strata into the mouth of a pipe of considerable diameter, which has been adduced as a proof of subsidence, may be only an extreme case of conformability to an irregular surface.

7. Above this irregular stratification, there are alternations of sand and clay over the pipes, which are perfectly horizontal.

8. It is only over pipes of large diameter that there are those irregularities of stratification, which have been supposed to indicate subsidence.

9. *Occurrence of calcareous matter in the Pipes.*—In the deeper furrows connected with the pipes, we find alternations of deposit distinct from the superincumbent strata ; and among these are layers of fragmentary chalk, which acidulated water, percolating from above, ought to have dissolved before it could have excavated the furrow.

10. *Pipes in inclined strata.*—The pipes on the surface of the tilted chalk of Alum Bay must have been formed before the disturbance ; for they are perpendicular to the original plane of stratification, and, when the chalk was horizontal, the sands above it were covered by the impermeable mass of the mottled clay. The position of the strata now is highly favourable for the downward percolation of water, but no new pipes are being formed on the inclined chalk.

Materials filling the Pipes.—Pipes and furrows, of various dimensions, occur more or less on all the following strata, and are filled with the following deposits. I arrange them in the order of relative antiquity, commencing with the oldest:—

1. In the chalk some are filled, in the tertiary districts of London and Hampshire, with the lower eocene sands. Others are filled with more recent deposits. The former infilling is distinguishable by means of the green-coated flints which it contains.

2. In Norfolk they are filled with the Crag. See fig. 3. p. 236.

3. There also some are filled with reconstructed gravel, formed from the materials of the Upper and Lower Erratic Tertiaries*, brought to lower levels during the period of re-elevation and denudation†.

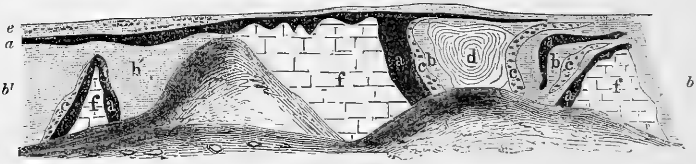
4. On the northern flanks of the North Downs they are filled with the Dartford gravel‡, which I refer to the same period of re-elevation.

5. Near the chalk-escarpments overhanging the Wealden area, and on the highest tabular summits of the chalk hills, the pipes are filled with "cledge §," a mixture of clay, sand, and unabraded and unfractured flints. This I refer to part of the same period of re-elevation, considering it to have been laid dry somewhat sooner than the Dartford gravel.

6. When any member of the erratic tertiaries, or the chalk on which they rested, has been so exposed by denuding action as to be the bed nearest the surface, it is worn into furrows and pipes of small dimensions, and these are filled with the loamy deposit which I call the "warp-drift ||," and which contains, and occasionally passes into, masses of sharply-fractured flints and heaps of chalk-rubble. This is part of the angular flint-drift of Sir Roderick Murchison**. I refer the

Fig. 1.—*Section near Portobello Inn between Farningham and Wrotham, Kent.*

N. Scale 12 feet to 1 inch. S.



a. Dark ferruginous clay with flints.
b, b'. Light-coloured sandy loam.
c. Seams of rounded eocene pebbles.
d. Red and yellow ochraceous sand.
e. Clay, sandy loam, and eocene pebbles, in irregular alternations, horizontally stratified; becoming obscure towards the south part of the section.
f. Chalk.

* The Lower Erratic Tertiaries comprise the Boulder-clay; the superincumbent gravels, &c. with erratic blocks being the Upper Erratics. See Quart. Journ. Geol. Soc. vol. vii. p. 21; and *ibid.* vol. ix. p. 295.

† See Table, Quart. Journ. Geol. Soc. vol. ix. p. 295.

‡ See Quart. Journ. Geol. Soc. vol. ix. pp. 287, 295.

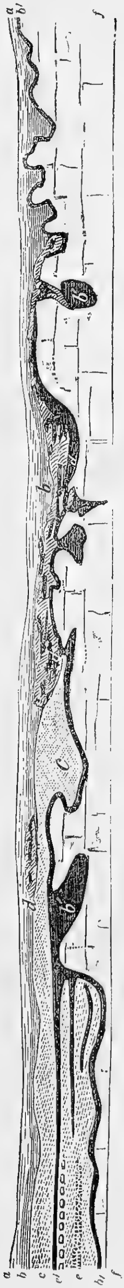
§ Quart. Journ. Geol. Soc. vol. viii. p. 275.

|| Quart. Journ. Geol. Soc. vol. ix. Table, p. 295.

** Quart. Journ. Geol. Soc. vol. vii. p. 349.

Fig. 2.—*Section in the Road by the Parsonage of Hartley, near Dartford, Kent.*

Scale 20 feet to 1 inch.



a, a. Clay loam, with numerous unabraded flints and pebbles of the eocene strata, passing downwards into *b*.
b, b. Dark ferruginous clay.
b', b', b', b', b'. Dark ferruginous clay, with flints and eocene pebbles, in contact with the chalk.
c, c, c. Yellow sandy loam.
d, d, d. Reconstructed chalk, with patches of clay.
e. A seam of small eocene pebbles, 6 to 10 inches thick.
e'. A layer of larger pebbles.
f. Chalk.

fracture of the flints, not to movements of disturbance in the chalk, which took place, I conceive, during the formation of the "cledge," but to the action of the atmosphere during the second terrestrial or second elephantine period*; and the distribution of these fractured flints, and their aggregation into heaps, I refer to those aqueous operations, which, whatever they were, were transient, violent, intermittent in their action, and suddenly arrested, and to which I attribute the formation of the warp-drift.

In the section near the Portobello Inn, between Farningham and Wrotham (fig. 1), the "cledge," with its unabraded flints, fills the large excavations in the chalk, and the "warp-drift," with its fractured flints (*e*, on the left of the section), overlies it horizontally, and may be traced thence along the northern slope of the chalk, with a thickness varying with the elevation and form of surface. The section near Hartley Rectory (fig. 2) shows this re-arrangement of the materials of the "cledge," during the distribution of the warp-drift, at a point intermediate between the edge of the chalk-escarpment and the valley of the Thames.

The above sections are in a district where the boulder-clay of the Lower Erratics is wanting; but in the sections (figs. 5 & 6), which I reproduce from the 'Journal of the Royal Agricultural Society,' vol. vii. p. 484, I exhibit cases, very common throughout Norfolk, of pipes and furrows in the denuded surface of the Boulder-clay which are filled with the warp-drift.

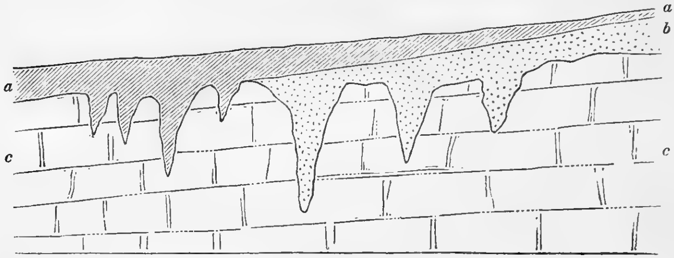
Fig. 3. This is a section over a chalk-pit at Guest, between Fakenham and Foulsham. In this case two contiguous sets of pipes have different infillings—crag in the one, warp-drift in the other.

Fig. 4. A section near Desborough, Northamptonshire. A pipe in sand is

* See Table, Quart. Journ. Geol. Soc. vol. ix. p. 295.

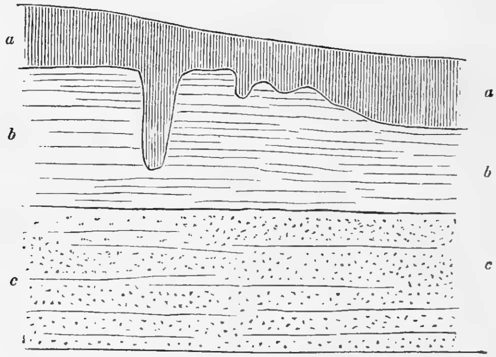
filled with Boulder-clay. This is the only case I have ever observed of pipes so filled.

Fig. 3.—*Section of Pipes, filled with Warp-drift and with Crag, in a Chalk-pit at Guest, between Fakenham and Foulsham.*



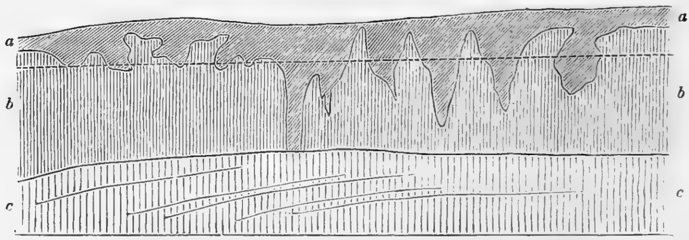
a. Warp-drift; sandy loam. *b.* Sand of the Crag. *c.* Chalk.

Fig. 4.—*Section of Pipes filled with Boulder-clay, near Desborough, Northamptonshire (on the Harborough side of the village).*



a. Boulder-clay; brown clay with chalk-flints, and rolled pebbles and scratched fragments of hard chalk.
b. Whitish sand.
c. Ferruginous sandstone. } Lower Oolite.

Fig. 5.—*Section of Pipes in the Boulder-clay, at Hardingham, Norfolk.*

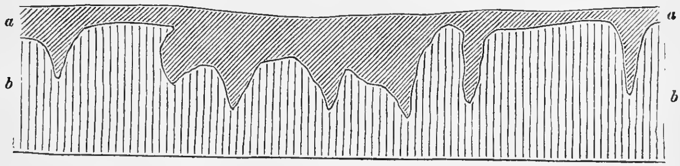


a. Loamy Warp-drift. *b.* Boulder-clay.
c. The same materials as the Boulder-clay, viz. chalk and clay, but containing irregular seams of sand and gravel.

Fig. 5. A section of the Warp-drift and Boulder-clay near Hardingham, Norfolk. Here the depth of the furrows and pipes filled with Warp-drift varies from 3 to 6 feet; one of the pipes, however, extending to the depth of 9 feet. If all the projecting points of Boulder-clay were removed to a level with the horizontal dotted line, it would give to the soil a regular depth of 3 feet.

Fig. 6. A section of the Warp-drift and Boulder-clay near Langham, Norfolk. In this case the greatest indentation is 3 feet deep, the depth of the Warp-drift varying, in the space of a few yards, from less than 6 inches to 3 feet.

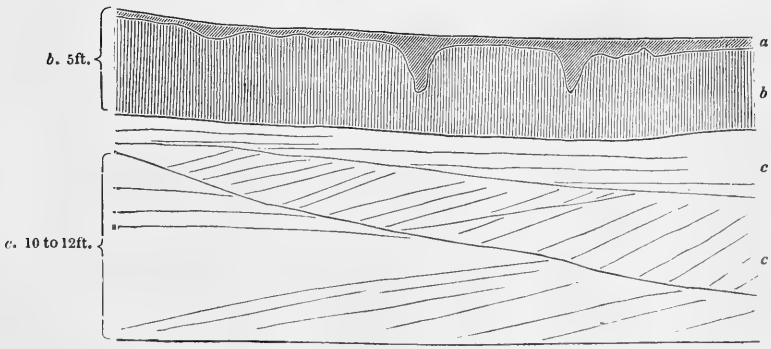
Fig. 6.—*Section of Pipes in Boulder-clay, at Langham, Norfolk.*



a. Loamy warp-drift.
b. Boulder-clay; flints and rolled fragments of chalk, in a base of finely comminuted chalk and clay.

In describing, in 1846, in the 'Journal of the Royal Agricultural Society,' these furrows and pipes between the soil and subsoil, that is, between the Warp-drift and whatever bed it rests upon, I pointed out their very general occurrence, not only on calcareous, but on non-calcareous strata; showing that, while furrows are common to both, cylindrical and conical cavities are more prevalent, and best developed, in calcareous strata; but that they are also occasionally found in sand and gravel. I also adverted to the bearing of this furrowed surface of the subsoil, not only as regards investigations in

Fig. 7.—*Section of Pipes in Boulder-clay, in a Sand-pit near Raveningham Hall, South Norfolk.*



a. Warp-drift; brown clayey loam; 6 to 18 inches.
b. Boulder-clay, with fragments of Chalk.
c. Crag, with false bedding.

pure geology, having reference to the agencies concerned in their formation, but having reference also to practical questions in agriculture connected with drainage, evaporation, the patches of burning soil technically called "scalds," and to the practice of deep or shallow ploughing, and subsoiling. Fig. 5 has special reference to the latter point.

To the above sections I now add from my note-book a sketch (fig. 7) of furrows and pipes in another form of Boulder-clay, overlying the fossiliferous portion of the Crag near Raveningham Hall, in South Norfolk.

Another deposit, whose surface, when denuded, is seen to be furrowed and pierced with small pipes, filled with warp-drift, consists of those beds of reconstructed chalk, pure enough to be burned for lime, which are found in the midst of the sand of the Upper Erratics. I described them in the 'Proceedings of the Geological Society,' vol. iii. p. 185, and in the 'Journal of the Royal Agricultural Society,' vol. vii. p. 463, but gave no sections. I am doubtful whether the bed "*r*" in the section near Burnham Market*, fig. 14, in which, among many small pipes, there is one 20 feet deep, belongs to this portion of the erratic period, or to that of the boulder-clay, which in that part of Norfolk assumes its most chalky form.

Fig. 8 represents pipes and furrows on the surface of the freshwater deposit at Gaytonthorpe†, which rests upon one of these chalky varieties of boulder-clay, and which I therefore refer to an elephantine period‡, subsequent to the desiccation of the Erratic Tertiaries.

Fig. 9 is a section taken nearer the head of the same valley, and represents pipes and furrows on similar deposits, in which no organic remains have been found.

The furrows in the Green-sand of Kent filled with loam, and containing land-shells and mammalian bones, as described by Sir R. Murchison§, I refer to this second elephantine period.

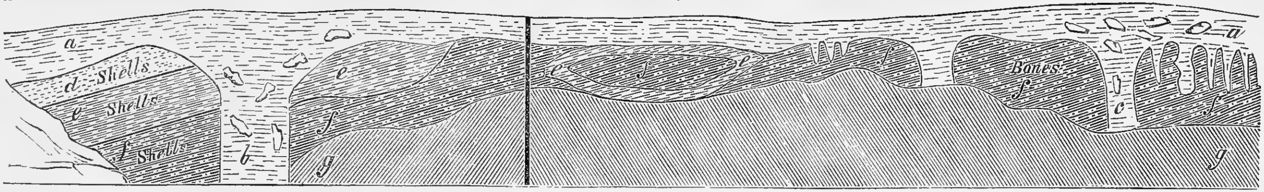
Conclusion.—On the whole, then, I conclude that pipes and furrows have been formed by the mechanical action of water, before the matter with which they are filled was deposited; and the nearest existing analogies I can find to them are the effects of breakers on the shore, and of the action of torrential rivers.

Their general distribution may be explained by the continued advance or retreat of the coast-line, during the repeated risings and fallings of the land throughout the tertiary era. The difference in magnitude between these ancient excavations and those now being formed by the sea, may be ascribed to the greater magnitude of waves, occasioned by the movements to which the land, quiescent now, was subject then. The prevalence of cylindrical cavities in the

* Quart. Journ. Geol. Soc. vol. i. p. 315.
† Quart. Journ. Geol. Soc. vol. vii. p. 26.
‡ See Table, Quart. Journ. Geol. Soc. vol. ix. p. 295.
§ Quart. Journ. Geol. Soc. vol. vii. p. 382, &c.

Fig. 8.—*Section at Gaytonthorpe.*

Vertical and horizontal scale, 20 feet to 1 inch.



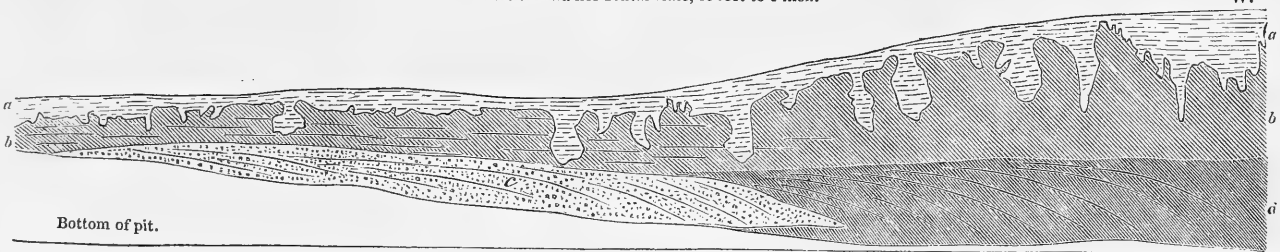
a, *a*. Warp-drift, sandy loam, containing unabraded flints, some of them of large size, as at *b* and *c*.

d.	White calcareous sand.	Freshwater beds.
e, e, e, e.	Grey and yellow silt.	
f, f, f.	Grey clay.	

g, g. Resembling the most chalky varieties of the Boulder-clay; and containing fragments of chalk with flints, and fragments of Kimmeridge clay and other oolitic rocks.

Fig. 9.—*Section at Gaytonthorpe.*

Vertical and horizontal scale, 10 feet to 1 inch.



a. Warp-drift, composed of fine, ferruginous sand, derived apparently from the greensand series, with angular flints dispersed through it, and filling pipes and furrows in the subjacent marl.

b. Marl more calcareous than *d*, slightly laminated, laminæ horizontal. It passes in the space of about 20 yards into a nearly unlaminated mass.

c. Gravel composed of small flints, both rounded and angular; false-bedded; resting, apparently, on clay like *d*, but the base of the section obscured by debris and by the floor of the pit having been cut up by cart-wheels.

d. Laminated, grey and yellow clay; laminations oblique, and from $\frac{1}{8}$ to $\frac{1}{2}$ inch thick; with occasional seams of ferruginous sand and false bedding. No fossils discovered.

chalk, in connexion with furrows, and their comparative rarity in sand, gravel, and clay, in which furrows prevail, may be due to the greater solidity of the chalk. It may also be partly due to its calcareous composition; for, though I contend for the prevalence of mechanical action in the formation of these cavities, I do not exclude that chemical action which water always exercises by means of the carbonic acid which it absorbs. Lieut. Newbold * observed that, while some of the rivers of India, in times of flood, excavated in their rocky beds basins of the different shapes which we find in the chalk, these cavities, when the river contracted its volume during the dry season, were left filled with stagnant water, and this water, by its chemical action, softened the gneiss in such a manner as greatly to facilitate the boring process during the ensuing rainy season. Similar alternations between vorticose and stagnant water, the one acting mechanically, the other chemically, would take place on the shore of the sea; and the greater liability of calcareous strata to be acted upon by acidulated water, combined with the fact of the greater prevalence of regular cavities in calcareous subsoils, warrants the conclusion, that in their formation the solvent power of carbonic acid, held in solution by stagnant water, has aided the operations of water in violent motion.

Neither would I wholly exclude subsidence of the matter with which the cavities are filled, though I believe that the irregular stratification over the larger cavities, which has been ascribed to this cause, is generally an original condition of deposit upon an irregular surface. The vertical striæ on the sides of some pipes are proofs of some amount of subsidence; but this is not incompatible with the formation of the pipes before the matter was deposited with which they are filled. Subject, as they have been, to the pressure of many hundred feet of strata, and many hundred fathoms of water, during the submergence of the Crag and Erratic periods, it is not surprising that there is evidence of subsidence to a certain extent, particularly if a pipe, formed by the mechanical action of water, has been at all deepened by the subsequent percolation of acidulated water. In a former paper I have given a section of some faulted strata, over a pipe, in which the greatest amount of displacement was 2 feet †.

With regard to the pipes and furrows filled with warp-drift which occur on the surface of various strata, I wish to offer no opinion whether they were formed, as Sir Roderick Murchison has suggested, by inundations analogous to those of earthquake-waves, or whether they indicate some anomalous atmospheric action. In the latter case, they may be compared to the excavations formed by torrential rivers. All I contend for is, that they are due to some aqueous operations, which were neither ordinary marine, nor ordinary atmospheric action, and that these took place upon a terrestrial surface which was inhabited by elephantine and other mammals now extinct, after the desiccation of the bed of the Erratic or Glacial sea.

* Proc. Geol. Soc. vol. iii. p. 704.

† Quart. Journ. Geol. Soc. vol. i. p. 308, fig. 6.

2. *On the* Origin *of the* Sand *and* Gravel Pipes *in the* Chalk *of the* London Tertiary District. By Joseph Prestwich, Jun., Esq., F.R.S., F.G.S.

[The Publication of this paper is postponed.]

[Abstract.]

After referring to the observations and researches of earlier writers on these peculiar cavities, the author dwelt upon the theory advocated by Dr. Buckland and Sir C. Lyell, that these cavities were due to the action of water, holding carbonic acid in solution, constantly percolating through the same cavity, dissolving the chalk and letting down the superincumbent sand and gravel. After pointing out the difficulties in the way of the hypothesis of mechanical water-action, such as the frequently great depth of the pipes (upwards of fifty feet), and the general absence of the rounded pebbles that should have remained in the cavities after having been the immediate agents in the perforation, the author (allowing that irregularities of the surface may have been caused by denuding action) proceeded to point out that the pipes occur wherever a stratum permeable to water overlies the chalk or other calcareous rock to any considerable extent, and suggested that they must have had their origin during a period when the chalk and the superincumbent tertiaries formed an extensive tract of horizontal dry land, previously to the surface assuming its present configuration; that at these former periods the tertiary sands or the gravel constituted extensive water-bearing strata, whilst, owing to the form of the surface, the water-level in the chalk stood at a height very much less than in the superincumbent beds; consequently the atmospheric waters, more or less charged with carbonic acid, percolating freely through the superficial sandy beds, rested on the chalk, and by its tendency to find a lower level, gradually dissolved passages through the chalk to that lower level at which water would stand in the latter formation. The superincumbent sands or gravels, as the case may be, gradually subsided, more or less conformably, into the deepening cavity caused by the loss of the chalk in the funnel or pipe below. When the chalk and overlying tertiary beds were locally upheaved, shattered, and partially denuded, the newly made valley-courses gave exit, in springs along their sides, both to the water of the lower water-level and the water of the superficial sands and gravels; the sand-pipes becoming almost all deserted as water-channels, except in such local instances, perhaps, as are now seen where cavities are forming in the chalk beneath existing gravels, or where "swallow-holes" in the chalk continue a somewhat analogous action.—*Vide supra*, p. 223.

February 1, 1854.

Charles Robert des Ruffières, Esq., Alexander George Gray, jun., Esq., George Milner Stephen, Esq., Barrister, and Edward Harman Sheppard, Esq., were elected Fellows.

The following communications were read:—

1. *On the* Geology *of the* Gold-bearing District *of* Merionethshire, North Wales. By Prof. A. C. Ramsay, F.R.S., F.G.S.

That part of Merionethshire to which this notice refers lies between Dolgelli and the Moelwyn and Manod range, north of Ffestiniog*.

A small part of this area has for some years been distinguished by discoveries of gold, of more or less importance. Its geological relations are as follows:—On the N. and W. of the lower part of the River Mawddach lie the lower part of the Lingula-flags and the Cambrian rocks. The latter consist of the coarse, thick-bedded, greenish-grey grits of Barmouth and Harlech. Their upper boundary is marked by a sinuous line which strikes in a north-easterly direction from Barmouth to Rhaiadr-Mawddach, and from thence trends northerly a little E. of Trawsfynydd to the turnpike road about a mile S. of Ffestiniog. The line then strikes S.W. to Morfa Harlech, on the coast of Cardigan Bay. These grits are overlaid by that part of the Lower Silurian rocks known as the Lingula-flags, which here consist mostly of blue slaty beds, generally more or less arenaceous, and partly interstratified with courses of sandstone. A well-marked portion of the series, composed of rusty ferruginous slate, occupies part of the cliffs of Moel Cynwch that overhang Dol-fawr on the Mawddach.

Both Cambrian and Silurian rocks have been penetrated by numerous greenstone-dykes. Many of them are of a light grey colour and highly calcareous. Others assume the colour and texture of ordinary greenstone. Some of them are magnetic. Among the Cambrian sandstones they run in all directions, sometimes with, but more generally across, the strike. In the Silurian region they more usually run more or less parallel with the lines of bedding.

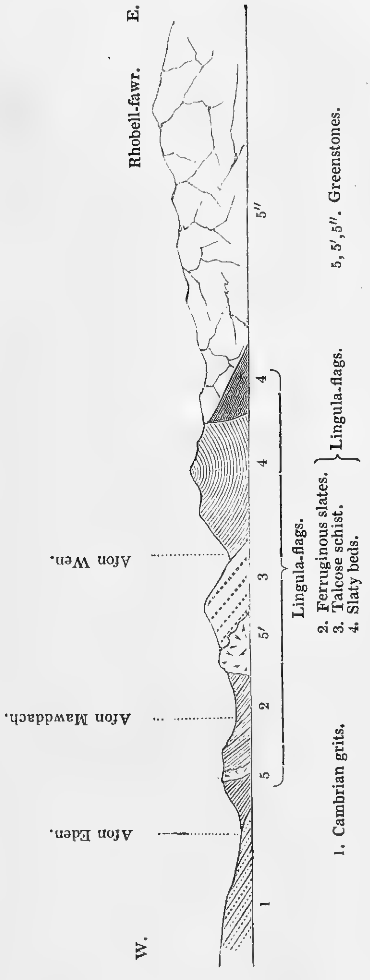
In the hard and solid Cambrian sandstones, the fractures into which they were injected were capricious and irregular; while in the Silurian shales they have more frequently been intruded between the beds. Some of them fill cracks which pass into lines of lode. A case of this kind occurs on the N. and W. of Tyn-y-groes. A strong lode, bearing quartz and lead, commences between Dol-y-melynen and the fifth milestone on the Dolgelli and Ffestiniog road. For about three-quarters of a mile it divides the Cambrian and Silurian rocks. Passing into the former on Cefn-coch, the fracture, as it crosses Craig-y-Cae and Y-garn, becomes filled with greenstone. Several other metalliferous lodes occur in this neighbourhood. They all traverse the Lingula-flags or their associated igneous rocks. There

* Geological Survey Maps, 75 N.E., S.E., and 59 N.E.

are four quartz-lodes, bearing a little copper, in a mass of trap that lies on the W. of the road between the third milestone and Tyn-y-groes. One of these at Cae-nant runs E. and W. Three near Tan-'rallt run N. and S. There are two quartz-lodes with lead a little N.E. of Moel Ispri, and at least seven similar lodes yielding a proportion of copper on the hills immediately N.W. of the Barmouth road, between Llanelltyd and the fourth milestone from Barmouth.

The country in which the Dol-y-frwynog mine lies is interesting, and in part peculiar. I shall describe its geology in some detail.

Section of the Auriferous Lingula-flags from Afon Eden to Rhobell-fawr.



Immediately north of the third milestone on the Dolgelli and Ffestiniog road, a mass of very felspathic greenstone, mentioned above, breaks through a low part of the Lingula-beds. It occupies the heights on which stand the houses of Tan-'rallt and Hafod-y-fedw. It is about a mile in length from N. to S., and extends from the road about three-quarters of a mile westward. Three of the lodes already noticed as yielding copper lie on its eastern slopes; and I have been informed by my friend Mr. Byers, of Dolgelli, that a very little gold was detected in one of them, in the year 1836, by Mr. O'Neil.

For four or five miles N. of this area several other lodes occur in the Lingula-flags and their associated traps, on the banks of the Mawddach and of Afon-wen. The accompanying section explains the geological relations of part of this country that lies between Rhobell-fawr and the Cambrian rocks immediately N. of Dol-y-melynen.

On the W. are the Cambrian grits (No. 1), dipping eastward at angles varying from 40° to 60°. These are overlaid conformably by slaty beds of the Lingula-flags (No. 2) traversed by greenstone dykes (No. 5) on the hills immediately N. of Pigswch. They are succeeded by a mass of intrusive greenstone (No. 5′), which is bounded on the N. by an E. and W. fault and lode on the N. part of Moel-Hafod-Owen. From this point the greenstone passes S., with two interruptions, by Tyn-y-Ben-rhos to Moel Cynwch, about two miles further S. E. of this greenstone are a set of rocks (No. 3), which possess a very peculiar lithological character, and which occur very sparingly elsewhere, either among the Lingula-flags or in any other geological area in Wales. It is in a lode traversing this "country" that the most important of the gold discoveries has lately been made. The rock commences at what may be called the S.W. angle of Moel-Hafod-Owen, above Buarth. The same E. and W. fault that bounds the greenstone, limits it on the N. A line of fault drawn southward from thence to where the brooks join, nearly opposite Dolau, forms its eastern boundary so far. From thence the Afon-wen forms its boundary for nearly a mile and a half S. It is not improbable that this may also be a continuation of the same line of fault. The boundary-line then crosses the stream, and still passes southward to the ground that lies between Cefn-mawr and the precipitous rocks that overhang the Mawddach above Dol-y-clochydd. The rock itself is one of those problematical masses to which it is difficult to give a definite name. In some places it is so hard and massive, that a hand-specimen is difficult to distinguish from some of the felspathic traps of the neighbouring country. Even then, however, it is more or less flaky, and constantly passes into a talcose rock, which in places at the surface and in the lodes decomposes into a kind of talcose unctuous clay. In many places it graduates in the line of strike into ordinary slaty rocks, which then become largely interstratified with it. As it passes southwards it becomes more and more slaty and sandy, and passes by degrees into rocks possessing all the characters of the Lingula-flags of the district. On the E. it is bounded by slaty Lingula-flags (No. 4), on which rests the massive greenstone mass of Rhobell-fawr (No. 5″). The ordinary Lingula-beds spread far to the northward, by Ffestiniog, towards the southern slopes of the Manods and the Moelwyns. They are slaty and sandy by turns. Several lodes occur in this country in the neighbourhood of Dol-y-frwynog and Cwm Eisen. The gold at Cwm Eisen was discovered in 1843, by Mr. Arthur Dean, who, in a paper published in the Report of the British Association for 1844, also stated "that a complete system of auriferous veins exists throughout the whole of the Snowdonian or Lower Silurian formations of North Wales." Recent events would seem, in a slight degree, to verify this bold assertion; but from that date to this time no one has heretofore attempted to work any mines in North Wales for gold, except that at Cwm Eisen; nor have I ever met with any miner who has seen any gold of the alleged auriferous veins, with many of which I am also well acquainted. Cwm Eisen has been several times worked; but, I believe, never with a steady profit. The gold is found in a branching lode containing lead. Its principal branch runs north-easterly, and is mostly composed of exceedingly hard quartz, which crosses the river about half a mile above Rhaiadr Mawddach. Another quartz-lode, bearing lead, occurs a little above the waterfall. A north-west lead-lode lies a little W. of Moel-Hafod-Owen; and two others (one of them bearing silver) cross the river in the same direction, about half a mile below the fall. They pass through arenaceous slates and greenstone. Two N. and S. copper-lodes cross the little valley that lies between Moel-Hafod-Owen and the hills behind Dol-y-frwynog. Two others occur on the steep slopes that overhang Afon-wen on the W., about half a mile S. of Dol-y-frwynog. These four are in the talcose rocks above described. Several large quartz-lodes traverse this country on Moel-Hafod-Owen. They are in the ordinary Lingula-flags. The largest is on the E. flank of the hill. The rocks are there much disturbed and altered, and numerous little bosses of greenstone are intruded among its beds.

Dol-y-frwynog stands on the W. of Afon-wen*. It lies in the heart of the talcose schist, which almost everywhere contains much iron-pyrites in small crystals, scattered through the body of the rock, together with specks of the yellow sulphuret of copper. Small veins of this ore are also scattered through the mass. It was in part of this area, about half a mile S. and S.W. of Moel-Hafod-Owen, that the famous Turf Copper Mine was situated. A peat-bog occupied the greater part of the bottom of the valley. The turf was pared off the surface and burned in kilns, and being partly saturated with copper, a large residue of valuable ore was left in the ashes. Many thousand pounds worth were thus extracted. The hills have since been burrowed in all directions in search of the great lode, or bunch, from whence the copper was supposed by many sanguine adventurers to have been carried in solution to the peat. It has never yet been found, and perhaps does not exist; the water that percolated through the rocks and rose in the springs having more probably carried the copper, in the form of a sulphate, from those minuter quantities that are more or less diffused through the mass of the hill immediately above the Turf Mine.

When I inspected the geology of this country in the spring of 1853, the most remarkable and promising lode was the new gold-lode at Dol-y-frwynog. The lode runs about W.N.W. and E.S.E. in the low ground S. of Moel-Hafod-Owen, on the east watershed. It is principally composed of a white saccharoid quartz, irregularly traversed by numerous small loose joints. Chlorite, decomposing talcose matter, and pink carbonate of lime are intermingled with it. In parts the quartz assumes a semi-granulated aspect, profusely intermingled with soft, unctuous, decomposing talc. It is largely charged with iron-pyrites. As a rule, the substance of the lode is easily shivered into fragments, a great advantage both in the original working of the lode and in subsequent operations. It was first opened in search of copper; and a shaft was sunk to a depth of about

* This stream is inserted, but not named, in the Ordnance Map. It washes the E. base of Moel-Hafod-Owen and passes through a deep valley to the Mawddach, into which it flows nearly opposite the fourth milestone on the Dolgelli road.

20 fathoms. During the process, however, it soon proved to contain more attractive metal. On examining a heap of quartz which lay at the mouth of the shaft, and turning over a few pieces, I readily saw, with the naked eye, gold in small flakes and grains, irregularly disseminated through the quartz. In a more select heap of quartz, on all the pieces it was distinctly visible to the unassisted eye; and one mass in particular, heavier than a strong man could lift, was literally spangled all across its surfaces with rich glittering gold. Gold has also been detected by Mr. Byers in the matrix of the copper-bearing lodes about a mile further S., and in the west Dol-y-frwynog lode by the spot marked Turf Copper Mine on the map. All of these occur in the same talcose rock. It was this peculiar character of the rocks that induced me, in 1851, to recommend my friend Mr. Attwood, before he started for California, to go down and examine this very ground for gold. He proposed doing so, but engagements, consequent on his speedy departure, prevented its accomplishment. A portion of this rock, taken from the wall of the Dol-y-frwynog lode, has been analysed in Dr. Percy's laboratory by Mr. Richard Smyth. It yielded no gold.

On the banks of Afon-wen, about a mile above the bridge, "are some ruins of buildings, and below them, close to the river, the remains of charcoal-ashes and bits of bones, mostly covered with herbage. This place has a very singular, and in conjunction with the late discoveries, a very significant name, which it has maintained from time immemorial, expressive of gold having been melted or worked there. This name, 'Merddyn Coch 'r aur,' signifies 'the ruins of red gold.' The tradition is, that the Romans formerly worked gold there. It may be well to observe, to those unacquainted with Welsh names, that no ancient place has a name but what is generally characteristic of its locality, or of some event that has taken place on or near the spot*."

I may state, on the authority of Mr. Byers, that in several spots in this neighbourhood where quartz-lodes occur, associated with copper, blende, lead, and talc, there gold has been found, instances of which he cites as occurring at Tyn-y-llwyn, near Moel Ispri, and other localities, principally, I observe, in the Lingula-flags between Tyn-y-groes and the Mawddach, towards Barmouth, all in the area already cited in the beginning of this paper as containing lead and copper lodes. Though I know the geology of this area well, I have no personal knowledge of the occurrence of gold in its lodes. It is also stated that gold has been detected in several other places N. of Cwm Eisen; as, for instance, at Penmaen, and at Gelli-gain, about three miles S.S.E. of Trawsfynydd; also in the Newborough Mine, in an E. and W. lode, immediately N.E. of Manod, and on the S. side of Moel-wyn, in blende and gossan. I can answer for none of these personally. The whole of these lie either in the Lingula-flags, or in the beds immediately adjoining above or below; and they lend some additional evidence to the views that have often been promulgated by Sir Roderick Murchison.

* Mr. Byers, of Dolgelli, MSS.

Whether all the reports in circulation of the occurrence of gold be actually true or not, it is at all events a fact that at Dol-y-frwynog it has been found in an unusual quantity, and also that its existence is certain in various other places*. If in the lodes a considerable amount be scattered through the country, then we should expect that gold would be detected by washing the marine drift that rises on the mountains of North Wales to a height of over 2000 feet. In this drift it might in places be somewhat concentrated, partly by an ancient natural process of sea-shore washing, partly by the more modern action of rivers, as in the case of the stream-tin of Cornwall, and of the gold in the superficial deposits of the Ural, of Australia, of California, and in those of Canada some years ago discovered by Mr. Logan. Gold, in appreciable quantities, was, indeed, found by washing in the bed of the Mawddach, in the summer of 1852, by the Honourable Frederick Walpole and Sir Augustus Webster (then Mr. Webster). I think it probable that in this river attempts might probably be most successful immediately below the confluence of the Mawddach with Afon-wen, and in places in the bed of the Wen, on the E. and S. water-shed of the range of hills that runs from Tyn-y-Benrhos northwards towards Moel-Hafod-Owen. In favourable spots it might be well worth the pains to wash the detritus on the Mawddach between Dolfawr and Y-Gelli-gamlyn, and in the bed of the Wen from thence to Dol-y-frwynog. This opinion is founded on the fact, that the talcose rocks which the Dol-y-frwynog lode traverses lie on the east watershed of the above-mentioned range; and, if gold be in them elsewhere in any parallel quantity between Moel-Hafod-Owen and the lower part of the Llanfachreth valley, then it might be expected in the detritus in the bed of the stream between Dolau and Y-Gelli-gamlyn, nearly opposite to which, streams that traverse the talcose rocks empty themselves into the Mawddach.

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2. *On* Auriferous Quartz-rock *in* North Cornwall. By S. R. Pattison, Esq., F.G.S.

The parish of Davidstowe in the north of Cornwall is situated at the edge of the granitic boss of Roughtor. Next to the granite occur coarse slaty rocks, much affected by quartz-veins, and interrupted by large developments of trap.

By the aid of *Spirifer Verneuilii* in the slates at Trevivian (which I found in the bed of a water-course there), and obscure traces in the limestone at Treblary, we may confidently state that these slate-rocks are the prolongation of the Petherwyn beds, which, with all their associates, here sweep round the northern flank of the granite. We therefore characterize the district as *uppermost* Devonian.

These slates are succeeded, on the east of the parish, by still

* Since this paper was written, rich discoveries of gold have been made at Clogau, on the hills north of the Dolgelli and Barmouth road. I have also seen a small specimen from Penmaen, between Cwm Eisen and Trawsfynydd. [July 1854.]

coarser shales and grits, which, by the aid of plant-fragments in the latter, are ranked as Carboniferous.

The actual junction with the granite is concealed by a covering of detrital matter, and similar beds occur irregularly on the hill-sides throughout the district. This deposit is in all cases unrolled, and evidently local, the result of some action of brief duration.

The Devonian rocks dip at an angle of about 40° away from the granite, or rather from a point in advance of the latter, so that the district forms a dome of elevation, having the high ground of Cadon-barrow (slate) for its centre, and connected with the granite by an anticlinal line; one portion of the dome dips into the sea, another towards the south in the great Delabole quarries, a third towards the north, and the other is held up by a connecting line towards the granite at Roughtor *.

The strike of the beds, in a large curve round the granite, not only prevails in the slate-rocks, but affects the masses of trap, which, as the Ordnance Geological Map shows, are uniformly elongated in the same direction. The small patches of calcareous matter, and even the fissile slates, follow the same rule.

The small dykes of trap are ordinary hard greenstone; the larger masses are soft chocolate-coloured and purple masses, occasionally vesicular.

Full information on the general geology of these trappean rocks, and of the whole district, will be found by consulting Professor Sedgwick's Memoir, in the fifth volume of the Society's Transactions; Sir H. De la Beche's Report; and a paper by the writer, on the geology of the Tintagel district, published in the Report of the Royal Geological Society of Cornwall for 1847.

The Devonian rocks here are traversed by siliceous bands in the form of veins of coarse quartz. These are *subordinate quartzose portions of the slate-rocks*; not cross-courses or strings, but metamorphic conditions accompanying fissures in the line of the bedding and strike, and attended with the segregation or addition of various minerals. They were produced by a cause affecting apparently the whole mass. The veins are variable in character as regards the admixtures present with the quartz. Trappean matter is often visible, usually mica, rarely pyrites. In some places the quartz is much intersected by ferruginous partings and hollows; these contain "gossan," varying in colour from light pink to dark red and brown. It is these gossaniferous portions, in the vicinity of trappean matter, which have been found to be auriferous.

In the summer of 1852, the description of gold-rocks in California led me to examine very cursorily similar rock-formations in North Cornwall. From a portion of a quartz-vein at Davidstowe I then obtained a trace of gold, and reported the fact to the Geological Society of Cornwall. It is duly recorded in the published Report of that Society for the year 1852. I mention this merely to show that the discovery (if such it may be termed) is due to our science, and not to hap-hazard.

* See Report of Cornwall Geol. Soc. 1847, p. 8.

Recent experiments, made on the gossaniferous quartz from this locality, have shown that it is not merely auriferous, but, in some small portions at least, highly so. I forbear, however, giving the result of experiments which are yet, as to their scale, insignificant; and also because I am glad that our Society is, by the existence of a competent governmental department, quite relieved from all social responsibility as to the economics of the question. *Here* we may pursue our researches in descriptive or theoretical geology with true philosophic tranquillity, undisturbed by the harsh cry of '*cui bono*?' which so often and so usefully checks us elsewhere.

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3. *On the* Physical Geology *of the* Himalaya. By Captain Richard Strachey, Bengal Engineers, F.R.S., F.G.S.

[Abstract.]

The author having, in a previous communication to the Society*, described the geological structure of a part of the Himalaya mountains, in the present paper he proposed to complete that sketch, at the same time taking a rather larger field of view, offering some explanation of the manner in which the chain in general had been raised to its present position—first, with reference to the mechanical action of the forces in operation; and secondly, as to the epochs at which the upheavement took place.

Attention was first directed to some of the more prominent points of the physical structure of the great mountain mass, of which the Himalaya forms a portion. Among these were specially noticed:—1st. The general form of the section of the mass, which shows that the Himalaya mountains are merely the southern slope of a great protuberance, the summit of which forms the table-land of Tibet, while the northern slope is a mountainous region, marked on our maps as the Koneulun, similar to the Himalaya, and terminating in the great plains of Central Asia. 2nd. The parallelism to one another, and to the outer edge of the mountain area, of the great ridges or lines of elevation; of the great valleys or lines of drainage, which are also lines of rupture; of the strike of the strata; of the lines of igneous action; and of the distribution of the various deposits, considered both in reference to their mineral character and geological age. 3rd. The arrangements of the drainage, in accordance to which the crests of the northern and southern slopes of the great mass form two main lines of water-shed, proposed to be termed the "Turkish and Indian Water-sheds," to the north and south of which, respectively, the rivers flow off directly to the plains of Turkistan on the one side, and to those of Northern India on the other; while the waters of the summit of the table-land are collected into two streams alone, the Brahmaputra and the Indus, which are discharged from

* Quart. Journ. Geol. Soc. vol. vii. p. 292.

the mountains at two distant points, at opposite ends of the chain. 4th. The constancy maintained for great distances along the length of the chain, both in the geological structure, and in the elevations to which the mountains rise; which last character is particularly shown by the almost perfect horizontality of some of the most elevated stratified deposits, by the extremely small slope of the main drainage-channels of the Tibetan table-land, and by the general similarity of the altitudes even along the most rugged ridges.

After allusion to the question of the reality of upheavements, as opposed to the view which attributes elevations on the earth's surface to subsidences of the lower parts, and having stated reasons for believing that in the present instance the elevation was real, a review was taken of the igneous rocks which might appear to have been connected with the upheavements of these mountains, and the conclusion was arrived at, that none of them were specially related to the last great movement that had taken place.

Hence it was inferred that the agent of elevation was probably a development of elastic vapours, as has been considered by Mr. Hopkins to be likely in a general point of view. The probability of this in the present instance was shown to be upheld by the extreme regularity of the upheavement, when regarded as a whole, which seems to indicate a fluid body as the medium through which the forces have been applied to the superincumbent masses; while this regularity also shows the comparatively great thickness of the part of the earth's crust that has been raised, as compared to the heights of individual ridges or peaks above the general level.

Assuming the general unity of the upheavement of the whole area as evident from the consideration of the form of the section of the mountains, the results of such an upheavement were then examined by help of the principles laid down by Mr. Hopkins.

The first of these results was stated to be a main system of longitudinal fissures, parallel to the major axis of the elevated area; with a secondary system perpendicular to the former. As the manner in which these fissures would open, and all the subsequent effects of the upheavement, must depend in great measure on the state of the interior of the earth, of which we can know nothing directly, we must be guided in our suppositions on this point by the phenomena actually observed in connexion with the ruptures at the surface; and, in the present case, we seem to be able to account for many of the peculiarities of structure already noted, by conceiving that the state of the upheaved mass, at the moment of rupture, was similar to, but just the reverse of, that of a beam supported and held down at the ends, and loaded at the centre.

On this hypothesis we should expect to find the chief longitudinal ruptures in the centre of the area, with others important, but in a less degree, along the margins, while there would be two portions intermediate between the axis and the edges, where the tendency to rupture would be a minimum. Further, as the tendency to transverse rupture is proportional to the amount of the elevation, it would have a minimum along the edges of the area; at the same time, as in any part of the mass, the tendency to transverse rupture would be least where the general coherency was least disturbed, we should expect to find fewest transverse fissures on those lines of minimum longitudinal fracture just noticed.

Comparing these theoretical views with the observed facts, we find:—

1st. The existence, in a marked degree, of the longitudinal and transverse fissures, in every part of the mountains.

2nd. The more open character and greater importance of the longitudinal fissures in the centre of the area, as evinced by the direction of rivers on the Tibetan table-land.

3rd. The existence of an important line of fissure along the outer margin of the Himalayan slope, as proved by the narrow fringe of the latest formations that everywhere skirts the foot of the mountains, which it is impossible to suppose could have been raised as they are, excepting in connexion with some larger mass.

4th. The occurrence of two lines of least rupture running parallel to the margin of the area, and intermediate between it and the axis, indicated by the Indian and Turkish watersheds; these features being dependent for their existence, not on any superior elevation that they attain over other parts of the chain, but only on their continuity, and on the few transverse fissures by which they are broken through.

5th. The few transverse fissures along the outer margin of the area, which affords a probable explanation of the accumulation of the drainage of considerable areas of the Himalayan slope, into the few great rivers that pass through the outer ranges.

After entering into some details as to the more important lines of fissure, it was remarked that the presence of more fissures than may seem to be necessary, or of others not in accordance with these views, may be readily expected to have been caused in movements anterior to the last great elevation. At the same time, the general parallelism of all the anterior movements to the last is indicated by the constant parallelism of the strike of the strata, the lines of rupture, the lines of elevation, and those of the directions of the stratified deposits; although a certain obliquity at the same time does exist, which, however, must be more closely examined before more can be said of it.

The author then passed to the chronological part of the subject. The age of the granite of the great line of snowy peaks was first considered, and shown to be probably anterior to the Silurian period; but doubts still remain on this subject, though the occurrence of rolled pebbles of this rock in the tertiary deposits of the Tibetan table-land, show that the eruption was certainly antecedent to the middle of the tertiary epoch.

The existence of a coast-line along the Indian water-shed, as indicated by a conglomerate-bed at the bottom of the Silurian rocks, was next noticed, with the presumption of the existence of a northern sea, having its boundary along this line during the Silurian epoch, as well as during the Jurassic, and the earlier portion of the Tertiary period. On the southern edge of the mountains there is nothing to prove the boundary of the land and sea, until the Tertiary period, when the coast-line is found along the general line of the existing outer hills. Still, the existence of fossiliferous beds in the Salt-range in the north of the Punjab, apparently synchronous with those of the Indian water-shed, seems to render it probable that there was a Southern sea, contemporaneous with the Northern, extending over the existing plains of North India, from the remotest times, and leaving an area of dry land between them, on what is now the Himalayan slope. The probability of this area of dry land is further shown by the almost total absence of fossils in these regions; nor does the existence of fossils at one single point in Kashmir, where only have they been found, indicate more than an irregularity of the outline of the land, such as might have been anticipated.

Turning next to the question of the dip, which, as a general rule, is everywhere towards the axis of the elevation, it was stated that there appeared to be nothing to connect this inclination with the last elevation, and that it is more probably due to some of the earlier movements of the surface. It was shown how an inclination, having been once imparted to any dislocated mass of the earth's crust, any subsequent motion would most likely maintain it, or even add to its amount; for the tilting of a mass displaces the position of the centre of gravity, so that it is no longer immediately over the centre of the base of the mass, at which the resultant of all elevating forces will act; and hence, in any subsequent elevation, the weight of the mass will tend to make it revolve, by the relative descent of the centre of gravity, and ascent of the point of application of the elevating forces, which will evidently tend to increase the dip.

The dip of the outer hills, however, which is almost everywhere towards the interior of the chain, just as is the case with the rest of the mountains, cannot be attributed to these older movements, for these ranges are among the most recent of the whole; nor is there, at first sight, any very evident connexion between the dip that they might be supposed to assume, and that of the older ranges beyond them. The phenomenon may, however, perhaps be explained, by supposing that the fissure which we have reason to believe to exist along the foot of the mountains was originally covered up by the deposits which now form the outer hills, when the ocean extended over the plains of Northern India. An upheavement of the mountains alone, the general sea-bottom remaining unmoved, would naturally terminate at the fissure, and a narrow fringe of the younger beds would be raised on the flank of the older mass, to which a dip the same as that of the older mass might be imparted, by that tendency to revolve already explained. The repetition of this process would make a succession of ranges, such as are seen in the outer hills, apparently dipping under one another and the older beds, of the fragments of which they are evidently made up, in an inverse order.

The paper concluded by a recapitulation of the progress of the Himalayan chain, as far as it could be traced, from the earliest geological period to the present time. In this was pointed out the probable existence of land with mountains already of considerable altitude, in the earliest ages; and to the general elevation of these older heights with the rest of the area, the position of the great line of Himalayan peaks was attributed, rather than to any special energy of upheaval along that particular line in any of the later changes. Until the commencement of the Tertiary period we can say little of the state of the area, but then the nummulitic sea may be traced extending across the greater part of Southern Asia, through Asia Minor, Persia, and Afghanistan, and along the foot of the Himalaya, even to the Khasiya hills, east of Bengal. The mountain-area above the level of the sea was at this time probably restricted, for the traces of the ocean of that period have been found in Tibet, at a place where a pass now rises to a height of 16,500 feet. At the close of the nummulitic period, a general elevation seems to have taken place over all Southern Asia, and the table-land of Afghanistan was finally raised above the Southern sea, which, however, still swept over the whole of the existing plains of India; while the Caspian probably extended over all the steppes of Western Turkistan, to the foot of the Hindu-kúsh. To the north of the Himalayas, the Northern sea appears to have covered the table-land of Tibet, occupying long fiords or estuaries between the mountain-ranges, which had already commenced to rise.

By the middle of the Tertiary epoch the Siwalik Range had been brought into its existing position, the whole of the great Tibeto-himalayan system had been greatly raised, and the upward motion extended to the basin of the Caspian, which sea was now separated from that of Aral. But the Indian Ocean probably still covered the northern plains of India, nor was it until long after that it retired to its existing shores. Finally, the evidences of the diminution of the Himalayan glaciers in the existing epoch, which are to be met with at all parts of the chain, were attributed to the change of climate that must have accompanied this last change of the marine area, by which the conditions, becoming more *continental*, the summer temperatures would be raised, and the fall of snow diminished. This, therefore, might have had the effect of causing the snow-line and glaciers to recede, although the actual elevation of the mountains had been increased about 1000 feet.

February 22, 1854.

Charles Lindsay, Esq., C. H. Burbidge Hamley, Esq., and James Augustus Caley, Esq., C.E., were elected Fellows,

The following communication was read :—

On the Geology *of the* Mayence Basin.

By William J. Hamilton, Esq., Sec. Geol. Soc.

Contents.

Introduction.

The insulated position of the Mayence Basin and the abundance of its fossil remains, particularly the marine molluscous fauna, had long ago invested it with an interest for the geologist far beyond what its limited extent would have led us to anticipate; and which the investigations of the last few years, while they have made us better acquainted with its fossil contents, have not yet exhausted.

Since the time when Brongniart first called attention to the fossils of the Weisenau strata*, the geologists of Frankfort, Wiesbaden, Darmstadt, Mayence, Hanau, and other places in the neighbourhood have contributed their share towards the investigation of the peculiar features of this formation. The results, however, are not generally known in this country; and, having lately had several opportunities

* Mémoire sur les Terrains supérieurs calcareo-trappéens du Vicentin, et sur quelques Terrains d'Italie, de France, d'Allemagne, &c. 4to. Paris, 1823.

of visiting some of the most interesting localities in the district, I propose in the following remarks to lay before the Society the results of my inquiries. The subject is as yet, however, far from being exhausted; many localities require a more searching examination; the fossils need a more careful and exact comparison with those of other tertiary districts; and the relations of the formations to those of the north of Germany demand further examination.

I propose in the following observations, in making which I have been indebted for many valuable suggestions to Mr. R. A. C. Austen, who accompanied me on my last visits to Hochheim and to Alzey, in the first place, to describe the physical features of the district and the stratigraphical position of the different beds; secondly, to give an account of the palæontological contents of the beds in question, with a special reference to the marine mollusca; and thirdly, I shall conclude with some remarks on the original position of this marine basin, its probable connection with a former ocean, and the means by which it has been brought into its present relative position.

Part I.

Extent of the Mayence Basin and Stratigraphical account of its different constituent beds.

Extent of the area occupied by the Mayence Tertiaries.—The district to which the term Mayence Basin has been applied forms the extreme northern limit of that portion of the great valley of the Rhine, which extends in an almost N. and S. direction from the northern flanks of the Jura to the southern or south-eastern flanks of the Taunus and the Hundsrück (see Map, fig. 1). It is in fact no basin in itself, although, in one sense, the whole of the depressed Rhine Valley, bounded on the W. by the mountains of the Vosges, the Haardt, and Mont Tonnerre, and on the E. by the mountains of the Schwarzwald and of the Odenwald, might not inappropriately be so called. The general character of this valley is well exhibited in the excellent relief-maps of Bauerkeller and of Ravenstein.

The so-called Mayence basin itself stretches in a general direction from W.S.W. to E.N.E., commencing between Kreutznach and Alzey on the S. side of the Hundsrück, and extending to the N.E. or E.N.E along the S. flank of the Taunus beyond Frankfort and Hanau into the Wetterau, a distance of from 60–70 English miles. Its western limit rests against the Carboniferous formation of the Donnersberg, and the numerous porphyritic outbursts which characterize that country; while its northern beds repose against the talc-slates and sericit-slates of the Taunus. To the S. and E., the formation gradually disappears, partly in consequence of the gentle dip of the beds in that direction, and partly owing to the abrading action of the waters of the Rhine, which now wash its low escarpments or cliffs. To the S., the tertiary formation extends beyond Neustadt to Landau, gradually thinning out, and in a few places only leaving insulated patches adhering to the flanks of the Haardt mountains, and forming steep cliffs or escarpments to the eastward, which will be more distinctly pointed out hereafter.

Fig. 1.—GEOLOGICAL MAP OF THE MAYENCE BASIN.

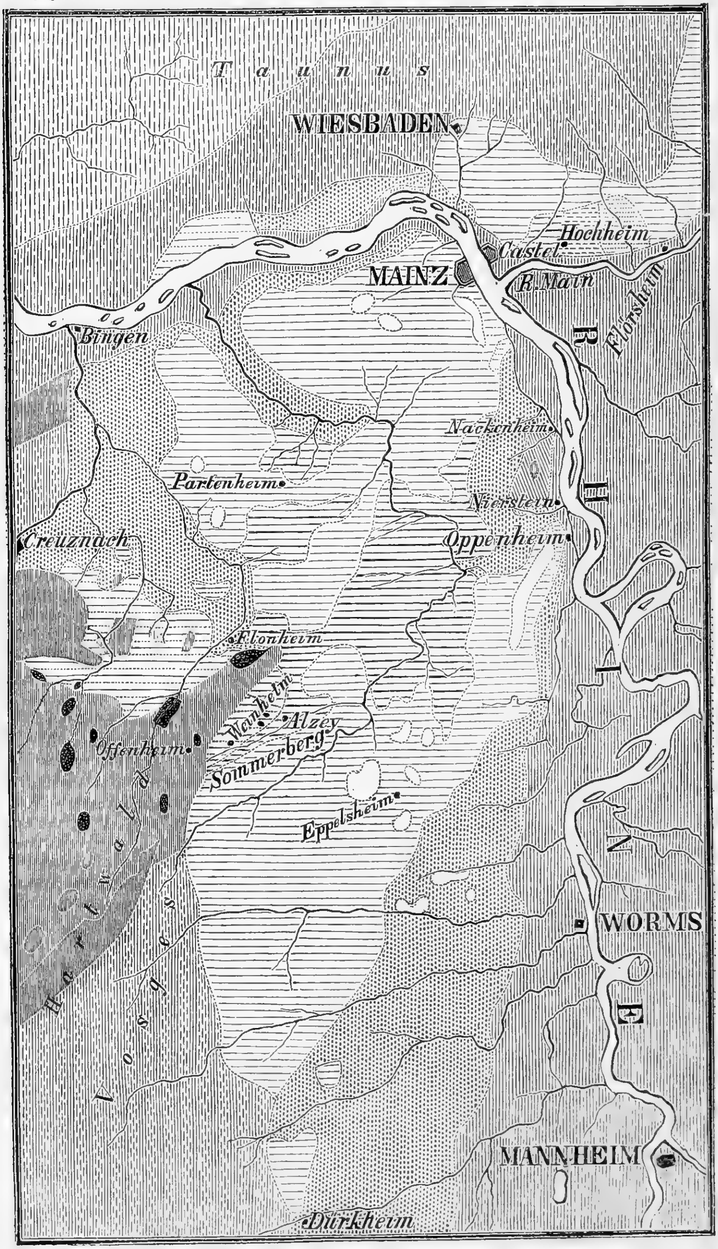
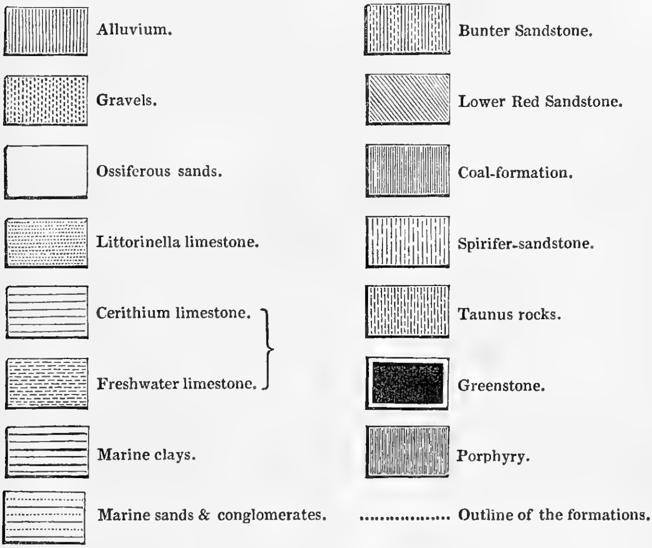


Table of Signs.

[This map is taken from M. F. Voltz's Geological Map of the Grand-duchy of Hesse.]



Description of the Strata.—The following Tabular statement of the nomenclature of the deposits of the Mayence Basin, adopted in this paper, will facilitate a reference to the Sections.

C. Post-pliocene .... { 2. Loess. 1. Gravel.

B. Tertiary .... {
7. Ossiferous sand.
6. Upper or leaf-bearing sandstone.
5. Upper blue Brown-coal clay.
4. Littorinella-limestone.
3. Cerithium-limestone.
2. Lower blue Brown-coal clay, or Cyrena-clay.
1. Marine sand and quartz-conglomerate.

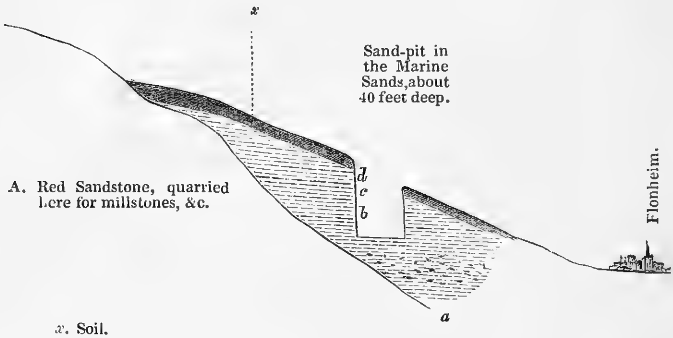
A. Carboniferous, or Lower New Red .... } Red sandstone, &c.

A. Basement Rocks.

Carboniferous, or Lower Red Sandstone.—The lowest tertiary deposit invariably rests, wherever its basis has been observed, on red and yellow micaceous sandstone, which occurs as great underlying spurs, particularly in the neighbourhood of Weinheim and Flonheim, as seen in the sections, figs. 2, 3, 4 (see page 258); it forms a portion of the Coal-measures, which are extensively developed round the base of the porphyritic mountain of the Donnersberg.

Spurs of this red sandstone must have extended from the Donnersberg eastward into the ancient sea, from the wearing away and disintegration of which rocks the marine sands appear to have been prin-

Fig. 2.—*Section of the "Marine Sands," near Flonheim.*

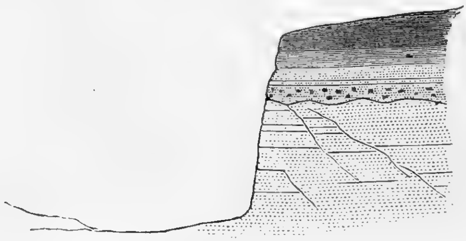


x. Soil.
d. Fine sand.
c. Sand with bones (bone-bed).
b. Loose sand, with *Ostrea*, *Pecten*, and Shark's teeth.
a. Gravel and quartz-conglomerate.
} B. 1. Marine Sands.

Fig. 3.—*Section of the "Marine Sands," near Uffhofen.*

A. Red Sandstone.
References as in Fig. 2.

Fig. 4.—*Section of the "Marine Sands" and "Cyrena Clay," resting on the Red Sandstone, at Weinheim.*



C. Soil.
B. 2. Clay.
c. } Sands. } B.1.
b.
a. Gravel, with Oysters, Shark's teeth, &c

A. { Carboniferous sandstone and shales.

cipally derived; and, although the distinction between them was at one time overlooked, these underlying sandstones are mineralogically distinct from the tertiary sands and sandstones. The former are generally thin-bedded, micaceous, and interstratified with bands of black argillaceous shale; and I have never seen or heard of any fossil remains having been found in them. Of the Sections, that of Weinheim, fig. 4, p. 258, is the most complete. In this section, A shows the Carboniferous sandstone, separated by thin bands of black argillaceous shale; in which no organic remains could be detected. In places it is much shattered, and traversed by faults and cracks. It is overlaid by the "Marine Sand" (B. 1 *a*), which is the lowest member of the tertiary formation of the district.

We have here abundant evidence that the Carboniferous or red sandstones form the base on which the marine formations of the Mayence basin were deposited; and they were penetrated in various localities by porphyritic masses previously to the deposition of the marine beds, inasmuch as the latter sometimes repose directly upon the porphyries. These marine beds also mark the commencement of the tertiary period in this district; and, appear to be confined to its north-western extremity.

One of the spurs of this red sandstone which forms the nucleus of the range of hills between Alzey and Flonheim, and is penetrated in several places by outbursts of basaltic or porphyritic rocks, extends in a N.E. direction from the Donnersberg. The prolongation of this ridge of hills in the same direction, nearly brings us to a conspicuous hill of red sandstone between Nackenheim and Nierstein on the banks of the Rhine. An excavation near the summit of the table-land near Nierstein, which I visited some years ago, brought to light, in the midst of the opening, a large mass of basalt which had penetrated the red sandstone, and was the probable cause of its upheaval (see fig. 11, page 270).

The remarkable appearance of these red cliffs between the hills of white Cerithium-limestone on either side had frequently attracted my attention. They appeared to be overlaid by the Cerithium-limestone, and I therefore determined last summer to visit the locality, expecting there to find a junction-bed between it and the overlying rocks. I was also desirous of ascertaining whether it had formed an island or at least a promontory in the tertiary sea, or whether it had been subsequently elevated. If the latter, it must have brought up the marine sands with it in a tilted position, and I might then expect a rich harvest of new species from this new locality: if an island, I hoped to find traces of the old sea-beach. I proceeded accordingly to Nackenheim, and, ascending the red sandstone hill behind the village, I found it to be principally a micaceous sandstone alternating with marly beds, the sandstone sometimes forming nodules in the marl, and the whole dipping about 10° N.N.E. In some of the ravines behind the village I found that the overlying beds consisted of thick masses of *loess* instead of limestone; neither this latter nor the marine sands appeared anywhere to overlie the red sandstone. There was, therefore, every reason to believe that the red sandstone in question must have been an island or promontory in the tertiary sea; on further search, I found in the valleys the "loess," resting in general directly on the red sandstone, but occasionally separated from it by a bed of shingle or gravel, in which, in a few places, I found fragments of marine bivalves, amongst which were chiefly *Pectunculus* and a single valve of *Nucula Lyellii*, thus clearly proving even here the existence of a true marine beach. Further west, or inland from the river, the red sandstone is so covered up by "loess" that there was no opportunity of finding any junction between it and the tertiary formation, except beds of small pebbly gravel, probably much more recent.

B. Tertiary Formation.

The following series, in an ascending order, is given in all the German works on the Mayence basin*:—

1. Marine sand and quartz-conglomerate.
2. Lower blue brown-coal clay.
3. Freshwater limestone.
4. Cerithium limestone.
5. Littorinella limestone.
6. Upper blue brown-coal clay.
7. Upper or leaf-bearing sandstone.
8. Ossiferous sand.

The introduction of the Freshwater limestone (No. 3) into the above list appears to me an error. It tends to encourage the idea that we have here a system of alternation of marine and freshwater formations, as in the London, Hampshire, and Paris basins, an idea which the evidence does not in any way justify. I shall therefore omit it in the following description, merely stating where the land-molluscs occur which have given rise to this nomenclature.

B. 1. *Marine sand and quartz-conglomerate.* (List at p. 257.)

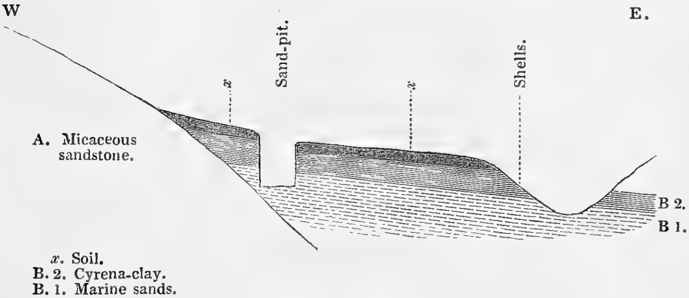
This is unquestionably the lowest member of the tertiary series; it is frequently non-fossiliferous; near Weinheim, however, some of the beds contain numerous fossils. The section (fig. 4) exhibits a bed of sand and gravel (B. 1 *a*) about a foot thick, containing a great number of Sharks'-teeth, some bones of fish, and *Ostreæ*, in many places still adhering to the underlying rock. Above this is a thin bed of fine sand (B. 1 *b*), overlaid by clays (B. 2), belonging to the blue clay of the brown-coal formation, which on the opposite hill, called the Sommerberg, contains a great abundance of *Cerithium margaritaceum* and *Cyrena subarata*.

Wherever fossils are abundant, as in the neighbourhood of Wein-

* Walckner's Geognosie, 2nd Edit. Uebersicht der geologischen Verhältnisse des Gross-Herzogthum Hessen, v. Friedr. Voltz, Mainz 1852. Uebersicht der geologischen Verhältnisse des Herzogthum's Nassau, v. Dr. Frid. Sandberger, Wiesbaden 1847. Untersuchungen über das Mainzer Tertiär Becken, v. Dr. F. Sandberger, Wiesbaden 1853 (published and received in London long after the commencement of this paper).

heim, this sand, which is there coarse and shelly, alternates with beds of hard compact limestone, also fossiliferous, although, in such cases, it is almost impossible to extract their contents. A few miles S.W. of Weinheim, between the villages of Offenheim and Beckenheim, is a good section of this marine sand, overlaid by thin beds of blue and mottled clays, close to the very edge of the basin, as shown in the neighbouring quarry (only a few paces above it) of micaceous sandstone-grit, evidently belonging to the Carboniferous system. The accompanying section, fig. 5, will show the relative

Fig. 5.—*Section of the "Marine Sands" and "Cyrena Clay."*



position of these beds. This spot, which had been opened apparently as a sand-pit, offered the following section in descending order:—

	ft.	in.
Upper blue clay, with septaria	0	4
Brown clays	1	0
Second band of blue clay	0	1
Brown clay, with small nodules of phosphate of lime? .	1	1
Ferruginous clay	0	4
Lowest blue clay, with traces of vegetable matter	0	9
Ferruginous clay	0	4
Ferruginous sand	3	4
White sand, with ferruginous streaks	10	0

—the latter in fact extending to the bottom of the pit, as far as was exposed, and probably much deeper. It should be observed, that in this pit we found no fossils whatever, nor even a pebble or other extraneous matter. To the E. and S.E. the same beds are seen stretching away from the ancient shore, and increasing in thickness; and at no great distance we found in a bank by the road-side a section nearly on the same level as the sand-pit, in which the clays abounded with *Cerithium margaritaceum*, another smaller *Cerithium*, probably *C. plicatum*, *Cyrena subarata*, and a small *Ostrea*, proving these clays to be the same as those which near Weinheim and elsewhere overlie the marine sands, and belong to the lower brown-coal formation or Cyrena-marl of the German geologists.

The lower or true marine formation extends, or rather has hitherto been observed, only over a small portion of the Mayence district. It dips slightly to the east, and, commencing at the western extremity of the region, either soon thins out or is lost under the more recent accumulations of the tertiary period. It has never been observed in the sections or quarries near Mayence, nor does it occur on the right bank of the Rhine. It may be said to be confined to a small tract of country in the neighbourhood of Weinheim, near Alzey, and about Fürfeld, Uffhofen, Flonheim, and a few other localities in that region; it may also be occasionally traced in small patches along the hill-range to the south towards Dürckheim and Neustadt, but without fossils, with the exception of a small spot near Dürckheim, underlying the Cerithium-limestone, where I found a bed of *Pinnæ*, which, however, were difficult to extract. They lie in a white and incoherent sand, and the shells are generally as incoherent and friable as the sand itself, with the exception of a few small masses cemented together by a more calcareous matrix. This is, I believe, the only locality where *Pinna* has been found in this formation.

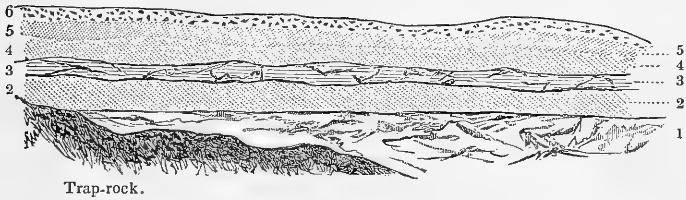
Associated with this Pinna-sand is a bed of red ferruginous clay, containing large septaria, but I was unable to ascertain the relative position of the two beds in consequence of the broken nature of the ground, and their not occurring in the same section. Both are, however, below the Cerithium-limestone, and the section seen near Beckenheim affords, I have no doubt, the true explanation of their occurrence, viz. that the Pinna-sand represents the marine sands; and the clay with septaria, the lower brown-coal formation or Cyrena-marl.

The two sections of the true marine formation in the vicinity of Weinheim, near Alzey, are so much more important in respect of their fossil contents than any others in this formation, that a more detailed notice of them is perhaps necessary. The first locality, fig. 6, is on the high road, a few hundred yards to the E. of Weinheim. The rocks here form a low broken escarpment, serving as the northern boundary of a small valley, watered by the stream which flows through Alzey. On the south the ground rises gradually over the undulating hill of the Sommerberg to the general table-land of the country, which consists of the overlying Cerithium-limestone. The marine beds themselves dip very slightly to the E. and S.E., and on approaching the village of Weinheim they are seen reposing directly on a dark greenish trappean rock.

Such igneous rocks, it may be here observed, are very abundant throughout this district, particularly towards the Donnersberg, and in the direction of Kreuznach, appearing as porphyry, melaphyr, or greenstone, and frequently containing geodes of agate and tabular veins of chalcedony. Sometimes they have cut through the underlying red or carboniferous sandstone, at others they have only caused the elevation of the sedimentary rocks, but they are all anterior to the deposition of the tertiary beds.

The section, fig. 6, represents the general appearance of the beds opposite the Wirthsmühle. A hard bed of compact limestone rests rather irregularly against the trap-rock. It contains a few remains of *Ostrea*, *Pectunculus*, &c. Over it is a loose shelly sand, 3 or 4 feet in thickness, in which the greatest number of shells is found; the lower portion in particular is almost a complete mass of such remains,

Fig. 6.—*Section of the "Marine Sands"* (B. 1), *near Weinheim; opposite the Wirthsmühle.* Height of Section about 20 feet.



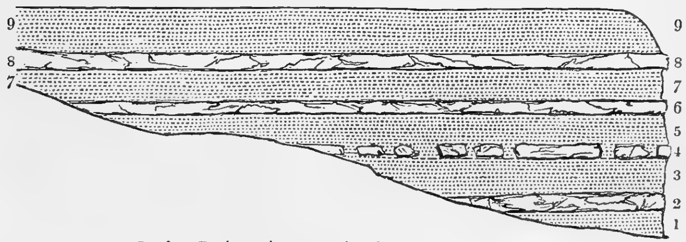
6. Gravel.
5. Calcareous sand; *Pectunculus*, abundant.
4. Shelly sand. (At about this level on the opposite side of the valley, the *Cyprina rotundata* occurs; fig. 7.)
3. Hard-bedded limestone; *Pectunculus crassus*, &c.
2. Shelly sand; *Natica gigantea*, &c.
1. Compact limestone. Few *Ostreæ*.

many of which are broken, while others have their valves pierced by borers, showing that they were probably already dead before they were washed into this locality. Those in the upper portion are better preserved.

This shelly sand is again overlaid by a compact hard calcareous sandstone, in which the large *Pectunculus crassus* (Phil.) is very abundant; this passes into a softer arenaceous bed, in which the *Pectunculi*, in consequence of the denudation of the intervening strata, are in immediate contact with the diluvial gravel.

The section, fig. 7, represents the beds as seen in the hollow-road,

Fig. 7—*Section of the Alternations of Sandy and Calcareous beds in the "Marine Sands,"* B. 1, *at the Hollow Way behind Weinheim.*



9. Sandy; *Pectunculus*, very abundant.
8. Calcareous.
7. Shelly sand.
6. Calcareous.
5. Sandy; *Cyprina rotundata*.
4. Calcareous.
3. Loose sand.
2. Calcareous. *Halianassa* bones.
1. Sandy.

or pass, behind or to the north of the same hill, at a somewhat higher level. The fossil remains found here are generally the same as those near the Wirthsmühle, but there is a more frequent alternation of soft shelly arenaceous, and hard compact areno-calcareous beds; we observed as many as four or five of these alternations. In the lowest of them, Mr. Austen found some fossil bones, but which, from the extreme hardness of the rock, it was impossible to extract. They belonged in all probability to the *Halianassa Collinii*, the remains of which are found not unfrequently in this lowest marine bed.

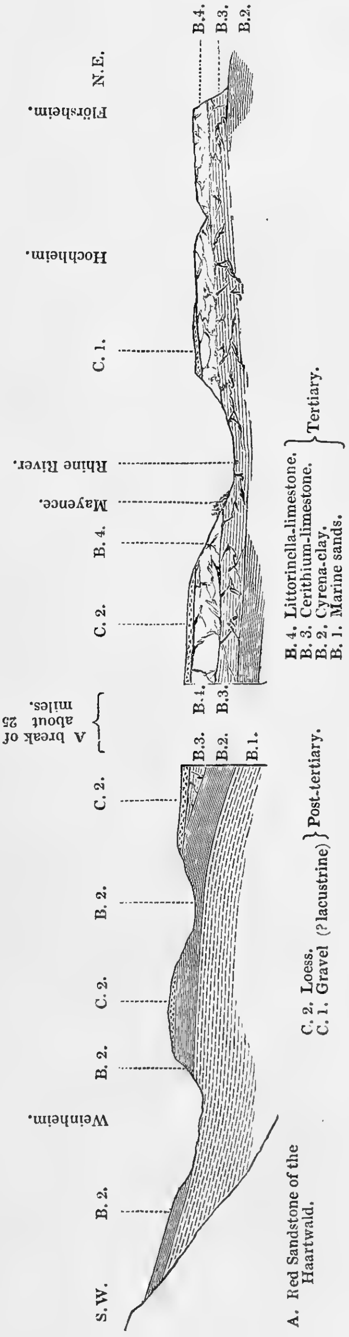
The remains of Mollusca were most abundant in the two upper beds, *Pectunculus arcatus* and *P. crassus* particularly abounding in the uppermost. The large *Cyprina rotundata* occurs chiefly in the sand below, in which few other fossils were found. The limestone-bed below the Cyprina-sand does not run continuously along the face of the scarp, but occurs in the shape of large nodules, which, from their greater resistance to the weathering action of the air and rain, project beyond the softer sands like the gigantic rafters of a building.

On the opposite or northern side of the red-sandstone ridge which separates the valley of Alzey from that of Flonheim to the N.E., the marine sands are seen in considerable thickness near Flonheim and Uffhofen, as has been already observed. Near Flonheim they are seen resting on the red sandstone in a sand-pit a little way above the town. The sand here contains but few fossils, and evidently represents a sandy beach along an open line of coast. Section fig. 2, page 258, will give an idea of this character. A depth of from 30 to 40 feet is exposed in the sand-pit, but they have dug 15 feet lower through the sand. The lowest portion (*a*) consists of a gravel of small quartz-pebbles, like that seen near Eckelsheim. (*b*) represents an Oyster-bed, amongst which Shark's-teeth are not unfrequently found; these latter indeed occur generally throughout every portion of this section. At (*c*) is the stratum in which bones have been frequently found, and on the occasion of my last visit I succeeded in extracting one, apparently a rib of *Halianassa*.

At Uffhofen are sand-pits of the same character and at nearly the same level, abounding in *Ostrea Collinii*, which form in the lower portion regular thick banks; many of these Oysters are covered with large *Balani*. Here, a few days before my last visit (July 1853), a most interesting and entire skeleton had been discovered imbedded in the soft incoherent sand, and was still lying as it had been found when we visited the spot. The lower jaw, and upwards of thirty vertebræ with their ribs, some slightly broken, were lying almost in their true position. The upper jaw and skull, having been found a short time before, had been sold to a neighbouring collector; the sand-digger, who found them, never dreaming that the remaining portions of the skeleton were then so near. From the short examination which Dr. G. Sandberger and myself could give them, there is little doubt but that they belong to the *Halianassa Collinii*, of which it is the most perfect specimen yet found*.

* I have since learned that this fine specimen has been secured by Prof. Kaup for the Museum at Darmstadt.

Fig. 8.—*General Section across the Mayence Basin,—from Weinheim near Alzey to Flörsheim.* Length about 40 miles.



Between Uffhofen and Eckelsheim, a short distance further north, these marine beds assume the character of a quartzose conglomerate or gravel, passing into a coarse incoherent sand, and the fauna is somewhat different from that of Weinheim. Here two or three species of *Ostrea,* including the peculiar form *O. rhenana,* together with two species of *Pecten,* are almost the only representatives of the numerous species found elsewhere. A single *Pectunculus* and an *Astarte* found in this sand were so soft that it was impossible even to touch them without injury; they crumbled to powder on removing the sand. The Pectens and Oysters seem to have a peculiar facility for resisting the decomposing effect of the water which percolates so easily through this loose sand.

II. *Lower blue Brown-coal Clay* (*Cyrenen-Mergel*), *Cyrena-marl.*

With the exception of the few hard calcareous bands intercalated in the shelly sands of Weinheim, there does not appear to have been any great change in the mineralogical character of the deposits formed at the bottom of this tertiary sea, so long as it maintained its true marine character. Fine sand and gravel, derived from the disintegration of the surrounding rocks, and mixed with an abundance of broken shells in the upper portion, are the chief materials in which the marine mollusca are found; but we here suddenly reach a totally different formation. A stiff tenacious blue clay overlies the shelly sands, and a corresponding change in the animal remains shows how the conditions of life were modified by those events which produced this change in the nature of the subaqueous deposits. These marly beds are considered by the German geologists to represent the lower brown-coal formation of the Wetterau, and are called by some the Cyrenen-Mergel or Cyrena-marl, from the abundance of *Cyrena subarata* found in it; with this are associated several species of *Cerithium*, and a few forms of littoral Gasteropods.

This formation occupies a considerable area in that portion of the Mayence basin which lies to the westward of the Rhine (see fig. 8), appearing in many of the bottoms and hollows, and even constituting low undulating hills. Here it has generally a very slight dip or inclination to the eastward; but on the opposite or eastern side of the Rhine the dip is reversed, and it only appears in a very few localities, and at a very low level. Between Hochheim and Flörsheim it occurs on the bank or in the bed of the Maine, where it contains *Cerithium margaritaceum* of a large size. Here a slight rise towards the east appears to be indicated; for in the section taken near Hanau, fig. 9, it forms the basis of the whole tertiary series, at a slight elevation above the bed of the river. This section, which is the most eastern point I had an opportunity of examining, extends from the lower to the upper blue clay, and will be subsequently described. (Hanau is about 30 miles N.E. by E. of Flörsheim.)

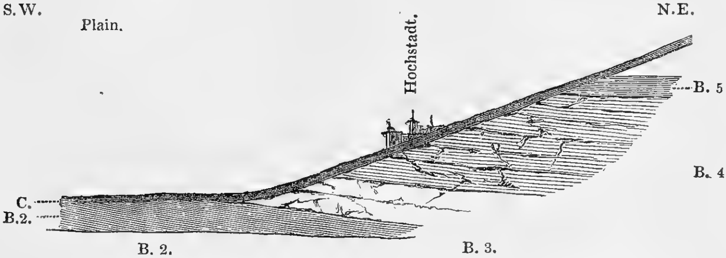
The principal localities where this blue clay has come under my notice, in addition to those already incidentally mentioned, are the Zeil Stück near Weinheim, where many fossils have been found, and the Sommerberg, opposite Weinheim; it also occurs abundantly on the road between Alzey and Mayence, near the village of Ensheim, where Mr. Austen and myself found *Cyrena subarata* and a small *Cerithium*; and again, on another road to Mayence, near Partenheim, where I obtained numerous *Cerithia* on a former occasion. The septarian clay near Dürckheim also evidently belongs to this formation, while to the N.W. it extends at intervals from Alzey to Kreutznach.

III. *Cerithium Limestone.* (Nos. 3 and 4 of the German list, p. 260.)

I omit the No. 3 of the German table, which is evidently only the lower portion of this limestone, into which considerable numbers of land-shells have in particular spots been drifted. The beds of which this division of the series consists are generally hard, compact, and thick-bedded. In many places, indeed, it is difficult to detect evidence of distinct stratification. They are also generally more extensively developed on the left bank of the Rhine than on the right, where the next succeeding bed, the Littorinella-limestone, is more abundant. It is however difficult, if not impossible, to draw any distinct line between them, except in so far as their fossil contents differ, and that the Littorinella-limestone is somewhat less thickly bedded, and is often interstratified with beds of marl or clay. The two formations pass gradually into each other, and should only be looked upon as subdivisions of the great calcareous deposit, formed during the period when this lacustrine basin was passing from a brackish to a freshwater condition.

The following section, fig. 9, taken at Hochstadt, near Hanau, will show how the two formations, extending from the lower to the upper blue clay, pass into each other.

Fig. 9.—*Section of the Cyrena Clay* (B. 2.), *Cerithium and Littorinella Limestones* (B. 3, B. 4), *and the Upper blue Clay* (B. 5), *at Hochstadt.*



1. (B. 2.) Blue clay (*unterer blauer Letten*) without fossils, said to rest immediately on the red sandstone (*Bunter-Sandstein* or *rothe-todte-liegende*). The pits where this blue clay had been dug out are at the foot of the hill below Hochstadt, but had all been filled up before I was there, so that I was indebted for my information to M. Roessler of Hanau, who accompanied me to the spot.

2. (B. 3.) Compact blue limestone passing into yellow. This bed is also unfossiliferous and slightly bituminous.

3. Hard limestone, occasionally nodular and concretionary, containing *Littorinella* and *Dreissena Brardii.*

4. (B. 4.) Limestone of a similar character, with numerous *Littorinellæ* and *Helices* of various species. We did not find *Dreissena* in this bed; but bones are said to have been occasionally found in the lower portion of it. It is the occurrence of these numerous *Helices*, in particular spots of this formation, which has led the German geologists to call it a freshwater limestone, but there seems to be no sufficient ground for such an assumption. No freshwater shells are found in it, neither *Planorbis, Limnæus,* nor *Paludina.* It is evidently a continuation of the brackish-water formation, into which land-shells have been drifted by the rivers. The abundance of these molluscs in particular spots has been accounted for by supposing them to have been deposited in those places where a great river, flowing into the brackish-water lake, impinged against particular promontories more exposed to the currents of fresh water. Supposing this ancient tertiary river to have occupied the bed of the present Maine, issuing into the plain (then a lake) from the narrow defiles near Aschaffenburg, the current would naturally deposit on the opposite bank the land-shells brought down by freshets from the

Spessart, or the River Kinzig in like manner might have brought them down from the Fichtel Gebirge.

5. Alternating beds of sand and limestone; the sand is in some places slightly ferruginous, and contains fragments of shells; the limestone occasionally alternates with sandy marl, containing a small *Littorinella*; it is a kind of junction-bed with No. 4, into which it sometimes passes. The singular small round bodies, described by some naturalists as snakes'-eggs*, have been found in this part of the section.

This bed brings us to the level of the little town of Hochstadt, built on the slope of the hill. Many small pits have been opened on the ground above the town, by means of which the section can be tolerably well traced upwards. *Littorinellæ* abound in most of these beds, but the *Helices* are less frequent than below.

6. The only characteristic horizon which I observed in this upper succession of limestone beds, more or less compact or arenaceous, is a band nearly a foot thick, containing *Mytilus Faujasii*.

7. (B. 5.) The highest bed in this section which I had an opportunity of observing consists of blue clay, in which the small *Cyrena Faujasii* and a *Cerithium*, probably *C. cinctum*, are tolerably abundant.

IV. *Littorinella-limestone*. (No. 5 of the German list, page 260.)

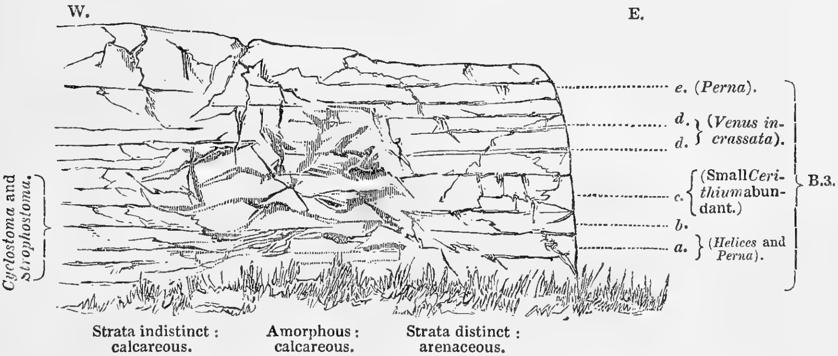
One of the chief localities for observing the various beds of this portion of the Mayence basin, which in a general sense may be considered as the upper portion of the brackish-water limestone formation, is the district lying between the towns of Hochheim and Flörsheim on the Maine. The numerous quarries opened on the slope of these hills have produced an abundant harvest to the palæontological inquirer, and have, in connection with the railway cuttings, brought to light a great variety of new forms of land-shells of the genera *Helix*, *Pupa*, *Bulimus*, *Clausilia*, and *Cyclostoma*. The valley of the Mühl-thal, leading from Biebrich to Wiesbaden, is a portion of this formation, and appears to represent its upper beds. It is moreover remarkable for containing, in addition to the molluscs found near Hochheim, a considerable number of freshwater shells.

I visited the Hochheim beds in company with Mr. Austen. The best section we obtained was at the eastern end of the line of quarries near Flörsheim, at a place called the Ziegel Hütte. The section of the lower part of this group here is remarkable for presenting on the same horizon two distinct series of beds, apparently without a fault (see fig. 10). The mass of rock in the centre consists of hard concretionary mammillated calc-sinter, made up of minute hollow stems, the interstices between which are often filled with fine sand. It looks as if the calcareous matter, the produce of springs highly charged with carbonate of lime, had been deposited on masses of Mosses or *Confervæ*, an appearance not uncommon in other parts of the formation. I particularly noticed it near Dürckheim, where the limestone also

* Quart. Journ. Geol. Soc. vol. vi. part 2. Miscell. p. 42.

appeared to be the produce of calcareous springs. To the north-west of this mass, the beds, which are nearly horizontal, are essentially calcareous, varying considerably in their degrees of hardness, and

Fig. 10.—*Section of the Cerithium Limestone* (B. 3) *with Calc-Sinter, between Hochheim and Flörsheim.*



sometimes passing into soft calcareous marl; while on the east or south-eastern side, they are essentially arenaceous, the stratification, especially at a short distance from the central mass, being more distinct than on the other side. On this eastern side we observed the following features in an ascending order:—

a. Loose sand, with a few *Helices* and *Perna,* from 10 to 20 feet thick.

b. Several bands of concretionary limestone-nodules, running through the same greenish sand.

c. Bands of hard limestone, 6 inches thick, containing numerous casts of a small *Cerithium.*

d. Two bands, a few inches thick, and three or four feet apart, containing *Venus incrassata.*

e. Band containing *Perna Soldanii.*

On the north-western side the palæontological evidence is less clear, and the stratification is much less regular. Numerous *Helices* and *Cyclostomata,* particularly *C. sulcatum,* occur in patches here and there, together with *Venus incrassata* and *Perna.* The great difference in the lithological character of the two sides of the section may, I think, be accounted for in this way:—if we suppose that a large river, occupying the position of the present Maine, flowed into the lacustrine basin from the Spessart, viz. from the E. or E.S.E., the action of the water on the calcareous spring would cause the calcareous matter to be deposited on the western or further side of the spring, while the matter deposited on the eastern side consisted of the more arenaceous sediment brought down by the river itself.

Another section further westward, and nearer Hochheim, produced an abundance of small *Cerithia,* with *Mytilus socialis,* fragments of

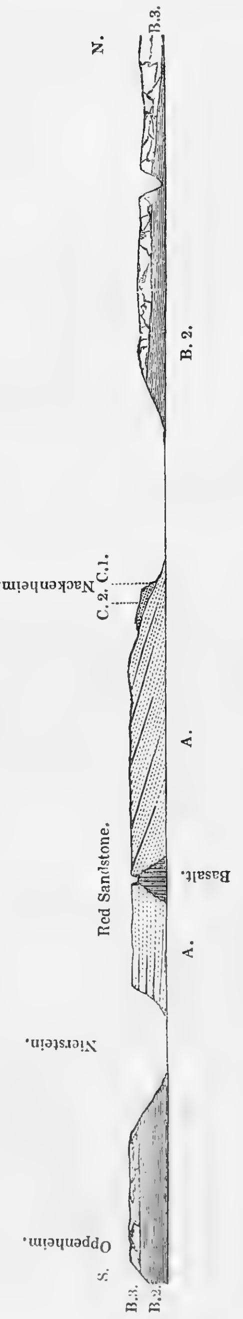


Fig. 11.—*Section from Oppenheim to the neighbourhood of Mayence.* Length about 15 miles.

Perna, and a small *Neritina* and *Nerita,* underlaid by a hard compact bed of limestone without fossils. In other portions of the section, casts of *Cerithium* occur in the hard limestone.

The valley of the Mühl-thal, between Biebrich and Wiesbaden, represents the upper portion of this formation, and the *Littorinella acuta* is here so abundant as to constitute almost the entire mass of the rock in many places. With it the *Mytilus Brardii* is also abundantly found, and a few freshwater shells, as *Paludina lenta, Melanopsis, Limnæus,* and *Planorbis,* here make their first appearance, plainly indicating the diminished saltness of the water.

Another instructive section of the calcareous portion of the Mayence tertiaries, including the Cerithium-limestone and the Littorinella-limestone, is exhibited in the quarries and other cuttings extending from the fortifications of Mayence, through the village of Weissenau, as far as Oppenheim on the left bank of the Rhine (fig. 11). The three localities of the Kästrich in Mayence, the quarries of Weissenau, and those of Oppenheim will complete our investigation of these beds.

1. Kästrich in Mayence. This section is exposed in the upper part of the town, in cutting a new road to the fortifications: it represents the upper portion of the Littorinella-limestone, and consists of frequent alternations of thin beds of flaggy limestone with arenaceous marly beds. Two species of *Littorinella* abound in these beds, but they are not less abundant in the arenaceous beds. On the whole, from 30 to 50 feet are exposed here.

2. Near the village of Weissenau, about one mile S.S.E. from Mayence, extensive quarries have long been opened in the limestone rocks, showing the passage downwards from the Littorinella-limestone to the Cerithium-limestone. The Littorinella-limestone appears to thin out gradually as the hills rise towards the S.E. The following sequence, in ascending order, will show how the beds succeed each other:—

1. Cerithium-limestone; generally compact and close-grained, containing *C. margaritaceum* and *Dreissena Brardii*, with here and there a cast of *Helix*; the lower portion of this bed is almost unfossiliferous, and seems to rest upon more marly beds. Its thickness is at least 50 feet.

2. Compact limestone, full of a small species of *Cerithium*, *Neritina*, and *Dreissena*; about 10 feet.

3. Limestone-beds, containing a large *Cerithium*, *Dreissena*, and *Cyrena Faujasii*; about 4 feet thick.

4. Alternating beds of sand and marl. The lowest sandy beds are full of *Littorinella*; I am, therefore, disposed to look upon these beds as marking here the junction between the Cerithium and Littorinella limestones. They have a thickness of about 30 feet.

5. A bed of broken fragments.

6. Alternating beds, containing *Littorinella* and *Cyrena*. The *Littorinella* generally occurs in the harder beds. Some of the Cyrena-beds are completely made up of casts of that shell.

7. Sand.

8. Littorinella-limestone, alternating with marls and sands. Thickness uncertain. This is the same formation as that which is seen at the Kästrich in Mayence.

9. Diluvial gravel; 2 feet.

10. Loess; 3 feet.

11. Soil.

3. Oppenheim. The lowest bed in the quarries at this place consists, like those of Weissenau, of compact limestone, containing very few fossils, and those chiefly *Cerithium*. A few bones are said to have been found here. It belongs evidently to the Cerithium-limestone. Above it are beds with *Mytilus Faujasii*, and a bivalve (*Cyrena subarata*? or *Venus incrassata*). Near the top of the section is a loose marly limestone, containing angular fragments of limestone, immediately overlying the oolitic-looking rock which in some places appears to form the upper portion of the Cerithium-kalk.

V. *Upper Blue Clay*. (No. 6 of the German list, page 260.)

The Littorinella-limestone is immediately overlaid by the Upper blue Clay or Upper Brown-coal Clay. I had no opportunity of observing it, except in the small section near Hochstadt (fig. 9, page 267), where it contains a small *Cerithium* and *Cyrena Faujasii*. It is, however, in some respects a very important formation, as containing the brown-coal beds of the Wetterau, the Westerwald, and the Middle Rhine, which are extensively worked and are remarkable for the interesting flora they contain. Some account of this flora will be found in the above-mentioned works of Walckner, Sandberger, and Voltz. It is, however, possible that the marly beds which overlie the Littorinella-limestone in the Mühl-thal, near Wiesbaden, are the representatives of this formation. In the second quarry from Wiesbaden, down the Mühl-thal, is a section of 10 or 12 feet of yellow, green, and dark-coloured marls, without fossils, overlying the

Littorinella-limestone. In another quarry these marls are 20 or 30 feet thick, very near the surface, overlying the Littorinella-limestone, from which it is separated by a white calcareous band.

VI. *Leaf-bearing Sandstone.* (No. 7 of the German list, page 260.)

Of the next formation in ascending order, as they are laid down by the German geologists, viz. Sandstone with impressions of leaves, I am unable to give any satisfactory account. It occurs in the neighbourhood of Wiesbaden, overlying the upper marls and clays, and overlapping the slaty metamorphic rocks of the Taunus.

VII. *Ossiferous Sand.* (No. 8 of the German list, page 260.)

This bed appears to indicate a different state of things from that belonging to the preceding beds, which it overlies unconformably, although belonging to the same general epoch, inasmuch as many of the fossil remains are the same as those found in the underlying beds. It is deposited in hollows in the pre-existing Littorinella-limestone, and is decidedly of a freshwater character. Some of the insulated patches are remarkable for the great number of Mammalian bones found in them: most of these are deposited in the museum at Mayence. One of the chief localities for these remains are the sand-pits near Eppelsheim, into which the animals or their bones would appear to have been washed from the surrounding dry ground, on which they must have lived and roamed after the drainage of the great lacustrine basin. The following section in descending order will show the superposition of the beds. It is taken from the top of the hill, distant about a mile N.W. from the village of Eppelsheim:—

1. Soil; 2 or 3 feet thick.
2. Loess; yellowish sandy loam; 4 feet.
3. Yellow gravel, with limestone boulders, and a few fragments of small bones.
4. Yellow clay, varying in thickness from 4 to 12 inches.
5. Loose sand and small gravel, containing boulders of hæmatitic ironstone; 3–4 feet.
6. Fine loose sand; about 14 feet exposed, but the bottom not visible; said by the workmen to rest on hard rock.

The Mammalian remains and teeth were said to have been found in No. 5, but little has been found of late. These sands, &c. are perfectly horizontal, but the Littorinella-limestone in the neighbourhood has been very much disturbed.

The Rhinoceros jaw which I obtained from one of the sand-diggers, was said to have come from bed No. 5.

Descending into the valley, near Bischheimer Hof, three or four miles distant to the S.E., I found the same formation of sands and clays filling up the hollow, and containing a specimen of *Mytilus Faujasii*, too soft and crumbling, however, to be extracted.

Although this Ossiferous Sand is unquestionably more recent than the underlying formations; and although it may be difficult, from from want of proper means of comparison, to fix its exact relative age, yet the great analogy between the numerous land and freshwater molluscs found in the underlying Littorinella and Cerithium limestones with those now living in the southern regions of Europe will justify us in assuming that the terrestrial and climatological conditions of life were not very different from those now existing, and that the superficial surface of the ground had already assumed its present form and configuration.

Part II.

On the Zoological Characters and Age of the Marine Molluscous Fauna of the Mayence Basin.

Having endeavoured in the preceding statements to describe the geographical position and the physical features of the various strata of the Mayence basin, with their relative succession and superposition, I now propose to allude to their palæontological contents, and to point out their analogies with the tertiary deposits of neighbouring regions, so far as they have yet been examined, with the view of ascertaining their true position in the tertiary series, and the period to which they should be referred.

Although I have succeeded during several excursions in collecting a considerable series of the fossils of this region, I could not expect to be so successful as those who, from long residence in the neighbourhood, have such constant opportunities of collecting, as the geologists of Wiesbaden, Mayence, Hanau, &c.; and who, in extending their knowledge of the fossil contents of the Cerithium and Littorinella limestones, had the additional advantage of examining the ground during the construction of the Mayence, Wiesbaden, and Frankfort railways. I am therefore compelled to have recourse to the lists of fossils published by these observers; amongst which I may particularly mention those of M. Walckner and of Dr. F. Sandberger, to which I am most indebted.

Although the fossil contents of the overlying brackish and freshwater formations are not without considerable interest in reference to the question of Age now immediately before us, their importance is but small, when compared with that of the underlying Marine Sands. It is the marine fauna to which we have principally to look, as the key of the whole question. Wherever this bed shall be placed, all the others follow immediately and without interruption. Their superposition is self-evident, and the gradual passage from one into the other is proved by mineralogical no less than by palæontographical evidence. In this marine sand, principally derived from the disintegration or abrasion of the previously existing and underlying red or carboniferous sandstones and shales, we have the evident commencement of a new state of things, the basis of a new formation; we here see the first proofs of a new deposit thrown down upon a new sea-bottom, when, after a sudden change in the relative levels of land

and water, the sea rushed into the newly-made depression, forming a deep inlet or æstuary, in which, for a time, marine life alone existed, until the conditions of life being again altered, and the waters having gradually become brackish, the true marine fauna also disappeared, and was replaced by one adapted to the altered conditions of life.

How, and where, and when these changes may have taken place, are questions which must be deferred to the concluding portion of this paper. We have now to compare the fossils of the marine sand of Weinheim with those of other tertiary deposits, and to endeavour by means of such comparison to ascertain their relative age and position with regard to the other tertiary beds of Europe, as well as their absolute place in the tertiary system.

The following list of fossils in the Marine Sand of Weinheim is chiefly taken from that given by Dr. Sandberger in his last-published work.

Table I.

Tabular view of the Mollusca of the Marine Sands of the Mayence Basin, showing some of the other localities where they have been observed.

	Belgium.			Paris.	Magdeburg.	Vienna.	Bordeaux.
	Older than the Limburg series.	Limburg series.	Younger than the Limburg series.				
Teredo anguinus, *Sandb.*, n.s.	......	......	......	......	* ?		
Saxicava, 3 or 4 species, undetermined							
Leguminaria papyracea, *D'Orb.*	......	......	......	*			
Solecurtus appendiculatus, *Desmoul.*...	......	*					
Panopæa intermedia, *Sow.*...............	......	*	......	......	*		
=*P. Hebertiana*, Bosq. (? the same)							
Thracia phaseolina, *Kiener*							
Corbulomya polita, *A. Braun*	......	*					
=*C. complanata*, Nyst.							
Corbula pisum, *Sow.*	*	*	*	*	*		
—— striata, *Lam.*	......	*	......	*	*		
—— scalaris, *A. Braun*..................							
Tellina donacina, *L.* ?....................							
—— Hebertiana, *Bosq.*	......	*	*				
=*T. Benedenii.*							
——, 2 species undetermined							
Crassatella Bronnii, *Merian*							
Astarte plicata, *Merian*							
——, species undetermined							
Diplodonta fragilis, *A. Braun*							
Lucina Bronnii, *Merian*..................	......	* ?					
=*L. squamosa*, Lam.							
—— Galeottiana, *Nyst*	......	......	*				
—— lepida, *Bosq.*	......	*	......	*	......	*	
—— uncinata, *Desh.*	......	*					
—— tenuistria, *Héb.*	......	*					
—— commutata, *Phil.*							
=*L. divaricata, var.* Nyst.							
—— saxorum, *Lam.*	......	*					

TABLE I. (*continued*).

	Belgium.			Paris.	Magdeburg.	Vienna.	Bordeaux.
	Older than the Limburg series.	Limburg series.	Younger than the Limburg series.				
Cytherea incrassatoides, *Nyst*	......	*	......	*			
—— minima, *A. Braun*	*						
= *C. deltoidea*, Lamk.							
—— splendida, *Merian*	......	*					
= *C. lævigata*, Nyst.							
—— Bosqueti, *Heb.*	......	*					
?—— nitidula, *Lamk.*	*						
—— Goldfussiana, *A. Braun*							
Cyprina rotundata, *Braun*	......	*	*				
= *C. islandica*, Lam.?							
Cardita orbicularis, *Bronn*	*	*	*	......	*		
—— var. minor, *Sandb.*							
—— — Omaliana, *Nyst*	......	*					
—— — lævicosta, *Sandb.*							
—— — Kickxii, *Nyst*	......	*					
—— — scalaris, *Goldf.*	......	*	......	......	......	*	
—— — chamæformis, *Nyst*	......	......	*				
Cyrena ambigua, *A. Braun*							
Isocardia transversa, *Nyst*	......	*					
—— cyprinoides, *A. Braun*							
Cardium tenuisulcatum, *Nyst*	......	*	......	*	*		
—— scobinula, *Merian*	......	*					
—— turgidum, *Brander*	......	*	......	*			
——, species uncertain							
Chama exogyra, *A. Braun*							
Arca hiantula, *Desh.*	......	......	*	......	*		
= *A. hians*, A. Braun.							
= *A. umbonata*, Lamk.							
—— diluvii, *Lamk.*	......	......	*	......	......	*	
—— multistriata, *De Kon.*	......	*					
= *A. decussata*, Nyst.							
Pectunculus crassus, *Phil.*	......	*	......	*	......	*	
= *P. polyodonta*, Goldf.							
—— arcatus, *Schloth.*							
—— angusticostatus, *Lamk.*	......	......	*	*			
—— lunulatus, *Nyst*	......	*					
Limopsis Goldfussiana, *Nyst*	......	*					
Nucula Lyelliana, *Bosq.*							
—— margaritacea, *Lamk.*	*	*	*				
—— placentina, *Lamk.*	......	......	*				
= *N. lævigata*, Goldf.							
—— Deshayesiana, *Duch.*	......	......	*				
—— minuta, *Defr.*							
Modiola micans, *A. Braun*	......	......	*	......	*		
? = *M. sericea*, Bronn.							
Mytilus Nystii, *Kickx*	......	*	......	......	......	......	*
Perna Soldanii, *Desh.*	......	......	......	......	......	*	*
Pinna	......	*	......	......	*		
Avicula ? trigonata, *Lamk.*	......	*					
Lima subcylindrica, *Sandb.*							
——, spec. undetermined							

Table I. (*continued*).

	Belgium. Older than the Limburg series.	Belgium. Limburg series.	Belgium. Younger than the Limburg series.	Paris.	Magdeburg.	Vienna.	Bordeaux.
Pecten pictus, *Goldf.*	......	*					
—— Deshayesii, *Nyst*	......	*?					
—— furfuraceus, *A. Braun*							
——, 3 species undetermined							
? inæqualis, *A. Braun.*							
? decussatus, *Münst. and Goldf.*							
? striatus, *Münst. and Goldf.*							
Spondylus auriculatus, *Nyst*	*						
——, sp. n.							
Ostrea callifera, *Lamk.*	......	......	*	*			
= *O. Collinii*, Merian.							
—— mutabilis, *Desh.*							
—— flabellula, *Lamk.*	*	.....	*	*			
= *O. rhenana*, Merian.							
Plicatula, sp. (rare)							
Anomia tenuistriata, *Desh.*	*	......	......	*			
Terebratula							
Cleodora?							
Dentalium entalis, *Gmel.*	......	*	*				
—— Kickxii, *Nyst*	......	......	*				
—— fissura, *Lamk.*	......	*					
Patella moguntiaca, *A. Braun*							
——, n. sp.							
Emarginula Nystiana, *Bosq.*	......	......	*				
——, n. sp.							
Calyptræa striatella, *Nyst*	......	*	......	*			
Capulus, uncertain							
Crepidula, uncertain							
Natica gigantea, *A. Braun*	......	......	......	*			
= *N. crassatina*, Lamk.							
= *N. maxima*, Grat.							
—— glaucinoides, *Sow.*	......	*	......	......	*	*	
= *N. Guilleminii*, Payr. & Bronn. var. *β*. major.							
—— crassa, *Nyst*	......	......	*				
—— Hantoniensis, *Sow.*	......	*	......	......	*		
—— Bronni, *Merian*							
Nerita rhenana, *Thom*							
——, sp. (major)							
Neritina concava, *Sow.*							
= *N. pisum*, Merian.							
—— pisiformis, *Fér.*	......	......	......	*			
Volvaria acutiuscula, *Sow.*	......	......	......	*			
Tornatella sulcata, *Lamk.*	*	......	......	*			
—— simulata, *Brand.*	......	*	......	......	*?		
Ringicula, sp. uncert							
Pyramidella cancellata, *Nyst*	......	*					
—— subulata, *Merian*							
——, 2 sp. uncert.							
Niso terebellata, *Risso*	......	......	......	*			
Eulima subulata, *Risso*	......	......	*	*			

TABLE I. (*continued*).

	Belgium.						
	Older than the Limburg series.	Limburg series.	Younger than the Limburg series.	Paris.	Magdeburg.	Vienna.	Bordeaux.
Turbonilla elegantissima, *Leach*							
—— Nystii, *Duch.*							
—— lævissima, *Bosq.*	......	*					
——, sp. uncert.							
Rissoa plicata, *Desh.*	......	*	......	*			
—— Duboisii, *Nyst*	......	*					
—— succincta, *Nyst*	......	*					
—— Michaudi, *Nyst* ...... =*R. tumida*, Merian.							
Vermetus, sp. uncert.							
Scalaria rudis, *Phil.*	......	......	......	......	*		
—— pusilla, *Phil.*							
Turritella crenulata, *Nyst*	......	*					
Phasianella (aff. *P. Prevostina*, Bast.).							
Delphinula, sp. uncert.							
Rotella nana, *Grat.*							
Phorus umbilicaris, *Brand.* ...... =*Trochus agglutinans*, Lamk.	*	*					
Trochus fragilis, *Desh.*	......	......	......	*			
—— rhenanus, *Merian* ...... =*T. striatus*, Gmel.							
—— bicarinatus, ...							
—— margaritula, *Merian*							
——, 2 sp. uncert.							
Turbo, sp. uncert.							
Solarium, sp. uncert.							
Xenophora Lyelliana, *Bosq.*	......	*	*				
Littorina, 2 sp. uncert.							
Cerithium mutabile, *Lamk.*	......	......	......	*			
—— subvaricosum, *A. Braun*							
—— dentatum, *Defr.*	......	......	......	*			
—— plicatum, *Lamk.*	......	*	......	*	......	*	
—— intermedium, *Braun*							
—— lima, *Brug.*	......	*	......	......	......	......	*
—— lævissimum, *Schloth.*							
—— conoidale, *Lamk.*	......	......	......	*			
—— margaritaceum, *Sow.* ...... =*C. elegans*, Desh.	......	*	......	......	......	*	
—— abbreviatum, *A. Braun*							
—— (aff. *C. lapidum*, Lamk.)							
——, 6 sp. undetermined							
Chenopus vittatus, *A. Braun*							
—— speciosus, *Schloth.* ...... =*C. tridactylus*, A. Braun. =*C. pes-pelecani*, Phil.	......	*	......	......	......	*	
——, sp. undeterm.							
Tritonium argutum, *Brand.* ...... =*T. rugosum*, Phil. =*T. flandricum*, De Kon.	......	*	......	......	*		
——, 3 sp. undeterm.							
—— anguinum, *Merian*							

TABLE I. (*continued*).

	Belgium.						
	Older than the Limburg series.	Limburg series.	Younger than the Limburg series.	Paris.	Magdeburg.	Vienna.	Bordeaux.
Tritonium cerithioides, *A. Braun*							
Typhis cuniculosus, *Nyst*	......	*	......	*	*		
—— scalaris, *A. Braun*							
—— pyruloides, *A. Braun*							
Murex Deshayesii, *Duch.*	......	*					
——, sp. uncert.							
—— affinis, *Eichw.*							
Fusus elongatus, *Nyst*	......	*	......	*	*		
—— multisulcatus, *Nyst*	......	*					
—— rostratus, *Defr.*							
Fasciolaria (aff. *F. Lynchi*, Grat.)							
——, sp. undeterm.							
Pyrula elegans, *Lamk*	......	*	......	*			
——, uncert. sp.							
Pleurotoma Waterkeynii, *Nyst*	......	*	......	......	*		
—— belgicum, *Goldf.*	......	*	......	*			
—— regulare, *van Bened.*	......	*	*				
—— Selysii, *De Kon.*	......	*	......	......	*		
—— subdenticulatum, *Münst.*	......	*	......	......	*		
—— Morrenii, *De Kon.*	......	*					
—— scabrum, *Phil.*	......	......	......	......	*		
—— flexuosum, *Münst.*	......	*	......	......	*		
—— conoideum, *Brand.*	......	*	......	......	*		
—— canaliferum, *Merian*	......	*					
= *P. Borsoni*, var. *tumida*, Bronn.							
Cancellaria evulsa, *Brand.*	......	*	*	......	*		
—— Brauniana, *Nyst*							
—— minuta, *A. Braun*							
—— cornigera, *A. Braun*							
Cassidaria depressa, *von Buch*	......	*	......	......	*		
—— Nysti, *Kickx*							
= *C. pulcherrima*, A. Braun.							
Cassis belata, *Beyrich*							
—— megapolitana, *Beyrich*							
——, sp. uncert.							
Buccinum cassidaria, *Bronn*							
Voluta Rathieri, *Héb.*	......	*	......	*			
—— modesta, *Merian*							
—— Schlotheimi, *A. Braun*							
Mitra perminuta, *A. Braun*							
Oliva, sp. uncert.							
Conus dormitor, *Soland.*	......	*					
Cypræa inflata, *Lamk*	......	*					
—— subcolumbaria, *D'Orb.*	......	*					
Bulla? concinna, *Wood*							
= *B. ovulata*, Lamk.							
—— Bronnii, *Merian*							
= *B. angystoma*, Desh.							
——, sp. uncert.							
Serpula, sp. uncert.							
Spirorbis, sp. uncert.							

Table I. (*continued*).

	Belgium.						
	Older than the Limburg series.	Limburg series.	Younger than the Limburg series.	Paris.	Magdeburg.	Vienna.	Bordeaux.
Bairdia subdeltoidea, *Münst.*							
—— arcuata, *Münst.*	......	......	*	*			
Cytheridea Mulleri, *Münst.*	......	*	*	*			
Cytherella tenuistriata, *Reuss*							
Cythere Voltzii, *Reuss*							
Krebs (Crab ?)							
Sphærodus, sp. uncert.							
Piscium, 9 sp. uncert.							
Myliobates							
Zygobates							
Lamna cuspidata, *Ag.*	......	*	......	......	*	*	
—— contortidens, *Ag.*	......	*	......	......	*	*	
—— denticulata, *Ag.*	......	......	......	......	*	*	
Carcharodon angustidens, *Ag.*	......	*	......	......	......	*	
Notidanus primigenius, *Ag.*	......	*	......	......	......	*	
Crocodilus, sp.							
Trionyx, sp.							
Emys hospes, *von Meyer*							
Halianassa Collinii, *von Meyer*	......	......	......	......	......	*	
Anthracotherium magnum, *Cuv.*							

If from this list we direct our attention to Belgium, we find in Sir C. Lyell's paper* "On the Tertiary Strata of Belgium and French Flanders," that the fossils of the Limburg beds near Kleyn Spawen are in a very large proportion identical with those of Weinheim and its neighbourhood. The Pectunculus-bed at Bergh†, so called from the extraordinary number of *P. fossilis* contained in it, has its exact counterpart at Weinheim in a bed occurring, as has been already observed (p. 263), near the top of the section, containing a surprising number of *P. crassus*, Phil. and *P. arcatus*, Schloth., overlying beds of shelly sand abounding in fossil Gasteropods and Conchifers like those of the Bergh sands, *d* and *f* of fig. 2, *l. c.* p. 305. *P. crassus*, Phil., is the same as *P. fossilis*, Linn., and *P. arcatus*, Schloth., is *P. terebratularis*, Lam.

Unfortunately, the Weinheim fossils have not yet been so accurately worked out and referred to the different sandy beds in which they occur, as those of Kleyn Spawen. For the sake of comparison, therefore, we must take the whole of the lists referred to in Tables VIII. and IX. (*l. c.* pp. 304 and 312) of Sir C. Lyell's paper, in order to ascertain the resemblance between them and the Weinheim beds, as given in the above table. As far as I have been able to ascertain, it seems that about sixty species or nearly fifty per cent. are common to the two formations, many of these being very characteristic shells, such as *Nucula Deshayesiana*, *Pectunculus arcatus*,

* See Quarterly Journal Geol. Soc. vol. viii. p. 277. † *Loc. cit.* p. 305.

P. crassus, Cyprina rotundata, Cytherea lævigata, Cardita Omaliana, Voluta Rathieri, &c. Dr. Sandberger makes out no less than sixty-three species common to Weinheim and the Limburg series. A large proportion of these shells are evidently much water-worn, and many of the bivalves have been perforated by boring animals. From this it might, perhaps, have been inferred that they had been washed in with considerable violence, and drifted into particular places as dead shells. But the occurrence of Sharks'-teeth, which in some localities are very numerous, shows that this region must have been for a long time an arm or basin of the sea inhabited by marine animals until the brackish nature of the water interfered with their existence.

The beds immediately overlying the Marine Sands, while still containing many truly marine species, show a decided commencement of a brackish-water fauna, and this character increases as we ascend to the Cerithium and Littorinella limestones. The following is the list of fossils hitherto found in the Lower blue Brown-coal Clay or Cyrena-marl.

Table II.

Fossils of the Cyrena-marl, or blue Brown-coal Clay.

Saxicava, sp.
Solecurtus, sp.
Mya pusilla, *A. Braun.*
Corbulomya polita, *A. Braun.*
—— triangula, *Duch.*
Tellina faba, *Sandb.*
Bornia, sp.
Cytherea Bosqueti, *Héb.*
—— incrassata, *Sow.*
Cyrena subarata, *Bronn* (very common).
Cardium scobinula, *Merian.*
Pectunculus crassus, *Phil.*
Nucula piligera, *Sandb.*
Leda Deshayesiana, *Duch.*
Tichogonia clavata, *Krauss.*
Mytilus (aff. *M. gallo-provincialis*, Lam.)
—— Faujasii, *Brongn.*
Avicula ? trigonata, *Lam.*
Perna Soldanii, *Desh.*
Ostrea cyathula, *Lam.*
—— callifera, *Lam.*
—— var. β. minor.
Natica glaucinoides, *Sow.*
Trochus rhenanus, *Merian.*
Littorinella Draparnaudii, *Nyst.*
—— obtusata, *A. Braun.*
—— acicula, *A. Braun.*
—— helicella, *A. Braun.*
—— gibbula, *A Braun.*
—— angulata, *A. Braun.*
—— lubricella, *A. Braun.*
—— compressiuscula, *A. Braun.*
—— acuta, *Desh.*
Nematura granulum, *A. Braun.*
Rissoa plicata, *Desh.*
—— nitida, *Grat.*
Scalaria (aff. *S. reticulata*, Phil.).
Littorina moguntina, *A. Braun.*
Melania oviformis, *A. Braun.*
—— pernodosa, *Sandb.*
Cerithium incrustatum, *Schloth.*
—— var. α. elongatum, *Sandb.*
—— — β. Meriani, *A. Braun.*
—— margaritaceum, *Brocchi.*
—— var. α. calcaratum, *Grat.*
—— — β. incrassatum, *Grat.*
—— plicatum, *Lam.*
—— var. α. crassum, *Sandb.*
—— — β. intermedium, *A. Braun.*
—— — γ. Galeotti, *Nyst.*
—— creniferum, *Desh.*
—— abbreviatum, *A. Braun.*
——, sp. uncert.
Chenopus tridactylus, *A. Braun.*
Typhis cuniculosus, *Duch.*
Murex conspicuus, *A. Braun.*
Pleurotoma belgicum, *Goldf.*
—— subdenticulatum, *Münst.*
Buccinum Cassidaria, *Bronn.*
——, sp. incert.
Mitra perminuta, *A. Braun.*
Bulla ? concinna, *Wood.*
Planorbis pseudammonius, *Voltz.*
Limnæus, spec. 2 uncert.
Helix, sp. (aff. *H. lacticina*, Ziegl.)
Serpula sinistrorsa, *Sandb.*
Balanus, sp. 2.
Cytheridea Mülleri, *Münst.*
Sphærodus lens, *Ag.*
Lamna cuspidata, *Ag.*
—— contortidens, *Ag.*
Zygobates, sp.
Anthracotherium alsaticum, *Cuv.*

With regard to the proper parallelism of this formation, I may quote the words of Dr. F. Sandberger, who, after giving the various localities in which each of these fossils is found, observes that "out of the whole list of twenty-eight species common to the Cyrena-marls and other tertiary deposits, eighteen are common to the Middle Limburg formation, and eight to the upper marine sand of Paris; but, as we have found a still larger number of species which these formations have in common with the sands of Weinheim, and have consequently recognized them as the equivalent of the Middle beds of Limburg, and as the Cyrena-clay is proved by its position to be newer than the sands of Weinheim, I believe that it must be paralleled with the Upper Limburg and the Septaria-clay of Northern Germany."

I have already observed that the "freshwater limestone" of the German geologists must be considered as the lowest member of the Cerithium-limestone, we must therefore take the two following lists together; No. III. being that of the so-called "freshwater limestone," and No. IV. that of the Cerithium-limestone.

Table III.

Fossils of the "Freshwater Limestone of the Germans." (No. 3 of the list at p. 260.)

Littorinella acuta, *Desh.*
Neritina picta, *Fér.*
Cerithium subcorrugatum, *d'Orb.*
—— submargaritaceum, *A. Braun.*
Planorbis parvulus, *Reuss.*
Limnæus Thomæi, *Reuss.*
Auricula minutissima, *A. Braun.*
Truncatella microceras, *A. Braun.*
Acicula subtilissima, *A. Braun.*
—— suturalis, *A. Braun.*
Cyclostoma (Craspedopoma) utriculosum, *Sandb.*
—— (Megalomastoma) Dolium, *Thom.*
—— (Cyclostomus) bisulcatum, *von Zieten.*
—— (Pomatias) labellum, *Thom.*
Vitrina intermedia, *Reuss.*
Helix Ramondi, *Brongn.*
—— Brauniorum, *Thom.*
—— deflexa, *A. Braun.*
—— var. α. communis,
—— — β. hortulana, *Thom.*
—— — γ. minor,
—— oxystoma, *Thom.*
—— subsulcosa, *Thom.*
—— similis, *Thom.*
—— Kalmitana, *A. Braun.*
—— Rahtii, *A. Braun, Th.*
—— phacodes, *Thom.*
—— lapicidella, *A. Braun.*
—— pulchella, *Müll.*
—— var. γ. costellata, *A. Braun.*
—— uniplicata, *A. Braun.*
—— lepidotricha, *A. Braun.*
Helix osculum, *Thom.*
—— var. α. communis,
—— affinis, *Thom.*
—— involuta, *Thom.*
—— var. α. communis,
—— pupula, *A. Braun.*
—— var. α. Corculum, *A. Braun.*
—— — β. paludinæformis, *A. Braun.*
—— stenotrypta, *A. Braun.*
Helix verticilloides, *A. Braun, Th.*
—— var. β. euryomphalos, *A. Braun.*
—— hypoleios, *A. Braun.*
—— β. compressa, *A. Braun.*
—— discus, *Thom.*
—— disculus, *A. Braun.*
—— nana, *A. Braun.*
—— subcellaria, *Thom.*
—— sublucida, *A. Braun.*
—— nitidulosa, *A. Braun.*
Bulimus gracilis, *Thom.*
Achatina (Glandina) subsulcosa, *Thom.*
—— (——) Sandbergeri, *Thom.*
—— (——) lubricella, *A. Braun.*
Clausilia exarata, *Ziegl.*
Pupa variabilis, *Drap.*
—— var. β. gracilis, *Sandb.*
—— cylindrella, *A. Braun.*
—— Dolium antiquum, *A. Braun.*
—— quadrigranata, *A. Braun.*
—— subdentata, *A. Braun.*
—— cryptodonta, *A. Braun.*
—— var. β. lævis, *A. Braun.*
—— (Vertigo) trifurcata, *A.*
—— (——), n. sp.

Table III. (*continued*).

Pupa (Vertigo) didymodonta, *A. Braun.*
—— (——) palustris, *Turton.*
—— var. γ. minor oblonga, *A. Braun.*
—— trigonostoma, *A. Braun.*
—— tiarula, *A. Braun.*
—— acicula, *Sandb.*
Cypris faba, *Desm.*
Salamander.
Frogs, 5 sp.
Snakes.
Lizards, 2–3 sp.
Birds, 3 sp.
Microtherium Renggeri, *von Meyer.*
Rhinoceros, sp.
Palæomeryx pygmæus, *von Meyer.*
Rodentia, 5 sp.
Carnivora, 3 sp.
Insectivora.

It may be observed, that, with scarcely an exception, only those species have been introduced into this list which have been found at Hochheim.

Table IV.

Fossils of the Cerithium Limestone.

Foraminifera, 2 sp.
Bryozoa.
Modiola angusta, *A. Braun.*
Mytilus socialis, *A. Braun.*
—— ? antiquorum, *Sow.*
—— Faujasii, *Brongn.*
Perna Soldanii, *Desh.*
Pinna ?, sp.
Pisidium antiquum, *A. Braun.*
Cyrena donacina, *A. Braun.*
Cytherea incrassata, *Sow.*
Corbulomya donacina, *A. Braun.*
Littorina moguntina, *A. Braun.*
Littorinella acuta, *Desh.*
Planorbis declivis, *A. Braun.*
Limnæus Thomæi, *Reuss.*
Neritina picta, *Fér.*
—— concava, *Sow.*
Nerita rhenana, *Thom.*
Cerithium submargaritaceum, *A. Braun.*
—— plicatum, *Lam.*
—— var. γ. Galeotti, *Nyst.*
—— —— forma calva,
—— var. δ. curviplicatum,
Cerithium var. ε. pustulatum,
—— —— forma calva,
—— var. ι. plicato-granulatum,
—— incrustatum, *Schloth.*
—— var. α. elongatum,
—— —— forma nodosa et calva,
—— var. β. Meriani,
——, n. sp. (aff. *C. Scalaroides.*)
Fusus brevis, *A. Braun.*
Nassa, sp. (aff. *N. reticulata*, .)
Cyclostoma bisulcatum, *von Ziethen.*
—— Dolium, *Thom.*
—— labellum, *Thom.*
Strophostoma tricarinatum, *M. Braun.*
Helix deflexa, *A. Braun.*
—— oxystoma, *Thom.*
—— valdecarinata, *A. Braun.*
—— phacodes, *Thom.*
—— parvula, *A. Braun.*
—— verticilloides, *A. Braun, Th.*
—— subcellaria, *Thom.*
—— sublucida, *A. Braun.*
Balanus, sp.
Cypris, sp.

The great peculiarity of list No. 3 is the very large proportion of land-shells which it contains; but these, it must be remembered, are all derived from one or two small localities. They are only sparingly found in other parts of the formation, and it may be observed that every one of the *Helices* and *Cyclostomata* found in table No. IV., which comprises the general contents of the whole formation, is also to be found in list No. III., which latter professes to give only the contents of one or two small localities near the edge of the formation, and where we might fairly expect the remains of the terrestrial fauna of the district to have accumulated on the shores and margins of the waters. The two lists must, therefore, be looked upon as contemporaneous; the one showing the terrestrial fauna washed into and found on the margin of the lake, the other the real inhabitants of the brackish water.

But to resume ;—the increasing brackishness of the water during this period is apparent from these lists, and by the greater number of land and freshwater shells which are found promiscuously dispersed throughout the whole thickness, but in general more abundantly in particular localities. These have evidently been washed into the basin by large freshwater streams, emptying themselves and their contents into the lacustrine basin, and show how the diminished saltness of the water was in part at least occasioned. They also offer an argument in favour of our placing the whole Mayence basin higher rather than lower in the geological scale, inasmuch as amongst the land-shells we find at least four species still living in some parts of Europe, viz. *Helix pulchella* (Müll.), *Pupa palustris* (Drap.), *Pupa variabilis* (Drap.), and *Clausilia exarata* (Ziegl.).

In addition to these observations, I might also quote the comparison made by Dr. F. Sandberger between the land and freshwater molluscs of the Mayence basin and those now living, in which he has shown, that, with few exceptions, they have analogous, if not identical, representatives in those of the existing Mediterranean basin. With regard to the genus *Helix*, Dr. Sandberger observes that, amongst the numerous species of *Helix* found at Hochheim, the true Mediterranean groups of *H. verticillus* and *H. serpentina* preponderate, and amongst those found at Wiesbaden is *H. moguntina* (Desh.), an analogue of *H. splendida*. In the group of *Helix verticillus*, the fossil species *H. verticilloides* (A. Braun), *H. amplificata* (Th.), and *H. discus* (Th.) must be noticed.

The following tabular list will show some of the analogies observed by Dr. Sandberger :—

Recent.		Fossil.
Helix acies, *Partsch*	=	Helix discus, *Thom.*
—— olivetorum	=	—— subcellaria, *Thom.*
—— muralis —— serpentina —— globularis } (Italy)	=	—— deflexa, *A. Braun.*
—— serpentina, *Fér.*	=	—— subcarinata, *A. Braun.*
—— lens	=	—— phacodes, *Thom.*
—— lenticula	=	—— lapicidella, *A. Braun.*
—— scabriuscula	=	—— Rahtii.
—— rotundata	=	—— multicostata, *Thom.*
—— pulchella	=	—— pulchella.
—— triaria	=	—— plicatella, *Reuss.*
—— desertorum	=	{ —— Brauniorum. —— Mattiaca.
—— obvoluta	=	—— involuta, *Thom.*
—— Lefeburiana	=	—— Arnoldii, *Thom.*
—— personata	=	—— osculum, *Thom.*
Clausilia macarana	=	Clausilia bulimoides.
—— exarata	=	—— exarata.

But it is unnecessary to quote any more instances*.

* Sandberger, Untersuchungen, p. 73.

TABLE V.—*Fossils of the Littorinella Limestone.*

Tichogonia clavata, *Krauss.*
Mytilus? antiquorum, *Sow.*
—— Faujasii, *Desh.*
Cyrena Faujasii, *Brongn.*
—— lævigata, *Goldf.*
Cerithium margaritaceum, *Brocchi.*
—— plicatum, *Lamk.*
—— var. ε. pustulatum,
—— incrustatum, *Schloth.*
—— var. β. Meriani,
Neritina fluviatilis, *Lam.*
—— var. gregaria, *Thom.*
Littorinella acuta, *Desh.*
—— inflata, *Brard.*
Paludina lenta, *Sow.*
Melanopsis olivula, *Grat.*
—— var. α. minor.
—— var. β. major.
Melanopsis marginata, *A. Braun.*
Limnæus pachygaster, *Thom.*
——, n. sp.
—— subpalustris, *Thom.*
—— striatellus, *Grat.*
—— vulgaris, *Pfeif.*
—— minor, *Thom.*
Planorbis pseudammonius, *Voltz.*
—— declivis, *A. Braun.*
—— dealbatus, *A. Braun.*
—— Kraussii, *von Klein.*
Ancylus Mattiacus, *A. Braun.*
Auricula antiqua, *A. Braun.*
—— minutissima, *A. Braun.*
Helix Mattiaca, *Steining.*
—— sylvestrina, *von Ziethen.*
—— moguntina, *Desh.*
—— α. splendidæformis, *A. Braun.*
—— β. communis,
—— γ. subcarinata,
—— subcarinata, *A. Braun.*
—— n. sp. (aff. *H. candidissima*,)
—— punctigera, *Thom.*
—— phacodes, *Thom.*
—— pulchella, *Müll.*
—— var. β. costellata, *A. Braun.*
—— osculum, *Thom.*
—— var. β. depressa,
—— var. γ. globosa,
—— involuta, *Thom.*
—— var. β. dilatata, *A. Braun.*
—— stenotrypta, *A. Braun.*
—— verticilloides, *A. Braun.*
—— var. γ. increscens, *Thom.*
—— multicostata, *Thom.*
—— lunula, *Thom.*
—— Thomæana, *A. Braun.*
—— uniplicata, *A. Braun.*
Achatina subrimata, *Reuss.*
Clausilia bulimoides, *A. Braun, Th.*
Pupa quadrigranata, *A. Braun.*
—— Rahtii, *A. Braun.*
Pupa bigranata, *Rossm.*
—— retusa, *A. Braun.*
—— cryptodonta, *A. Braun.*
—— acicula, *Sandb.*
—— (Vertigo) obstructa, *A. Braun.*
—— (——) quadriplicata, *A. Braun.*
—— (——) palustris, *Turton.*
—— var. α. major ovata,
—— var. β. minor subglobosa,
Cypris faba, *Desm.*
—— angusta, *Reuss.*
—— trigonula, *Sandb.*, n. sp.
Phryganea Mombachiana, *Höningh.*
—— Blumii, *Hepp.*
Perca moguntina, *Ag.*
Pisces, sp.
Salamandra, sp.
Rana, sp.
Ophidia, sp.
——, eggs?
Crocodilus, sp.
Trionyx, sp.
Aspidonectes Gergensii, *von Meyer.*
Emys, sp.
Clemmys rhenana, *von Meyer.*
Palæochelys taunica, *von Meyer.*
Birds, sp.
——, eggs, 2 sp.
Hippotherium gracile, *Kaup.*
Microtherium Renggeri, *von Meyer.*
—— concinnum, *von Meyer.*
Hyotherium medium, *von Meyer.*
—— Meissneri, *von Meyer.*
Rhinoceros incisivus, *Cuvier.*
——, sp.
Tapirus Helveticus, *von Meyer.*
Palæomeryx Scheuchzeri, *v. Meyer.*
—— medius, *von Meyer.*
—— minor, *von Meyer.*
—— pygmæus, *von Meyer.*
Lithomys parvulus, *von Meyer.*
Brachymys ornatus, *von Meyer.*
Chalicomys Eseri, *von Meyer.*
Titanomys Visenoviensis, *v. Meyer.*
Rodentia, sp.
Carnivora, sp.
Stephanodon Mombachensis, *v. M.*
Acanthodon ferox, *von Meyer.*
Amphicyon dominans, *von Meyer.*
—— intermedius, *von Meyer.*
—— Klipsteinii, *von Meyer.*
Palæogale pulchella, *von Meyer.*
—— fecunda, *von Meyer.*
Erinaceus priscus, *von Meyer.*
Oxygomphius leptognathus, *v. M.*
Dimylus paradoxus, *von Meyer.*
Talpa brachychir, *von Meyer.*
Sorex pusillus, *von Meyer.*
Vespertilio præcox, *von Meyer.*
—— insignis, *von Meyer.*

This list shows an increasing proportion of land and freshwater shells throughout the general mass, although the whole number of species is hardly so great as in the lower beds of the Cerithium-limestone. There is also a considerable change of species between the two formations, and were it not for the *Cerithia* and *Mytili*, which are still abundant, although the species are few, this might almost be looked upon as a freshwater formation. This however is not the case; moreover certain species of *Cerithia* and *Cyrena Faujasii* occur in the overlying blue clays, so that the brackish-water period must not be considered as yet concluded. Here also, as in the preceding formation, several forms of land shells make their appearance which are strictly analogous to, some even identical with, those now existing in one part or other of the Mediterranean basin.

Table VI.

Fossils of the Ossiferous or Bone-bearing Sand.

Fish, sp.
Crocodilus, sp.
Tortoise, sp.
Hippotherium gracile, *Kaup.*
Chalicotherium antiquum, *Kaup.*
—— Goldfussii, *Kaup.*
Anthracotherium magnum, *Cuv.*
Tapirus priscus, *Kaup.*
Sus antediluvianus, *Kaup.*
—— palæochœrus, *Kaup.*
—— antiquus, *Kaup.*
Rhinoceros Goldfussii, *Kaup.*
—— Schleiermacheri, *Kaup.*
—— incisivus, *Cuv.*
—— minutus, *Cuv.*
Mastodon longirostris, *Kaup.*
Dinotherium giganteum, *Kaup.*
—— Bavaricum, *v. Meyer.*
Macrotherium, sp.
Agnotherium antiquum, *Kaup.*
Dorcatherium Nani, *Kaup.*
Palæomeryx minor, *v. Meyer.*
Cervus Bertholdi, *Kaup.*
—— Partschii, *Kaup.*
—— anocerus, *Kaup.*
—— dicranocerus, *Kaup.*
—— curtocerus, *Kaup.*
—— nanus, *Kaup.*
Chalicomys Jægeri, *Kaup.*
Gulo diaphorus, *Kaup.*
Machairodus cultridens, *Kaup.*
Felis aphanista, *Kaup.*
—— ogygia, *Kaup.*
—— prisca, *Kaup.*
—— antediluviana, *Kaup.*

The isolated character of the deposits in which these osseous remains are found has been already mentioned in the former portion of this paper (page 272). It is only necessary here to observe, that the occurrence of *Anthracotherium magnum* (Cuv.), common to the Marine Sands, and of *Rhinoceros incisivus* (Cuv.), *R. minutus* (Cuv.), *Palæomeryx minor* (Von Meyer), and *Hippotherium gracile* (Kaup), common to the Littorinella-limestone, proves that these ossiferous sands, although somewhat newer, do in reality belong to the same general system of tertiary deposits as the underlying formations.

I will not attempt to point out any inferences as to the nature of climate or geographical features of the then existing country, which might be drawn from the habits and characters of the mammalian animals whose remains have been here preserved; I leave it to the palæontologists and cultivators of comparative anatomy, whom we rejoice to reckon amongst our members and to see on our benches, to work out the interesting problems connected with this part of the question; but I venture, with great diffidence, to lay before the Society the reasons which have led me to incline to the opinion that the Marine Sands of Weinheim ought to be looked upon as *Miocene* rather than *Eocene*.

I say *Miocene* rather than *Eocene*, because I am not altogether prepared to admit the correctness of these terms, in the sense of looking upon them as two subdivisions the exact boundaries of which can be accurately laid down or defined. I believe that if we could obtain sections of all the European tertiary deposits, from the nummulitic limestone up to the most recent post-pliocene formation, we should be able to make out, in one section or another, a constant unbroken sequence, without either break or interruption. I do not mean to assert that no local changes or interruptions took place during this period; on the contrary, they were probably very frequent. Animal life also was undergoing a slow but gradual change, from the earliest post-cretaceous to the existing forms, regulated according to the more or less favourable conditions under which it was placed, contemporaneously with the changes going on in the physical condition of the region; but I do not believe that these changes or disturbances were universal, or that the causes which occasioned the destruction of one species and the introduction of another operated at the same epoch in all parts of the then European seas. In process of time, as the different changes in relative height, in elevation above and depression beneath the mean level of the ocean, extended, did the change in animal life also extend, modifying it everywhere on the same general principles, again to be locally modified by the differences of soil, rocks, and sea-bottoms, until it had travelled through all the changes from the commencement to the close of the tertiary epoch.

I have said thus much to show that I do not attach any great importance abstractedly to the question as to whether the beds we are now considering should be called Upper Eocene or Lower Miocene; for although I think they contain a greater number of fossils identical with those found in other countries in formations above rather than below them, the mere name of the beds is not the real question before us. One thing however is certain, that they have a greater resemblance with the *Limburg*, and particularly with the *Kleyn Spawen* beds, than with any other known European formation. They contain also some fossils similar to those below, and others identical with those above. As however the question has been raised, whether they should be placed in the Eocene or Miocene subdivision, I will briefly state my reasons, founded on physical as well as on palæontological grounds, for the conclusion at which I have arrived.

It is well known that the author of this nomenclature founded his system on the different proportions of the fossil shells found in each formation which are identical with living species, on the assumption that, in proportion as we ascend to a higher bed, the greater is the identity between its organic contents and the existing fauna; and although he refuses to entertain the idea of connecting these divisions with sudden and violent interruptions in the ordinary course of events, or with violent revolutions in the physical geography of the earth's surface, he cannot deny that the changes of strata are owing to physical causes and to alternate elevations and depressions occasioned by subterranean convulsions. If, then, these subdivisions of Eocene, Miocene, and Pliocene are to be considered as representing true geological horizons, it must be admitted that they depend on some external facts, some natural, but partial convulsions, which, by altering the relative levels of land and water, or by other similar causes, changed the conditions of life, causing the destruction of some then existing species, and producing the necessary conditions for the introduction or creation of new ones. If this be not the case, the lines or divisions are made to depend on the accidental varieties of numbers, which may be owing to merely local or temporary causes, and could hardly be considered as a sufficient basis for a philosophically-established nomenclature.

It is, therefore, not unreasonable to assume, that, wherever the real line of demarcation between any two subdivisions is to be drawn, some physical change or convulsion must have occurred at no great distance, by which the conditions of life were suddenly altered, although further off no real break took place in the continuity of deposits, and there the change of species was so gradual, and almost imperceptible, that it was impossible to draw a true geological line of separation. Where, however, the sudden change did take place, there the line of demarcation can be distinctly drawn, and will thus serve as a correct guide to the separation of other beds. We have, then, no difficulty in saying, where one deposit ceases, "This is the end of the old system," and where a new deposit commences, "This is the beginning of the new system." Now, this is precisely the position we are in with regard to the Weinheim beds of the Mayence basin. They have been satisfactorily shown to be identical with the Middle Limburg beds; the Middle Limburg beds are part of a continuous series, gradually merging into those below and those above. They are called indiscriminately Upper Eocene by one author, Lower Miocene by another; and, belonging partially to both, they can yet be fully claimed by neither. With the Weinheim beds the case is very different; they can be shown, under successive modifications, clearly to belong to the same system as the beds above, but they have no relation whatever to those below. They lie unconformably on the Carboniferous Sandstone; they form the commencement of a series, the basis of the whole system. Here, then, we are enabled to say, "This is the beginning of the new system;" and we have consequently no difficulty, and ought to have no hesitation, in looking on the Middle Limburg, as well as the Weinheim beds, as the commencement of the Miocene series.

It would, I think, be inconsistent with all analogy to call a bed, which unequivocally forms the commencement of the whole tertiary system in the country, the upper bed of an old expiring series, rather than the lowest bed of a new series; the latter being in accordance with its true position, the former supposition being at variance with the local facts, and unsupported by satisfactory evidence.

These are the principal reasons which have induced me to refer the Marine Sands of Weinheim to the Miocene rather than to the Eocene formation, and not on account of any vague numerical proportion of forms agreeing more with the recent than with the older beds. No doubt they contain many Eocene forms, but we are not to assume that all life was destroyed at each successive period of change. The old forms were doubtlessly washed into the newly created seas, dead or alive, from the pre-existing Eocene waters; besides which, many species may have lived through the change, as we find species existing through the whole tertiary period, notwithstanding the many successive changes to which they must have been exposed*.

Part III.

On the Ancient Geographical Character and Connection of the Sea in which the Marine Fauna of the Mayence Basin was deposited.

One of the most interesting questions connected with the locality of the Mayence basin, and its marine fauna, is the insulated character of its position, and its probable channels of communication with the then existing ocean. The opinion generally entertained by the German geologists is, that the region occupied by these marine formations was at the period of their deposition an inland lake (Binnen-See), having no direct communication with the ocean, but containing a somewhat similar fauna in consequence of the saltness of its water. The abundant occurrence of Sharks' teeth of several species, and the remains of *Halianassa Collinii* in numerous places, sufficiently disprove this hypothesis. Notwithstanding the present difference of levels between the existing sea and the marine beds of Weinheim, amounting to between 500 and 600 feet, and the complete insulation of the region, these remains are a convincing proof

* It must, however, in justice be admitted, that, if this rule is fully carried out, we must not attempt to apply too arbitrarily the nomenclature of one place to the circumstances of another, when the physical changes which have disturbed the continuity of organic life have taken place at different periods. For example, in Belgium there is no break in the Limburg beds in the continuity of deposition. In Mayence the new system begins with the equivalent of the Middle Limburg series. In another country the physical change took place at a later period, viz. after the Upper Limburg beds or their equivalents were deposited. There we find a regular sequence of beds from the London clay to the Upper Limburg, and then it suddenly ceases, until it is overlaid by diluvial deposits. Here, then, we find that the equivalent of the bed which in the first locality was shown to be the commencement of a new series, and consequently is called Miocene, proves to be in another place the termination of the old series. We have no means of avoiding the conviction which forces itself upon us, that we must call it Eocene. Thus, the same beds which I call Miocene in Mayence, may with perfect propriety be called Eocene by Prof. Forbes, in the Isle of Wight.—July 12, 1854.—W. J. H.

that the sea in which the beds in question were formed must, at the period of their deposition, have been in direct connection with a then existing ocean. The numerous remains of Sharks also show that that ocean was not exclusively an Arctic one; and even the *Halianassa* tells the same story, its remains having hitherto been found in the Molasse of Switzerland, and at Malta. On the other hand, the large *Cyprina rotundata*, which can hardly, if at all, be distinguished from the recent *C. islandica*, shows that we must not look exclusively to a warm or semi-tropical connection.

The numerous volcanic regions, and the evidence of igneous agency of various periods, by which this district is surrounded, point at once to the causes which produced the different changes of relative level by which this connection was broken off. I will here only allude to a few of them. The great volcanic region of the Eifel, lying to the north and north-west of the Hundsrück, which forms the N.W. boundary of our district, is one of the recent results of igneous action. The outpourings of basaltic rocks, which have elevated and broken up the Brown-coal deposits of the Westerwald, must have been active agents in modifying the physical configuration of this country. The basalts of the Fichtelgebirge, and those in the vicinity of Hanau and of Frankfort, and in the Coal-field of the Wetterau, have probably been equally effective.

Let us now look at the various tertiary deposits existing in the neighbouring countries, to see how far any connection between their areas and that of the Mayence Basin may be supposed to have existed.

I. *Belgium.*—From the evidence brought forward in the former part of this paper (page 279), there can be no doubt as to the great resemblance between the fossils of the Weinheim sands and those of the Middle Limburg beds, and particularly the so-called Pectunculus-bed, constituting, according to Sir C. Lyell, the upper portion of those Middle Limburg beds.

The large proportion of identical species in these two formations is alone sufficient to lead to the conviction that some connection must have existed between these two marine basins. Three species of *Lamna*, viz. *L. cuspidata*, Ag., *L. denticulata*, Ag., and *L. contortidens*, Ag., also occur in these beds, which are not only found in the Limburg beds, but in those near Turin.

II. With the tertiary formations of *France*, no special direct communication appears to exist, beyond what may be traced through the tertiaries of Belgium. The two districts are here separated by a large tract of intervening mountain-ranges, consisting of jurassic, liassic, and carboniferous rocks, against which the Weinheim beds appear to have been subsequently deposited.

III. *Switzerland.*—I greatly regret not having yet had an opportunity of seeing Prof. Studer's second volume on the Geology of Switzerland, in which the fossils of the Molasse are worked out*.

* Since the above was written, the second volume of Prof. Studer's work has

The collection in the museum at Berne was not, when I visited it, completely arranged, nor were the localities given with such a degree of accuracy as to show from what portion of the Molasse the large collection of Mollusca, classed generally as belonging to it, was derived. The principal features which struck me were the great preponderance of Bivalves, and the rather more recent *facies* of the whole collection. It is well known that this formation is very generally extended over the great central valley of Switzerland, between the Alps and the Jura; it is to be traced in almost all the valleys of the Jura, forming terraces on the sides of the hills, or occupying the bottoms; and it also occurs in most of the valleys on the northern flank of the Jura, opening into the valley of the Rhine below Basle†; and a few miles from Basle, north of the Rhine, at Lörrach in Baden, is one of the best localities, according to Prof. Merian, for studying the Molasse formation, where it occurs as a kind of calcareous rock (formerly extensively quarried), and overlaid by freshwater limestone. Indeed it is said that this formation may be traced all round the basin of the ancient sea, and along the hills of Alsace, where a large species of *Ostrea* is found attached to the jurassic limestone, on which it once grew when this limestone formed the cliffs rising up from the shore of the tertiary sea.

When we look at the physical connection between the formations of the Mayence basin and the older rocks against which they are deposited, it is evident that the hills which constitute the western side of the Valley of the Upper Rhine, forming the mountains of the Haardt and the Vosges, had already assumed in a great measure their present forms and characteristic outlines before the deposition of the tertiary beds. On the western side of the Rhine the tertiary

reached England, giving the results hitherto obtained respecting the fossil contents of the Molasse. In general, however, the specimens are so imperfectly preserved, that it is difficult to make out the species accurately. Yet, from the list published by Prof. Studer, it is remarkable what a large proportion of the *Mollusca* of the older Molasse of Basle, Porrentruy, &c., are identical with the fossils of the Mayence basin. After describing these Molasse beds, and hesitating as to whether they should be referred to the Eocene or Miocene groups, showing that in some places they approach an eocene, in others a miocene *facies*, Prof. Studer observes that there is a remarkable analogy, which might almost be called identity, between the North Jura marine tertiary formation and that of the Mayence basin; not only in the rock itself, but in its organic remains, singularly like those of the Mayence basin; and, although many species are difficult to identify, some of the most characteristic, as *Halianassa* and Fishes, *Cerithia*, *Natica gigantea*, *Panopæa intermedia*, *Corbula pisum*, *Pectunculus crassus*, and *Ostrea Collinii*, are common to both formations.

† It now appears from Prof. Studer's work, that the Molasse formation must be separated into two chief divisions: 1. That of the Northern Jura; 2. That of the Interior or Mittel-land. The former is overlaid by a freshwater formation; the latter, which assumes a more recent character, is divided into two subdivisions,—the subjurassic and subalpine zones, and lies between two freshwater formations. Of these, the fauna of the Subjurassic zone has considerable resemblance with that of the Marine Molasse of Basle; while the fauna of the Subalpine zone is compared with that of Bordeaux, Vienna, and the Subapennine formation of the North of Italy.

limestones may be traced at nearly the same level, following the sinuosities of the valleys, and appearing as beaches of the ancient sea; thus agreeing with what we have already seen to be the case in the valleys of Switzerland. On the eastern side of the Rhine, where volcanic outbursts of a more recent period are visible, the evidence is not so conclusive; but even here, tertiary beds of sandstone and Molasse can be made out in various places, as at Heppenheim, between Darmstadt and Heidelberg, and further south near Offenburg.

IV. Extending our view to the other tertiary deposits round the district we are examining, we meet with the interesting formations of the Vienna Basin. The general character of most of the fossil remains,—for they are said to belong to two periods,—which have been found in this formation, to which the name of "Tegel" has been applied by the German geologists, and a list of the chief of which has been published by the Imperial Geological Institute of Vienna, appears to be more recent than that of the Weinheim fossils. According to Burmeister *, these middle tertiary formations extend in Germany down the Valley of the Danube from the Lake of Constance to Vienna, and stretch along the base of the Carpathian Mountains. This author considers the Tegel formation to be nearly if not quite contemporaneous with the Molasse and Nagel-fluhe of Switzerland.

The following species are common to the lists published by the Imperial Geological Institute and by Prof. Studer † as belonging to the younger Molasse:—

Conus Mercati, *Brocchi.*
Ancillaria glandiformis, *Lam.*
Mitra fusiformis, *Brocchi.*
Columbella curta, *Bellardi.*
—— nassoides, *Bellardi.*
Buccinum reticulatum, *Grat.*
—— semistriatum, *Broc.*
—— mutabile, *Linn.*
—— baccatum, *Basterot.*
Rostellaria pes-pelicani, *Lam.*
Ranella marginata, *Lam.*
Fusus burdigalensis, *Grat.*
Cancellaria cancellata, *Lam.*
Pleurotoma asperulata, *Lam.*
—— pustulata, *Broc.*
—— turricula, *Broc.*
Cerithium margaritaceum, *Lam.*
—— scabrum, *Desh.*
Turritella terebralis, *Lam.*
—— Riepellii, *Partsch.*
Trochus patulus, *Brocchi.*
Sigaretus haliotoideus, *Lam.*
Natica millepunctata, *Lam.*
Crepidula unguiformis, *Lam.*
Mactra podolica, *Eichwald.*
Corbula revoluta, *Broc.*
Lucina divaricata, *Lam.*
Cytherea pedemontana, *Agassiz.*
—— erycinoides, *Lam.*
—— multilamella, *Lam.*
Venus plicata, *Gmel.*
Cardium Deshayesii, *Payr.*
Arca barbata, *Linn.*
—— diluvii, *Lam.*
Pecten Solarium, *Lam.*

Many other identities will probably be found to exist, when the synonyms shall have been more carefully examined. Dr. Sandberger informs me that he was much struck, on visiting the Vienna basin last year, with the remarkable analogies between it and the upper portions of the Mayence basin.

V. The next tertiary deposit to which we must allude are the

* Geschichte der Schöpfung, fourth edition, p. 275.
† Geol. Switzerland, vol. ii.

Brown-coal beds, existing in numerous localities on the frontiers of Saxony and Bohemia. I am unable, however, to give any details of it; but its existence is worth mentioning in connection with the beds to which we must now allude.

VI. At Westeregeln, in the neighbourhood of Magdeburg, an interesting tertiary formation exists, abounding in fossils, which is now beginning to attract considerable attention. It is of peculiar importance with reference to the correct position of the Mayence basin, inasmuch as its exact relation to this formation appears from Dr. Sandberger's statements to have been satisfactorily made out. These sands or sandstones of Westeregeln are paralleled with the Septaria-clay of Celle, Berlin, and Mecklenburg. It is said to overlie the Brown-coal formation of the Westerwald, which is itself the uppermost of the two Brown-coal formations of the Mayence basin. It forms a portion of those tertiary formations which extend through Northern Germany, from the confines of Holland and Belgium, on the west, to the Oder, on the east, and the fossils of which are now in the course of publication by Dr. Beyrich of Berlin. It is a portion of the same great oceanic deposit which has been already observed in the vicinity of Cassel, although the exact parallelisms of age have not yet been fully worked out; but the general resemblance of the Cassel beds to those of Weinheim is sufficiently clear from the following extract of a private communication which I have received from Dr. F. Sandberger:—

"At Cassel I observed the following section, in descending order. 1st. Cassel marine beds. 2nd. Clay with calcareous nodules, containing the same fossils as the Wiesbaden beds. 3rd. Quartzose sandstones, occasionally containing leaves not yet made out. 4th. Brown-coal deposits separated by layers of clay. 5th. As the basis of the whole deposit, and immediately resting on the Muschelkalk, a bed of clay, containing the characteristic fossils of the Cyrena-marls" (the lower blue clay of Weinheim).

The following list will give some idea of the fossil contents of the Westeregeln beds. I have received it from Dr. Sandberger, and it must be understood as only giving those species which he has already received; I believe it, however, to be nearly complete.

Table VII.

List of Fossils from the Magdeburg Sands hitherto received by Dr. Sandberger.

(Those marked with an asterisk * occur in the Weinheim beds.)

*Teredo, sp.
Teredina Hoffmanni, *Phil.*
*Corbula striata, *Lam.*
*—— pisum, *Sow.*
—— Henkeliusiana, *Nyst.*
Tellina donacialis, *Lam.*
Astarte Henkeliusiana, *Nyst.*
—— vetula, *Phil.*
——, sp. (aff. *A. gracilis*, Münst.)
Diplodonta apicalis, *Phil.*
Cardium porulosum, *Brand.*
*—— tenuisulcatum, *Nyst.*

Table VII. (*continued*).

Cypricardia pectinifera, *Sow.*
Cardita (aff. *C. aculeata*, Poli).
—— Avellana, *Phil.*
*—— orbicularis, *Bronn.*
—— analis, *Phil.*
Crassatella intermedia, *Nyst.*
Pectunculus (aff. *P. pulvinatus*, Lam.).
Limopsis granulata, *Lam.*
Nucula Dechenii, *Phil.*
Leda Galeottiana, *Nyst.*
*Pinna margaritacea, *Lam.*
*Panopæa Hebertiana, *Bosq.*
Pecten Solea, *Desh.*
Ostrea ventilabrum, *Goldf.*
——, sp. undeterm.
Anomia orbiculata, *Nyst* (non *Brocchi*).
Bulla apicina, *Phil.*
——, sp. undeterm.
Tornatella, n. sp. (aff. *T. simulata*, *Brand.*)
*Natica Hantoniensis, *Sow.*
*—— glaucinoides, *Sow.*
Calyptræa, sp. undeterm.
Littorina sculpta, *Sow.*
Scalaria, n. sp.
Turritella, n. sp.
Planaxis, n. sp.
Solarium plicatum, *Lam.*
Pleurotoma turbidulum, *Nyst.*
*—— conoideum, *Brand.*
—— Volgeri, *Phil.*
—— uniseriale, *Desh.*
*—— flexuosum, *Münst.*
*—— Waterkeynii, *Nyst.*
—— granulatum, *Lam.*
*—— Selysii, *De Kon.*
—— var. *semilæve*, Phil.
Pleurotoma multicostatum, *Lam.*
—— ventricosum, *Lam.*
—— attenuatum, *Lam.*
Borsonia, n. sp.
*Fusus elongatus, *Nyst.*
—— funiculosus, *Lam.*
—— plicatellus, *Lam.*
—— conjunctus, *Desh.*
——, sp. undeterm.
Pyrula lævigata, *Lam.* var.
—— clathrata, *Lam.*
*Cancellaria evulsa, *Brand.*
——, n. sp.
Typhis, sp.
*Tritonium argutum, *Brand.*
Chenopus, sp.
*Cassidaria depressa, *v. Buch.*
Buccinum fusiforme, *Desh.*
Mitra marginata, *Lam.*
——, sp.
Terebra, sp.
Voluta semigranosa, *Nyst.*
—— suturalis, .
—— labrosa, *Phil.*
—— eximia, *Beyr.*
Cypræa sphærica, *Phil.*
Marginella ovulata, *Lam.*
Terebellum, sp.
Ancillaria, n. sp.
—— buccinoides, *Lam.*
Conus Allionii, *Michelotti.*
Dentalium acutum, *Héb.*
——, sp.
Serpula turbinata, *Phil.*
Nonionina magdeburgica, *Phil.*
Lunulites, sp.
*Lamna cuspidata, *Ag.*
*—— contortidens, *Ag.*

VII. Lastly, I will only briefly allude to the freshwater deposits of *Bavaria* and of *Wurtemberg*, found in the neighbourhood of Ulm. These contain nearly the same land and freshwater Molluscs as the Littorinella-limestone of Hochheim and Wiesbaden; but I am not aware that they have ever yet been found to rest on or to be associated with the marine tertiaries. They represent great inland freshwater lakes, and are therefore not so directly connected with the objects of this memoir.

Having thus briefly laid before the Society the principal facts connected with those tertiary marine formations which are found in the nearest propinquity to the Mayence basin, we shall be enabled to form some opinion as to the real connection between these beds and the ancient ocean. It seems probable that at some period during the middle tertiary epoch a communication existed between what now forms the Mediterranean to the south, and the great northern ocean which extended over the greater part of northern France, Belgium, Holland, and the north of Germany. The nucleus of the European Continent was then but a group of detached rocky islands, some of them consisting of long mountain-ridges or backbones, indicating the line of subsequent mountain-chains, and more or less connected by submerged reefs with each other or with other masses of land which appeared above the surface of the water. That a considerable portion of the Alpine chain has been elevated at a comparatively recent tertiary period, we know from the late investigations, amongst others, of Sir R. I. Murchison, whose elaborate paper, on the Geological structure of the Alps, Apennines, and Carpathians, not only points out the extraordinary disturbances which have occurred in the Alps, but shows that the earlier tertiary formations, the nummulitic limestone and the "Flysch," have been so tilted as to assume not only a vertical, but even an inverted position, and that, while they show a thickness of more than 8000 feet, thus proving the great length of time during which their deposition was taking place, they have been raised to the height of many thousand feet above the level of the sea. But this is not all: the same remarks apply to the Nagelfluhe and the Molasse formation, also exceeding 6000 or 8000 feet in thickness, and of a more recent date; so recent indeed, that Sir Roderick Murchison does not hesitate to refer them to the older Pliocene age; and yet they are described as having, both on the northern and southern flanks of the Alps, been raised into a vertical, and, in some places, even an inverted position. Thus, admitting even the Molasse to be of a more recent period than the Mayence beds, we have here sufficient evidence of a great portion of the North of Italy, the Alpine district, and even the Northern parts of Switzerland, having been covered by the waters of the sea, not only during the earliest, but during the most recent period of the tertiary epoch, leaving only the highest portion of the mountain-peaks as islands.

Again, to the north, we have evidence of considerable elevation and disturbance, although, perhaps, not to the same extent; nor can we be at a loss to ascertain some at least of the causes which have produced these results. The volcanic outbursts, attributable to the tertiary period, which abound in the greater part of the western and central portions of Germany, point out to us the causes of these disturbances. They belong, however, to different periods; consequently the results they have produced are local. But it is not only with phænomena of elevation that we have to do; evidence of depression is also there, and that is exactly what we should expect. Elevation in one spot is in most cases, if not always, accompanied by depression in another. The very fact of the enormous thickness to which the tertiary formations of the Alps have been accumulated, is a convincing proof, that, contemporaneously with their deposition, subsidence must also have been going on, or they could never have attained to such a thickness. The eruptive phænomena of the Eifel belonging to various ages, the basaltic outbursts of the Westerwald, the Fichtelgebirge, and the Wetterau have all contributed to bring about those changes which first produced and then cut off the communication between the Mayence basin and the German Ocean.

The Mayence beds rest immediately on the older formations of the New Red Sandstone, the "Rothe-todte-liegende" of the Germans. We may therefore conclude, that during the Cretaceous and earlier tertiary periods this portion of the country was dry land, sloping gradually to the southward from the mountain-districts of the Hundsrück and the Taunus, until it met the southern ocean in which the "Flysch" was being deposited, off and around the group of islands which formed the nucleus of the Alpine chain, now such an impassable barrier between the Mediterranean and the North Sea. This depression or gradual sinking continued, affecting in all probability, to a certain extent, the neighbouring continent, until it reached such a point, aided to all appearance by other local depressions, as to occasion the formation of that remarkable valley of the Upper Rhine from Basle to Mayence and Bingen, and opening to the eastward round the Taunus into the German or Northern Ocean.

There, in a bay of this newly opened sea, were deposited those beds now under consideration, which, while partaking of the quasi-tropical character of the Mediterranean, also combined many forms peculiar to that ocean which had long existed to the north of the Hundsrück and the Eifel, occupying the site of Belgium and the north of France, and depositing the various forms of the Eocene period. With such a change as this, however, new conditions of life must have been introduced. The volcanic agency exerted in many places rendered these waters for a time unfit for animal life. The deposits on the various coasts were modified and changed, new river-channels were formed, while old ones were blocked up, and species which could only exist under the former circumstances necessarily disappeared, while others adapted to the new conditions were introduced.

As far as has been hitherto observed, the animal whose remains have been found in the lowest portion of the Marine Sands of the Mayence beds is the *Halianassa Collinii*, associated with the numerous teeth of one or more species of *Lamna*. Now, we do not find *Halianassa Collinii* anywhere amongst the Belgian fossils; but it has been found in a portion of the Vienna basin, in Switzerland, and, if I am not misinformed, at Malta; thus showing a connection at this period between these beds and the southern or Mediterranean ocean. But this remarkable animal, of which the perfect skeleton was lately found in the sands of Uffhofen (page 264), does not occur in the upper beds; it may thence be inferred that soon after the opening of this channel, and before the more torpid and slowly moving Molluscs had reached a distance which the Sharks, &c. had rapidly traversed, the subsidence of the Alpine region, indicated by the vast thickness of the "Flysch" beds, had ceased, and, in compliance with that law of oscillatory movement, which appears in former periods to have been so universally prevalent on the surface of our earth, had been succeeded by an upward movement, which extended so far as to cut off the connection with the Mediterranean, leaving open only that with the northern and Belgic ocean. This continued for a long lapse of time, during which the Marine Sands of Weinheim were being deposited. But other changes accompanied this gradual elevation; as we approach the upper portion of these sands, we find *Cerithia* more abundant, indicating, if not already a brackish condition of the water, at least a diminution of depth and the presence of freshwater streams flowing into the sea at no great distance. And this is precisely what *à priori* we should expect. The closing of the communication by the Alpine range converted what had previously been an open passage, like the straits of Gibraltar, connecting one ocean with another, into a deep land-locked bay or æstuary, where the depth of water would necessarily diminish independently of any elevation, and the influence of the neighbouring streams would be constantly greater in diminishing the saline properties of the water.

But after a time, another change took place. The deposits changed from an arenaceous to an argillaceous character. The blue clay formation (Cyrenen-Mergel of Sandberger, and lower Brown-coal formation of former German writers) bears indications of important changes in the neighbourhood. Volcanic eruptions may have caused the rivers to bring down a thick and muddy sediment, which was carried to the northern point of this long narrow æstuary; or, more probably still, the partial and ever-increasing closing up of the channel leading to the North Sea may have caused those particles of clay and mud, previously carried out through the northern straits, to have been here deposited, containing in some places those accumulations of drifted vegetable matter which have contributed to the formation of the Brown-coal beds. How the closing up of the northern channel was brought about, we are not yet in a condition to explain; but it may have been occasioned by the elevation of the Fichtelgebirge, or by some of the neighbouring basaltic outbursts which I have not yet been able to examine.

At the same time a gradual, but general, elevation of the land appears to have been going on elsewhere; inasmuch as the presumed parallel beds of the Upper Limburg series were also becoming brackish, resting on the purely marine beds of the Middle Limburg formation. The analogy, however, is not complete. In Belgium the succeeding deposits maintain their marine character, whereas in the Mayence basin the blue clays are immediately succeeded by a thick deposit of calcareous matter, the fossil contents of which not only indicate the continued brackish nature of the water, but show that it was gradually losing its saline qualities, and becoming more and more fitted for the existence of freshwater molluscs. During this period, when all communication with the Northern Ocean appears to have been cut off, the calcareous beds of the Cerithium and Littorinella limestones were deposited in a great inland lake having no apparent outlet. Large streams of fresh water, flowing from the S., the W., and the S.W., the parents of the present Rhine, the Neckar, the Maine, and the Kinzig, brought down large accessions of material, to fill up the bottom of the basin, and to raise the surface of the water, imbedding in it at the same time, in particular localities, the *débris* of the terrestrial molluscs which had lived upon their banks. These remains, in certain favourable spots, have been heaped together in such abundance as to have obtained for those formations in which they are found the name of "freshwater limestone." At the same time, on the western shores of the lake, between Kreuznach and Dürckheim, it is probable that the saline character of the water was maintained by those abundant salt-springs, which, even in the present day, issue from the neighbouring rocks, bringing health and wealth to the surrounding population, and giving evidence of that secret and subterranean activity which in one form or another has at all periods and in all places modified the crust of our globe.

We have seen that during this period calcareous rocks were deposited to a great extent in this northern portion of the upper Rhenish lake. From whence was this calcareous matter derived?—and why should it have been mainly deposited in this portion of the basin? It appears to have been owing to one, if not to both, of the following causes. It may have been deposited from local springs highly charged with calcareous matter, or it may have been derived from the material brought down by the many rivers which flowed into the lake; and its deposition in this particular spot may have been partly brought about by the greater amount of animal life living in this still brackish water, to whose existence and growth this calcareous matter was subservient; or partly, perhaps, by some chemical influence, the result of the action of the salt-springs upon the water thus charged with calcareous matter. But, that it has in some places at least owed its origin to calcareous springs of a local character, is I think sufficiently proved by the structure of the rock itself. I need only refer to fig. 10. p. 269, where the hard portion of the limestone rock, evidently formed contemporaneously with the softer and more sandy beds to the S.E., containing the intercalated beds with *Venus incrassata*, is altogether made up of a congeries of hollow pipes and stems, as if it were the remains of a mass of incrustations around the delicate fibres of mosses or confervæ. A similar structure may also be seen in many other localities, particularly along the line of limestone cliffs to the S.W., in the neighbourhood of Dürckheim and Kahlstadt; and, wherever this occurs, the limestone itself is spongy and cavernous, full of small irregular cavities, and frequently containing nuclei of a harder and more solid texture.

Other changes subsequently took place, which we can now hardly stop to consider. In some parts of this lacustrine basin the calcareous beds were covered up by morasses and forests, as in the Wetterau and the Westerwald. A description of the fossil flora of this district would be a subject of great interest, for amongst the curious relics of the period which have been rescued from the Brown-coal of the Wetterau are perfect specimens of more than one species of Vine, the fruit itself being preserved in the form of petrified raisins*. These forests and morasses were subsequently converted into

* See Official Report of the 29th Meeting of the Society of German Naturalists at Wiesbaden, 1853, p. 155.

Brown-coal, and have been convulsed, contorted, and broken up by penetrating dykes and outbursts of basaltic and other igneous rocks. Again the alternate action of subsidence was introduced, and the northern portion of this Brown-coal became submerged under the waters of the northern sea, inasmuch as we find the Brown-coal again overlaid by the marine deposits of Westeregeln and Magdeburg. But it is almost premature to enter on this question; I have not myself yet visited the locality.

We have thus faintly attempted to trace the possible history of the origin of the Mayence basin formations, and of their gradual rise until the waters in which they were deposited had reached their highest level. It only remains, in conclusion, to say a few words respecting their probable drainage and the desiccation of the Rhine Valley. Assuming that no outlet existed for its waters, the surface-level of the lake must at last have reached a height at which they would overflow the mountain-barrier by which they were enclosed. This spot appears to have been at the commencement of the narrow gorge near Bingen, by which the Rhine now escapes from the Rheingau, and flows through the most picturesque and striking scenery of Northern Europe, between Bingen and Coblentz. The formation of this gorge was in the first instance probably owing to volcanic agency. The mountain-chains of the Hundsrück and the Taunus were already partially riven asunder, and the long pent-up waters, finding at length an outlet, rushed with overwhelming force through the chasm, removing all opposing obstacles, and carrying with them a large portion of those deposits which had previously formed the bottom of the lake. The imagination is bewildered in contemplating the details of this stupendous operation; but it is not unreasonable to suppose that something similar, if not indeed of a grander character, took place during the process of cutting back this mighty channel, to what we now see in the St. Lawrence, while cutting back its channel from Lake Ontario to Lake Erie. It is vain to attempt to calculate the time which must have elapsed during this operation, when we consider the hard nature of the Devonian schists through which the waters had to cut their way; but when we add to this, that a similar lacustrine basin exists between Coblentz and Neuwied, below which again the river has cut its way through another mighty gorge, from Andernach to the Siebengebirge, we can only wonder at the countless ages which must have gone by during this comparatively small period of the tertiary epoch, itself one of the shortest of the many successive ages which the study of the crust of our globe has brought to our knowledge.

MARCH 8, 1854.

Neville Story Maskelyne, M.A., Dep. Professor of Mineralogy, University of Oxford; B. Waterhouse Hawkins, Esq., S. P. Woodward, Esq., and Charles Wentworth Dilke, Esq., were elected Fellows.

The following communications were read:—

1. *On the* GEOLOGY *and* MINERALOGY *of* MOUNT ALEXANDER, *and the adjacent Country, lying between the* RIVERS LODDON *and* CAMPASPE. By ALFRED RICHARD CECIL SELWYN, Esq., Director of the Geological Survey of Victoria.

[Communicated by Prof. A. C. Ramsay, F.G.S.]

THE whole of the above district is occupied by four different geological formations—

1. Granite.
2. Metamorphosed palæozoic strata.
3. Basalt.
4. Auriferous drift.

The extent of country occupied by the first three of the above formations may be seen on referring to the accompanying map*; [by which it is shown that Mount Alexander forms part of a granitic range, extending from the River Coliban, on the east, to the Loddon on the west, with a breadth varying from four to twelve miles, and describing an irregular semicircle, with its convexity to the north. The granite is bounded on all sides by metamorphic rocks; and at its eastern extremity it is overlaid by patches of basaltic lava, amongst which the Coliban runs. The basalt occurs also to the east of the Coliban in still greater extent, overlying the metamorphic rocks along the course of the Campaspe River. At the western limit of the granite also, similar basalt forms the lava-plains on the Loddon.] The fourth is more or less universally distributed over the area occupied by the second.

Granite.—The granite everywhere forms an open forest country, consisting of high rocky ranges and undulating grassy hills; enormous blocks, standing out in bold relief, lie scattered on the summits and flanks of the hills, often affording the most picturesque scenery. These blocks are always *in situ*, and are the result of the decomposition of the softer portions of the rock. The rock itself is, for the most part, a coarse-grained ternary granite (quartz, felspar, and black and sometimes yellow mica), often very soft, friable, and easily decomposed. In some few places the granite appears to pass into Pegmatite, a compound of quartz and felspar. It generally possesses a large spheroidal or concretionary structure, composed of concentric

* [This map has been published in the First Report of the Geological Surveyor of Victoria.]

Section from the River Loddon over Mount Tarrengower and Mount Alexander to the River Campaspe.

coats. The whole being traversed by a system of north and south and east and west joints, causes it to break up into large, rectangular, slightly-curved slabs and blocks, affording a good and easily quarried building material.

Numerous "elvans" or dykes occur, cutting through the granite in various directions, in long narrow bands; they are generally composed of a hard, compact, and very fine-grained granitic rock, of a reddish colour, and are evidently of a posterior formation to the mass of the granite.

I have been unable to discover any metalliferous veins in the granite, and, from the general homogeneous character of the rock, and the entire absence of quartz-veins, I should not anticipate the discovery of gold or other metals in this district.

Metamorphosed Palæozoic Strata.—Surrounding the above district on all sides, except to the south-east, where the granite is overlaid by the lava plains of the Loddon, we have a mass of metamorphosed palæozoic strata, striking everywhere true north and south, and dipping east and west at angles varying from 45° to 90°.

These strata consist of—1st. Ferruginous, micaceous, and felspathic sandstones and grits, of various shades of red, grey, and brown; 2nd. Hard and soft arenaceous and felspathic clay-slates, and fine arenaceous-banded flag-stones; 3rd. Quartz-rock and fine-grained quartz-conglomerate.

The country occupied by these rocks consists chiefly of bold, rocky, scrubby ranges and gullies, and more openly timbered flats; the highest points of the ranges being immediately adjoining the granite boundary. This is a very marked feature; the junction of the granite and metamorphic rocks being almost invariably at the base or on the flanks of a steep rocky range. The palæozoic strata everywhere for a short distance from the granite exhibit traces of alteration, being generally more crystalline, harder, and more micaceous, but very rarely pass into true mica-schist.

The whole mass of these sandstones, clay-slates, &c., is traversed by an intense north and south cleavage, as well as by a system of large joints, both north and south and east and west; the former generally dipping at right angles, or in an opposite direction to the cleavage-planes. This system of joints and cleavage renders the true line of stratification very obscure; they [the strata] appear, however, generally to coincide in strike with the cleavage, but are dipping at a somewhat lower angle; this can only be detected on a close and very careful examination.

Coincident with the cleavage, both in strike and dip, and more or less numerous throughout the whole of the palæozoic strata I have examined, are veins of white and reddish quartz, from a few inches to 6 or 7 feet in thickness; associated with these veins, coating the joints and fissures, we often find much red hæmatitic iron. In the quartz, occurring in nests and cavities, I have seen—

1. Gold.
2. Galena (sulphuret of lead).
3. Blende (sulphuret of zinc).
4. Arsenical iron.
5. White iron-pyrites.

I have heard of platina having been discovered, but have never seen any.

I have been unable, as yet, to detect any organic remains in these rocks, and have, therefore, at present no good evidence as to their actual geological age; judging merely from lithological character, I should, however, consider them equivalents of the Cambrian or Lower Silurian strata of Great Britain, many portions of which, as seen in North Wales, they precisely resemble.

The total thickness of these rocks in this district is somewhere about 35,000 feet.

Basalt.—Resting horizontally on Nos. 1 and 2, in isolated patches and large tracts, forming table-lands, flat-topped rocky hills, with steep escarpments, or extensive undulating plains destitute of timber, are large masses of basalt, composed of augite, magnetic iron, and felspar, sometimes hard, heavy, and compact, and often cellular and scoriaceous, especially on the surface, having the appearance of subaërial lava. The vesicles are filled or coated with carbonate of lime and oxide of iron, in mammillated crystals. On the weathered surfaces these vesicles are generally empty, the carbonate of lime and the iron being decomposed, and the rock having externally a very red and rusty appearance.

This basalt is evidently the remnant of vast lava-streams, which appear to have flowed down and filled up the then existing valleys of the country, bringing them nearly to a level with the tops of the lower ranges. Through these lava-streams the present river-courses have been subsequently excavated, always exposing, when cutting sufficiently deep, the subjacent granite, or the stratified rocks on which it rests. On the surface, this lava has generally a spherical concretionary structure, breaking up into rounded or subangular blocks; this structure becomes columnar whenever the lava attains a considerable thickness, say 100 to 200 feet; this being probably due to the slower cooling and more perfect crystallization of the lower portions of the mass. A good example of this may be seen at the junction of the Campaspe and Piper's Creek, where the lava and subjacent stratified rocks are exposed in almost vertical cliffs from 200 to 300 feet in height.

Auriferous Drift.—This formation, of very late tertiary date, varies in thickness from a few inches to 100 feet and upwards, and consists of stratified and unstratified masses of ferruginous clays, sands, and gravel, interspersed with angular and partially rounded fragments of clay-slate, sandstone, quartz, &c. It occurs almost universally distributed in the gullies, on the flats, and over the hills occupied by the palæozoic strata, and is in fact formed from the decomposition, breaking up, and spreading out of the immediately subjacent rocks; the fragments found in it being, with a few local exceptions, seldom much water-worn, and bearing no evidence of having been transported from a distance. The lowest stratum or bottom almost always varies in colour and character with the nature of the subjacent rock, whether a ferruginous clayey sandstone, forming a red or mottled ferruginous sandy clay, or a soft felspathic slate, producing a white pipe-clay, &c.

With respect to the origin and present position of the gold, there can, I think, be little doubt that the whole of it has been formed in the quartz-veins which are now seen traversing the palæozoic strata; and that its present position in the drift is entirely due to the decomposition, breaking up, and spreading abroad of the quartz-veins, along with the ordinary sandstones, slates, &c. of the district. Its general position in the lowest portion of the drift, resting immediately on the solid rock, is due, 1st, to its great specific gravity, as compared with the rest of the materials forming the associated drifts. 2nd. It has always been supposed that gold-veins are richest near the surface, and, unlike other mineral veins, gradually become poorer the deeper they are followed. Such being the case, it follows that the deposits now occupying the lowest portions of the Drift, formed from those portions of the auriferous quartz-veins which were first broken up and distributed during the period of the Drift, would be much richer than any deposits formed by subsequent denudation from less superficial portions of the auriferous veins, and all experience tends to prove that such is actually the case.

With respect to the range and extent of this Drift-formation, I can only state, that every part of the country I have seen which is occupied by palæozoic strata (coloured lilac on the Map) is more or less covered with drift of the same character, derived from rocks abundantly intersected by quartz-veins. The real value of it can, however, only be ascertained by actual working.

Between the western boundary of the granite and the River

Loddon, this drift appears to attain a great thickness, forming an almost level forest-country, extending for many miles, and quite concealing the underlying rocks.

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2. *On the* Gems *and* Gold-crystals *of the* Australian Colonies. By G. Milner Stephen, Esq., Barrister, F.G.S., V.Pres. Geol. Soc. of Victoria.

Until the discovery of the great gold deposits in Australia*, the colonists considered no other mineral productions than copper and lead deserving their research; although specimens of native gold were publicly exhibited (and seen by myself) in a jeweller's shop in Sydney so far back as 1836, brought by a Bathurst shepherd periodically from that locality; and although in the sister colony of South Australia a vein of red ferruginous earth, richly charged with gold (specimen G.), had been found in a copper-mine near Adelaide in the year 1845, *six years* before Mr. Hargreaves made his first communication to the Sydney government.

And yet the colonists (those of South Australia especially, who were the earliest pioneers in the mining-field) could not be justly taxed with apathy on the subject of their hidden treasures, inasmuch as there was little inducement for them to make discoveries, whilst they found ample employment for their limited capital and scanty supply of labourers in their highly profitable agricultural and pastoral occupations. Indeed, in the colony of New South Wales, and in Van Diemen's Land, its offspring, there was a motive directly operating upon the mind of the landed proprietor (whose flocks and herds roamed unmolested over tens of thousands of acres) to *conceal*, if possible, the teeming wealth of the soil, as his title-deeds or land grants expressly reserved to the Crown all gold and silver, &c. The working of coal in New South Wales, moreover, was secured by the Government as a monopoly for years to the Australian Agricultural Company!

This obstacle to the advance of mineralogical science appears to have escaped the attention of some of the numerous writers upon Australia; but for the honour of the Australian colonists, whose spirit of enterprise is only second to that of the Americans, it should not be lost sight of by any writer who enters upon the topic.

As our countrymen at home, as well as the Australian colonists themselves, are not very well informed as to the extent and variety of the mineral productions of those interesting colonies, having to trust much to rumour for their information, and to the doubtful authenticity of such specimens as may come under their notice in this country, I have prepared a brief catalogue, showing the localities of such precious stones and chief metalliferous minerals as I have detected in the course of several years' residence in four of those colonies. And

* For notices of the Gold-fields of Australia, see Quart. Journ. Geol. Soc. vol. ix. p. 74; and *supra*, p. 302.

I will add, for the satisfaction of geologists, that on all occasions I investigated most rigorously, and with a suspicion worthy of the sceptic, the history of each specimen; most of them being sent to me for examination, or brought direct from the various "diggings," amidst a parcel of quartz crystals (often mistaken for diamonds) and other shining and coloured mineral substances. And I invariably satisfied my mind upon the authenticity of the specimen, or at once rejected it as fictitious. In making this collection, I can claim no merit, for I was mainly indebted to an extensive acquaintance with all classes, and latterly to my position as the Vice-President of the only Geological Society established in Australia, at a time when thousands were anxious to be informed as to what they were daily finding in the soil of that *terra incognita*.

It was thus that I was enabled to announce to the colonists the existence of *tin* (the oxide), in the form of "stream" tin and sand, at the River Ovens, which the energy and enterprise of Mr. Charles Terry, of Melbourne, by the formation of a company, has made so richly available to his fellow-colonists; as the ingot of tin, presented by that gentleman to me, and now in the museum of this Society, satisfactorily demonstrates. (See my letter published in the Melbourne 'Argus' of 31st March, 1853.)

It is well to remark, that up to the present time no systematic or scientific search for the precious stones has been instituted in the Australian colonies; such as have been discovered having been found in the tin dishes of the gold-diggers, whilst washing the soil (sands, gravels, &c.) in quest of gold. Yet, judging from analogy, and observing that the conditions under which the gems to which I shall presently refer are found are similar in Australia and the several countries now supplying them, I feel persuaded that the day is not far distant when the gems of Australia will be sought for as an article of commerce! As the observation applies to the condition under which nearly all the Australian gems have as yet been found, it will simplify this catalogue by stating that I detected the several specimens therein referred to generally in association with all the following minerals, viz. opake and transparent quartz, felspar, garnets, tourmaline, augite, olivine, titaniferous iron, oxide of iron, iron pyrites, and (in the case of the specimens from the River Ovens) associated with oxide of tin, in crystals, small lumps (pepitas), and sand.

None of them were found in existing river-courses, and rarely on the banks of streams; but, being found in a water-worn state, together with native gold, both amorphous and crystallized, equally water-worn, generally in ravines or gullies, there is little doubt that their present localities are the sites of ancient river-courses and their tributaries, whither they were borne, and rubbed by the action of running water*.

* Whilst this paper was going through the press, Mr. R. Jones has kindly drawn my attention to an interesting account in the Proc. Amer. Acad. 1850, p. 246, by Mr. Alger, of several large and curious gold-crystals obtained in California by Mr. Platt under circumstances very similar to those accompanying my discovery of the Australian specimens.—July 1854, G. M. S.

Catalogue of Precious Stones and Minerals from Australia *.

A. A blue and white *Sapphire,* so much water-worn as to have lost all its crystalline faces but one. This, with some others in my possession, came from Ballarat, in Victoria.

B. A beautiful *Sapphire*: hexagonal crystal; in blue and white bands (as described by Dufresnoy): from the Hanging Rock Diggings, on the River Peel, in New South Wales.

C. A highly perfect crystal of *Spinel Ruby* (of fine colour), in one of its ordinary forms; a flat triangular crystal, with the edges replaced, and the angles depressed: from the Peel River Diggings.

D. A water-worn octahedral crystal of *Spinel Ruby*; found in the same locality.

E. A *Ruby* of good colour; from the same locality.

F. Are small *Chrysolites*; from the same locality.

G. Are *Zircons,* obligingly selected by Professor Tennant out of a parcel of various stones brought to me from the River Ovens, in Victoria †.

H. A *Spinel Ruby,* in a similar triangular crystal to C, though of inferior transparency and colour; from the River Ovens.

I. Are "pepitas" of Oxide of *Tin*; from the same locality.

J. A prism crystal of *Tourmaline*; from the same locality.

K. A striated fragment of a pale yellow *Topaz*; from the same locality.

L. *Oxide of Tin,* in the form of sand, with gold dust and decomposed felspar (called "pipe-clay") &c., taken as a sample from a bag received by me from the River Ovens.

M. A *Garnet,* in a dodecahedral crystal (imperfect); from the same locality.

At Peel River, also, they find dodecahedral garnets, whilst at Mount Alexander *Pyropes* and common *Garnets* are met with.

Sir Thomas Mitchell deposited in the Museum of Practical Geology a *Diamond,* said to have been found in New South Wales. He also brought thence to London some limpid *White Topazes* ‡, almost as brilliant as those found in water-worn pebbles at Cape Barren Island in Bass' Straits, and which I have seen cut and equalling in brilliancy the celebrated Nova Mina Topaz of the Brazils.

Very fine hexagonal *Beryls,* exceeding an inch and a half in diameter, and in parts highly transparent, are found in South Australia, at Mount Crawford.

Tourmalines, also, of a very considerable size, are found at Encounter Bay in that colony, and also in D'Entrecasteaux's Channel in Van Diemen's Land.

An *Emerald* in a hexagonal crystal is stated to have been found

* These specimens were exhibited at the meeting of the Society.

† Mr. Foord, a very scientific metallurgist and gold assayer in Melbourne, showed me some Zircons from the same locality, in August 1853.

‡ Sir T. Mitchell has lately presented some specimens of Australian Topazes to this Society.

by the Commissioner of Police of South Australia at Mount Remarkable, and consumed under a blowpipe by a gentleman who understood its power better than its proper use. The Commissioner informed me of it one day too late!

Opals with slight play of colours have been shown to me in South Australia; but they were very remote in brilliancy from the Noble Opal of Hungary or South America.

Gold Crystals.

Gold is found in the colony of Victoria, under the most interesting forms of crystallization; and it may be inferred from the fact of my having collected so many splendid specimens, unassisted by the researches of others, that still finer specimens will hereafter be exhibited. There are also perceptible differences in the character,—as to form, colour, and quality,—of the gold, as found at the various gold-fields.

In purity, *i.e.* in reference to the standard, the gold of Ballarat *, M^cIvor, and the River Ovens, all in Victoria, is at the head of the list; whilst probably that of Louisa Creek, and some other localities in New South Wales, is the lowest in the scale.

The characteristic form of Ballarat gold is the "pepita" or "nugget," often of gigantic size, one having reached the enormous weight of 130 lbs. On the other hand, the gold of the River Ovens is invariably in very fine scales and dust. At Mount Alexander, "black" gold is often met with, being gold coated with a black substance, which resists all the acids, and cannot be acted upon by the magnet, or removed from the gold with a knife.

M^cIvor River has furnished fine specimens of groups of gold-crystals, as also a peculiar kind of dendritic gold, which, from its similarity to moss-copper, I have termed "moss-gold." (Specimens U. and V.; the latter was found at Mount Alexander.)

Gold is also found in New South Wales Diggings (universally, I believe) and at Mount Alexander, enclosed in, and sometimes enclosing, quartz; never in granite that I have heard of, but often in iron-stone. (See specimen No. 1.)

N. A conglomerate of chlorite, quartz, iron-stone, steatite, &c., bound together by oxide of iron, having gold distributed through the mass. It was broken out of a vein of similar substances, about a foot wide, forming a so-called "gold-lode," between walls of nearly perpendicular quartzose rock, at a depth of 90 feet, in my presence, at Specimen Hill, Mount Alexander, which was a low hill not far from the summit of the latter. The party digging there had a crushing machine, and found the yield of gold very satisfactory.

O. Gold from the River Ovens.

P. Gold in red ferruginous earth, found at the Montacute or "Victoria Gold Mine," in South Australia, about twelve miles from Adelaide, on a tributary of the River Torrens, in 1845.

* For a notice of the Ballarat Gold Field, see Mr. Wathen's Paper, Quart. Journ. Geol.Soc. vol. xi. p. 75.

Q. A sample of gold from Bendigo, Victoria; one of the richest gold-fields yet discovered.

R. Three *Octahedral* crystals of gold; from Ballarat.

S. Three *Dodecahedrons* of gold; from the same locality *.

T. A *Macle-crystal* of gold,—two dodecahedrons united. The faces are very perfect, and one of them is a *pentagon,* with a mamma on it. It is from Ballarat.

V. *Moss-gold,* coloured by oxide of iron; from the M[c]Ivor River Diggings, in Victoria.

U. *Moss-gold,* from Mount Alexander.

W. An interesting specimen of *Ramose* gold; from the M[c]Ivor.

X. A specimen of gold, resting upon galena in quartz. It was found near Mount Alexander.

Y. A *Cavernous Octahedron* of gold, of unusual size; from Ballarat.

Z. A *Cavernous Dodecahedron* of gold, of large size; from Ballarat.

1. Gold imbedded in iron-stone; from Ballarat.

2. Gold imbedded in quartz; from Louisa Creek, New South Wales. Its light colour shows it to be alloyed with silver.

3. A sample of gold, containing the *Black Gold*; from Forest Creek, Mount Alexander.

4. A very large crystal of gold ($\frac{5}{8}$ths of an inch in diameter) which I selected from a parcel of 10,000 ounces of gold from M[c]Ivor River. Its form is so peculiar that I found difficulty in classifying it, until the eminent crystallographer, Mr. Brooke, F.R.S., expressed the opinion that it is a dodecahedron, extravagantly distorted.

5. A group of gold crystals, *in cubes,* elongated *octahedrons,* and *dodecahedrons,* in most interesting forms, and surrounding a transparent hexagonal crystal of quartz, being the only specimen, excepting No. 6, which I ever saw in Australia, showing crystals of gold and crystals of quartz in connection. The cube of gold at the base has reached the extraordinary size of $\frac{7}{8}$ths of an inch in diameter, and has ascending planes, as if passing into the octahedron.

It was sold to me as a "peculiar nugget," from M[c]Ivor River, Victoria.

6. An equally interesting group of fine crystals of gold from the same locality; also interlacing an hexagonal quartz-crystal.

These two specimens are peculiarly interesting to geologists. It will be observed that such of the edges of the gold and quartz crystals as have been exposed to the contact of rough bodies are rubbed and destroyed, whilst the edges of the crystals which have been protected by surrounding crystals are as perfect and sharp as when formed by nature; thus proving that in bygone ages they

* Whilst in the Australian colonies, I never saw nor heard of any gold crystals being found there, excepting what I procured myself. But as I showed some to Messrs. Hopkins, F.G.S., Foord, Hood, and others, many will now be on the *look-out* for them. Since my arrival in England, however, Professor Tennant has shown me some dodecahedrons from New South Wales, which he considered properly authenticated.

have been water-borne by a stream of water, sufficiently powerful to move such a heavy substance, in a water-course which has long been obliterated by a deposit of from 15 to 25 feet of superincumbent soil and detritus, from the bottom of which these specimens were extracted by the gold-digger, in a situation covered with large timber and in the midst of undulating hills, miles away from any present body of water.

7. A third group of gold-crystals from the same locality; in which ironstone and opake quartz are imbedded.

8. A singular crystal of gold, presenting the appearance of an elongated *octahedron*; but Mr. Brooke considers it to be a *Macle-Crystal*, consisting of *two octahedrons*, so united, that two of their faces respectively present two elongated planes: from Ballarat.

9. Gold in opake quartz, from Ophir, New South Wales. Its light straw colour, like the generality, if not all, of the native gold of that colony, shows it to be much alloyed with silver.

10 to 13. Are four curious instances of *ramose*, *crystallized*, and eccentric forms of native gold, from McIvor River, Victoria.

3. *On the* Gold Regions *of* California. By Mr. James S. Wilson.

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

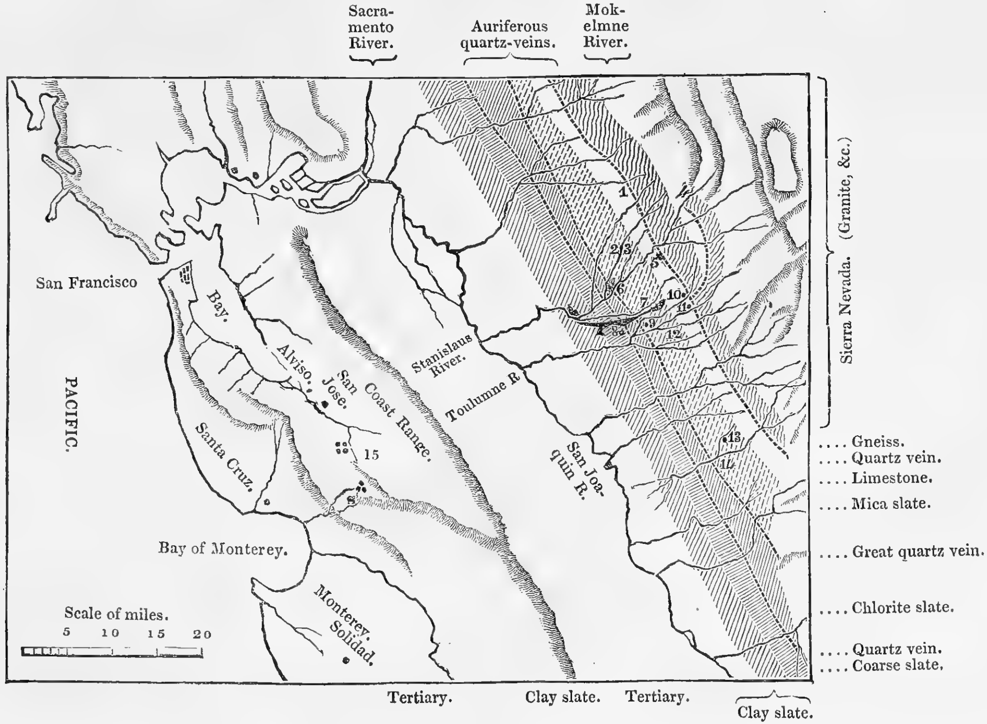
Having explored, during a residence of nearly three years, some of the richest auriferous tracts of California, I have been requested by Sir R. I. Murchison, to present through him to the Geological Society of London an outline of my personal observations.

Sonora Diggings.—The neighbourhood of Sonora was the place selected for the first operations of my associates and myself in gold-digging. Several kinds of rock presented themselves, identical with what I had seen in the mineral districts of South Australia; the prevailing rocks, and that on the surface of which the gold was deposited, were slates and gneiss.

Sulivan's Creek Diggings.—We commenced working at a place called Sulivan's Creek, about two miles south from Sonora. The diggings at this place were considered to be among the richest in the southern mines; but the greater part of the gold found there was supposed (and with great probability) to have been swept down by floods from Sulivan's Gulch, which is a ravine, rich in gold, about one mile in length, following the strike of the rocks, and having the gneiss on one side and a white crystalline limestone on the other.

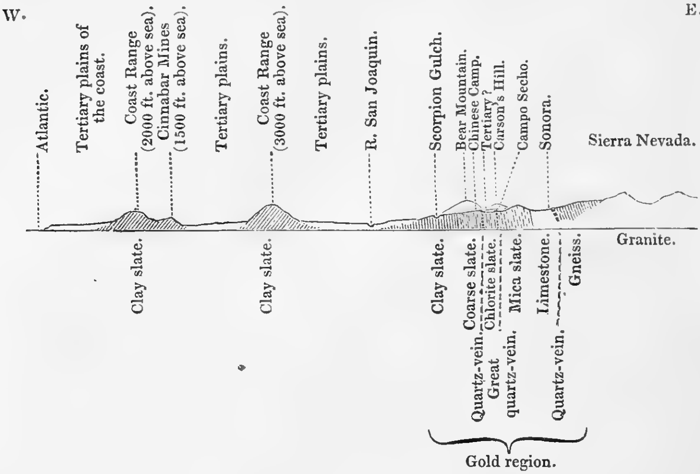
The rock, however, which had originally contained and yielded the gold, was the gneiss, as a vein of auriferous quartz is traceable in it, running along the top of the hill parallel with the ravine. Gold was likewise found in the debris on the gneiss, as well as in the bed of the ravine; but none on the limestone. These rocks are all

Fig. 1.—*Geological Sketch-Map of part of Upper California, comprising the Southern Mines.*



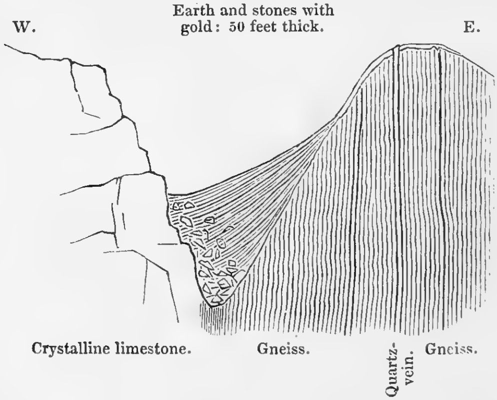
1. Murphy's Diggings.
2. Carson's Creek.
3. Coyote Creek.
4. North Fork of the Stanislaus River.
5. Columbia.
6. Carson's Hill.
7. Mormon's Creek.
8. Chinese Camp.
9. Campo Secho.
10. Sonora.
11. Sulivan's Diggings.
12. Blanket Creek.
13. Agua Fria.
14. Mariposa.
15. Cinnabar Mines.

Fig. 2.—*Section across Upper California from the Pacific to the Sierra Nevada.* Length about 70 miles.



vertical; and their direction is a few points west of north and east of south. The original ravine has been filled up, to a considerable amount, by clay and loose blocks of limestone, &c. (fig. 3).

Fig. 3.—*Section of Auriferous Detritus at Sulivan's Gulch.*



Miners have sunk pits to the depth of 100 feet without penetrating to the bottom of the debris. It appears to have been filled to its present level by frequent land-slips, the succession of which can sometimes be traced, not only by the colour of the different layers, but likewise by the gold being found in alternating beds of the debris.

Diggings on the North Fork of the Stanislaus River.—In the autumn, which is the best season for working in the rivers, the water being then low, one of my associates, Mr. Wallace, and myself joined a company on the North Fork of the Stanislaus, that had been formed for the purpose of cutting a new course for the river, in order to get the gold that might be in the river's bed.

The rock-formation was the same as that at Sulivan's Creek, but the hills are very precipitous. The boulders in the stream were of granite, indicating that the surface-rock of the country higher up was of that description. This was soon afterwards affirmed by a party who had traced the river to its source, but without finding gold.

Intermittent Spring.—About half a mile from our camp there was a small stream joining the river, which evidently flowed from a spring in the gulley above; but, having occasion to cross it frequently, we observed that about noon every day it ceased to flow. In one of my rambles afterwards, I came upon the place from which it sprung, but it was so filled with fragments of rock, that I could find no clue to the cause of its intermissions.

Stanislaus River Diggings; lower down the river.—We worked for three weeks on the northern branch of the river, but did not think the indications sufficiently encouraging to proceed with the work. We therefore removed to another bar, about twelve miles lower down the river, and in order to avoid the windings of the stream, we took the nearest track across the country. The first five miles were amongst hills of porphyritic rocks; but the remainder of the way was over slate-rocks and gold-fields.

The company to which we were now joined (forty men in number) had commenced operations for the purpose of turning the river; its bed being supposed to be rich, in consequence of the situation being a little below Carson's Creek, and other rich creeks, from which it was supposed that large quantities of gold might have been washed; and the vertical slates running across the bed of the river were supposed to have many crevices in which the gold would have been deposited.

While quarrying the hard slate-rock, through which we had to cut our canal for the purpose of draining the river, we found a *fossil bivalve shell* resembling an *Orthis*? (to which my attention has since been called by Sir R. Murchison). The position of the fossil (like that of the rock in which it was imbedded) was on edge; and, the fossil having been split through together with its matrix, there remained a perfect impression on each piece of rock. The substance of the shell had become soft like chalk.

Having completed our works on the river, we had the mortification of finding that it was not sufficiently rich to pay for working at the rates then required by miners, and the company was accordingly broken up, after having spent three months in fruitless labour on the Stanislaus.

River-workings; and Position of Auriferous debris in river beds.—Our experience taught us that gold is not to be found in the middle of a river, unless there be a deep bed of boulders and gravel for it to rest among; and even then it is rare.

The current has a tendency, derived from the more rapid motion of the middle water, to drive all heavy matter towards its margin; but gold, being heaviest, resists more or less the force of the water, and therefore remains towards the lower edge of the river's bank; but sand, being lightest, is driven highest up the bank; and, as the river continues to wear its bed deeper, or to work its way into the rock on one side and leave a ledge on the other, in receding thus, it leaves a bed of boulders and gravel in which gold may have been deposited.

The river-workings, with few exceptions, having been failures, and the winter now approaching, the miners left the streams to secure ground in the "dry diggings" for winter work, and to build cabins against the inclement season.

Sonora Creek Diggings.—On the breaking-up of our company, I returned to Sonora to obtain such information as I required to determine my next proceedings, in which I resolved to be more than usually cautious, as up to that time I had submitted to the judgment of others, and had been unfortunate. Nor was my resolve weakened on arriving at Sonora by finding the people at that place in a state of excitement in consequence of the discovery of rich deposits of gold in a spot that I had selected six months before, but had been prevented from working by my partners having voted in favour of the other ground at Sulivan's Creek. It was situated in the broad flat bed of Sonora Creek, but just at a place where it contracted to enter a narrower passage. A vein of greenstone crossed the river's course, and stood above its slaty bed like a ledge, behind which a deep bed of drift had collected; and, as this drift had been brought down by the stream from the rich country through which it passed, I had conjectured that rich deposits of gold might be found beneath it. As soon as the discovery became known, the entire bank, amounting to one and a half acres, was claimed, and divided into separate lots, of ten feet square to a miner, all of which proved exceedingly rich.

Campo Secho, and other diggings and quartz-workings in the neighbourhood.—I obtained employment at a place called Campo Secho (Dry Camp) and remained there two months. The diggings in that neighbourhood were of that description called "flats" (nearly level enough to be termed plains). The one in question (which was being worked at different points) extends from Table Mountain to Curtis's Creek, a distance of about six miles from north to south, and from one to one and a half in breadth, having a range of hills on the east side, and Wood's Creek on the west.

Gold is found in greater or lesser quantity over the whole tract, but chiefly about the water-courses by which it is intersected.

The western border is composed of chlorite-slate; and the eastern, of micaceous slate; the slates are vertical and in a state of rapid decomposition. Where the micaceous slate approaches the surface, it decomposes with a red colour like that of the earth with which it is covered; the plates or laminæ of the rock become open and earthy between, so as to be penetrated by roots, and are easily separated to a considerable depth; but where the mass of earth is considerable, or where water remains on the rock, the decomposing slate forms a bluish-white tenacious clay.

In the middle of the plain one hill rises rather abruptly to a considerable elevation, and has a large vein of quartz running through its greatest length, from which it has obtained the name of Quartz Mountain. This quartz-vein can be traced both to the north and south of the hill. To the south it rises high in another hill close to Sulivan's Creek. To the northward it mounts like a wall near to Table Mountain, under the porphyritic rocks of which it passes, and again appears with its associated slate at Mormon Camp, running in the direction of Carson's Hill. The quartz-vein was being worked at all the places here named; but the richest surface-diggings are at points intermediate, on either side of the line, indicating a greater waste at such places.

Geological characters of district between San Francisco and the Diggings.—Having business that required my presence in San Francisco, I made a detour by the Calaveras in order to include more mineral country in my route. My first day's journey brought me across the above-mentioned Table Mountain.

Table Mountain.—This mountain is a remarkable feature in the landscape; not from its elevation, which however is considerable, but from its perpendicular sides, and long, level outline, extending ten or twelve miles from N.E. to S.W. It is formed of a black porphyritic rock, which contains a large amount of iron. Crystals of felspar of the same colour as the rock are distributed through it, which become white as they decompose, and which leave their print in the rock when they have disappeared. In some places the rock is compact, and at others rises in the form of irregular columns or palisades. The mountain has no great breadth at any point, while at some places it is comparatively a mere wall. I found it overlying the slate-rock, and at some places, where the mountain presented a perpendicular wall, the slates were also perpendicular, and parallel to it.

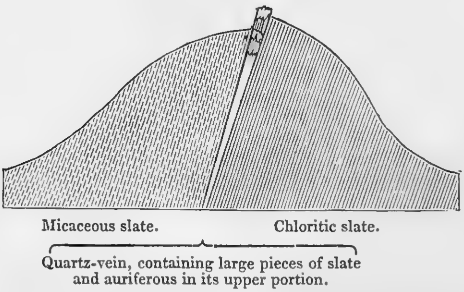
It appeared evident to me that the matter of which the hill is composed had, while in a state of fusion, been injected and moulded in the cavities and rents of the rocks which then surrounded it and stood immensely elevated above its present height. These rocks, being of a softer nature than the rock of which Table Mountain is composed, and having their vertical edges exposed, would be more rapidly decomposed than the intruded porphyry, so that the Table Mountain would eventually, as it does, look over the hills in which it once lay embosomed as a liquid mass. The sharp, high crags of ragged rock which then surrounded it are become low, smooth, rounded hills, and flats covered with vegetation, while the waste drifted from them has covered the valley of the San Joaquin with many feet depth of earth and gravel.

Origin of the Gold Drift, and comparison of drift and quartz-veins as to their auriferousness.—Thus, we can perceive, how nature has been employed, for ages, in a way in which thousands of miners now expend their labour; that is to say, in separating the gold from the rocky and earthy matrix, and washing away the refuse. Thus, gold may be found in most places over the metamorphic ranges, but more particularly in ravines where frequent land-slips have occurred on the steep sides of hills, and rains have washed the greater part of the earth away, leaving rich deposits of gold behind. According to this view alone (considering the amount of denudation that has taken place), it may be understood why the soil is so rich in gold, while many of the auriferous quartz-veins in the vicinity of rich surface-diggings are comparatively as poor, and it may reasonably be inferred that the superficial debris and clay contain more gold than may be found in the quartz-veins by mining to their utmost depth. See also *Carson's Hill* (*infra*), *Sonora*, &c., pages 312, 316, 318.

Mormon Creek and other Diggings.—On the north side of Table Mountain there is a stream running parallel with the mountain, and called Mormon's Creek, which has proved rich in some places. At right angles to this, and parallel with the great quartz-vein, runs a deep ravine, bearing the name of the Mormons also. This is about a mile in length, and has been extremely rich. Passing over the hill at the head of this, I came into another ravine of equal or greater length and steepness, called Jackass Gulch, trending in the same line with the former, but falling into the Stanislaus in the direction of Carson's Hill. On the other side of the river, another rich ravine (called Indian Gulch) commences and runs nearly to the top of Carson's Hill.

Carson's Hill Quartz Mining Works.—After crossing the river, by means of a ferry established at this place, I ascended Carson's Hill, and witnessed the works being carried on there in quartz-mining. The hill is composed of chlorite-slate, rises to the elevation of 500 feet above the level of the river, and is pierced by the quartz-vein already mentioned, which is easily traced down both sides, but projects above the summit like a massive wall. A cross-section of the vein (fig. 4) shows it to be wedge-shaped, being about 20 feet

Fig. 4.—*Section of the Quartz-vein in Carson's Hill: from the N.W.* Height 200 feet.



in thickness at the top and decreasing to about one foot at the bottom of the hill. In its thickest part it imbeds large masses of the slate, which seem to have fallen into the rent, previously to or during the formation of the quartz-vein.

It was in the highest part of this vein, and on its lower side (fig. 4), that the gold was first discovered, and it was certainly the richest portion of the rock; for, having been tried at different elevations, it is found to lose all traces of gold as it descends. At the top of the hill the quartz-vein was in a state of decomposition, and of a reddish colour; and, besides gold, it here contained a large amount of iron and slight traces of copper; but the lower part of the vein becomes white, glassy, and hard, and void of all traces of metal.

Looking from the top of this hill, in a north-westerly direction, the same quartz-vein can be seen cropping out in several other hills.

The line which I subsequently travelled being parallel to the range, there was little variety to notice; surface-diggings only occasionally occurred, which were similar to such as I had frequently seen.

Greenstone Vein near Sulivan's Camp.—After a few days I left San Francisco and returned to the mines, intending to continue my researches, commencing with a hill one mile to the eastward of Sulivan's Camp. It was altogether of granite, with the exception of a large vein of greenstone, passing through and dividing the hill into equal parts.

I traced the vein to the base of the hill, where it entered the gneiss and passed on through the crystalline limestone and mica-slate. Its section is wedge-shaped; and so regularly did it decrease in thickness, in descending towards the base of this hill, and again increased in thickness in ascending the next hill, which was of slate, that an approximative calculation of its depth (which cannot be very considerable) might readily be made. It was evident that this vein was of a much more recent date than the vertical metamorphic rocks through which it passed in a well-defined course. It also crosses a large quartz-vein in the slate. The crystalline limestone, a rock without any particular line of cleavage, was greatly fractured, and the crevices were penetrated by small lateral veins of the greenstone, some of which are not more than half an inch in thickness, are excessively hard, and produce a metallic sound when struck against another hard substance. It seemed evident with regard to this vein, that there had been no great amount of disturbance since it was formed, as is indicated by its close contact with the rocks through which it passed.

Toulumne River Diggings.—The Toulumne is a considerable stream, nearly equal in its volume of water to the Stanislaus. Gold is pretty equally distributed along its banks, and the workings paid a good average to the miners. In passing from Jacksonville on the Toulumne to Curtisville, I traversed a granitic district strewed with fragments of the slate-rocks, which are no longer seen there *in situ*.

Curtis Creek Diggings.—The diggings in Curtis Creek were tolerably rich, but not extensive; and the gold found there was commonly coated with quicksilver; indicating the existence of a vein of that mineral in the vicinity. This is not peculiar to Curtis Creek.

Blanket Creek and other Diggings.—Near to Blanket Creek, and about five miles south from Sonora, I found the remains of a large quartz-vein, resting apparently on the granite rock. It was about 20 feet long, 3 feet wide, and 3 feet high; with decomposed gneiss (the remains, probably, of its original matrix) lying against each side. On examination I could not discover that it anywhere penetrated the granite. There were no gold-diggings near, though the place had been well tried, from which fact it might be argued, that the gold had been removed (or at least the appreciable portions) long before the quartz-vein was worn down to its granite bed; and this was the more remarkable, as the remains in question formed a portion of one of the three great auriferous quartz-veins which traverse California. It is the most eastern of the three (see Map and Section, figs. 1 & 2), and passes by Sonora, which is considered the richest district of the southern mines.

Following the same line southward to Blanket Creek and Canaka Creek, I observed that the metamorphic rocks are worn very low. At one spot a few miners had discovered a deposit of gold in what had been a deep chasm in the crystalline limestone; but, with this exception, no gold was found so high up these creeks: and in descending, the first that was found in them was in large lumps, the finer and lighter gold, in all probability, having been washed away.

Coyote Creek.—At Coyote Creek, where I had worked for two months, the rocks had suffered great displacement, possibly in consequence of being in contact with a granite peak that rose high above the surrounding metamorphic rocks. In one branch of this creek that passed between the gneiss and limestone we frequently found garnets.

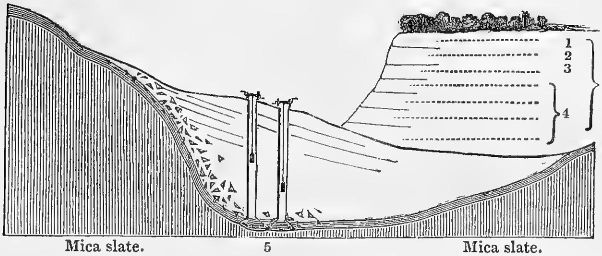
Sonora: workings in quartz-vein.—At Sonora I went to examine a quartz-vein that was being worked for the gold it contained, and was expected to prove rich. Its situation, on the side of a steep, high hill, afforded facilities for running levels, and accordingly one had been cut through the vein about 50 feet below the outcropping, and a shaft had then been sunk to a considerable depth into the vein, with the hope of finding it richer, but the gold found up to that time was so minute as to require grinding and amalgamation to collect it. The ravine below was very rich, and many large lumps were found which must have fallen from that same vein. One piece that I saw there weighed sixty ounces. See also p. 314.

Murphy's Diggings.—New diggings having been discovered near to Murphy's Camp, which were said to be in a new kind of ground, I went to see the workings, and found them situated on a hill formed of tertiary? calcareous deposits (fig. 5). See also *Mokelmne Hill Diggings*, p. 319.

The gold was found in a blue clay, or decomposed slate, mingled with pebbles of quartz beneath the calcareous deposit. Some of the miners had to sink 90 feet, and then found the auriferous earth in what seemed to be an old creek or water-course.

There are several of these hills in the immediate vicinity. One in particular (which is, in fact, a part of this same hill) seems to retain nearly its original height. A high cliff, on the eastern side, exposes to view seven distinct strata, the upper one of which is composed of volcanic cinders cemented with lime (fig. 5); the others are principally conglomerates, composed of granite boulders and calcareous deposits. Some of the boulders are extremely large and smoothly rounded; one which I measured was 8 feet in its greatest diameter.

Fig. 5.—*Section at Murphy's Deep Diggings.* Length about ¼ mile.



1. Volcanic ashes.
2. Sandy limestone.
3. Sandy limestone with boulders.
4. Limestone with sand and boulders; the beds being more calcareous downwards.
5. Shafts, 90 feet deep, piercing calcareous deposits, with boulders in the lower part, and reaching the auriferous clay that rests on the mica-slate.

Mode of formation of the Auriferous Drift.—To account for the manner in which the various rocks are arranged in the boulder conglomerate, I would suppose that the quartz-boulders of the lower strata belong to the veins of that rock in the neighbouring hills, which, after being left bare by the wasting of the slate-rock, and rent by frost or otherwise, rolled down into the creeks and rivers, and as the sea gradually encroached, these creeks and rivers would become bays and inlets, round the margins of which ice-banks might be formed, which at times of thaw and heavy floods would be detached and carried out to sea, with such attached matter as it could float; where meeting with north-west winds and the southward current of the ocean, they were drifted south and east, until they got stranded on or against the hills which then formed the sea-shore. But as the land continued to be submerged, the water penetrated farther among the hills and at length reached the granite ranges, from whence it carried out the granite drift while the quartz was protected by depth of water.

There are several of these tertiary? hills under which gold is found; but no gold is found in them, except at their immediate contact with the older rocks; which may be accounted for in this way. First, that when quartz is auriferous, it is highly impregnated with iron also, which on exposure to the atmosphere oxidizes and causes a disintegration of the rock, by which means the gold is liberated; which, if it then be drifted by water, settles in the lower stratum, and is in consequence less likely to be removed by either ice or water.

Again, if it be so removed, it is evident that the ice-drifted matter from these hills was never allowed to float far out to sea before it was thrown back against the beach again. To this I would add, that the gold found in what is termed the dry diggings is commonly on or near the western slopes of the hills, and in such places has the appearance of being abraded and water-worn, while a few samples that I have seen of the opposite character were found on eastern slopes, or in otherwise sheltered positions: from which facts it would appear that the abrasion suffered by the gold scattered over these broad districts was effected by the waves of the ocean, under whose action it would be again laid close against the ancient rock.

Comparison between Drift-workings and Quartz-vein-mining.—When the rage for quartz-gold-mining broke out, it was proposed by some members of our company that we should join in a work of that description. This I opposed, from a conviction that it would not pay so well as the surface-workings. The arguments I made use of were to this effect:—that in whatever superficial debris or earth gold is found, the lower it be in such soil the richer it is, and always richest next the rock: in gulleys where frequent land-slips have taken place, successive beds containing gold may be found, but the lowest is always the richest: the wealth of the gold is not only in quantity, but likewise in the size of the grains or lumps the deposits contain, while the opposite order seems to take place in the quartz-veins: the richest mines yet discovered occupy the highest situations, while the same matrix, when traced to lower ground, seems to contain little or no gold. From these facts I inferred that the top of the quartz-veins was the richest, and being the first to disintegrate, it was likewise the first to be deposited in the ravines below, and as the waste progressed, the deposits became poorer, until in most situations the later waste contained no gold, and by its continued deposits buried the precious metal deeper below. From the same train of argument, it follows that the deeper we sink into a quartz-vein the less productive and more expensive we shall find it.

One of the company (my friend, Mr. Allan), to satisfy himself practically, examined every quartz-mine then being worked from Carson's Hill to the Mariposa, and by his inquiries, he could not discover that any increase in richness was found by sinking, but rather the opposite result obtained, and the difficulty of working increased from the increased hardness of the rock, and the minuteness of the gold requiring more perfect machinery to effect a thorough separation. See also p. 314.

Chinese Diggings.—Mr. Allan and myself being satisfied that quartz-veins could not be worked profitably, I selected some ground for our joint operations in what is called the Chinese Diggings, which fortunately proved to be rich. The place was of that description known to miners as flat or dry diggings, from being situated on a flat piece of country bordered by hills, and having no running water, so that those working there in the summer season either sunk wells, or carted the earth to the nearest springs they could obtain. The auriferous earth was from 1 to 6 feet in depth, according to its situation with regard to the hills, being deepest and richest at the opening of the ravines, and in the middle of depressions. It is a tough whitish clay, intermixed with petrified wood and fragments of quartz and other rocks. The bed-rock is a coarse-grained slate, with crystals of felspar (like that of many other places). The rock was decomposed to a considerable depth, forming a clay that could only be distinguished from the best auriferous earth that lay on it by not having a mixture of quartz-gravel.

I found a small vein of asbestos in this rock that is similar to a specimen that I had obtained from Van Diemen's Land, attached to a fragment of similar rock.

Mokelmne Hill Diggings.—At Mokelmne Hill I found extensive remains of the tertiary? formation above-mentioned, under which mines of extraordinary richness were being worked, at great depths. This description of mine is known to miners by the general designation of "volcanic diggings," probably because the upper stratum of the series consists of volcanic cinders cemented with lime. See *Murphy Creek Diggings*, p. 316.

Volcanic Cinders.—The presence of these volcanic products is occasionally the cause of much speculation, no volcanos being known to exist in California, nor traces of any that could have been of such late origin. The course of the prevailing winds, and general drift of the Northern Ocean, might, however, lead us to look for their origin in the volcanos of Kamtschatka and the Aleutian Islands.

General Geology of the Region.—Having examined the country from the Mokelmne to near the Mariposa, and obtained information from others who had travelled farther north and south, I am enabled to state that apparently the same arrangement of the strata prevails throughout the range, and a section at right angles to the line of the strata at one point will represent the general order of the rocks. (See Map and Section, figs. 1 & 2.) If, therefore, a section be taken from the granite hill east of the town of Sonora, and drawn in a line to the Valley of the San Joaquin at a point near to Taylor's Ferry, the arrangement is—1st, gneiss; 2nd, white crystalline limestone; 3rd, mica-slate; 4th, chlorite-slate; 5th, a coarse slate, containing much felspar; 6th, clay-slate. These all stand vertically and parallel with the mountain-range, and are traversed by three principal quartz-veins, running in the same direction, from east of south to west of north. The first or eastern vein is in the gneiss, but near to the line of the limestone. The second or middle vein is in the mica-slate, but close to the chlorite-slate, and sometimes divides or passes between them; the third is in the coarse slate, but not so well-defined as the other two.

The Tertiary Rocks.—The tertiary? limestone formation has been very extensive. Its ancient margin may still be traced in places, occurring in boulder-conglomerate cliffs, attached to the sides of the hills formed by the older rocks, about 4000 feet above the level of the sea, and from 200 to 300 feet above the streams in the adjoining valleys. The remains of this formation abound in the neighbourhood of the Calaveras and Mokelmne. It has penetrated the recesses of the hills and filled them to the same level. Other fragments of these rocks, of an interesting character, occur in Coyote Creek, in the character of natural bridges, one of which I examined. The interior consists of two caverns, one on each side, connected by a dark winding passage, through which the water of the creek passes. The entire passage through the bridge is 240 feet. The interior of the caves is lined with stalactite.

The outside of the range bordering the valley of the San Joaquin is flanked with hills of the same formation, lying in horizontal strata. Looking toward the head of the valley, from an eminence at the Stanislaus, I could see them extending southward as far as the eye could reach, and these hills were easily distinguished by the uniform level of their summits.

Cinnabar Mines.

Bay of San Francisco.—Being at San Francisco, I went to San Jose, to visit the quicksilver-mines at the head of that valley. Finding a steamboat at the wharf, bound for Alviso, we went on board and got under way. Our course lying toward the head of the bay, we had a good view of the country on each side; and, both sides having a range of hills running parallel with the bay, the scene was highly picturesque. The water becomes shallow toward the head of the bay; and the low swampy country and mud-banks of the margin seem to be making rapid encroachment on the water of the bay. We were landed next morning at a low muddy swamp, on which the little town of Alviso is built, and we had still nine miles to travel in order to reach San Jose, across a plain of rich alluvial deposit. The town of San Jose is situated in the middle of a beautiful valley, well wooded, and watered by streams from the mountains on each side. As we passed along the valley we could not help admiring the beauty of the country, the greater part of which was still in its wild state. The trees, which were principally of oak, of several varieties, were thinly scattered across the valley.

The two mountain ridges of the Coast-range (see Map), which bound the bay and the valley on each side, meet about twenty miles above San Jose, and confine the view. I observed this particularly, as I think it enabled me to determine the cause of the peculiar character of the climate of the city of San Francisco and its immediate neighbourhood. During the summer season, the mornings are exceedingly warm until nearly noon, after which time the wind blows in from the sea, and is felt so extremely cold, that winter-clothing is found necessary. This daily variation of temperature appeared to me to be satisfactorily accounted for, by supposing that when the sun was near the meridian, its rays, refracted from the sloping sides of the mountains, heat the air, in consequence of which it is rarefied, and ascends, leaving a deficiency in the equilibrium, to supply which the more dense and cold air rushes in from the sea through the only opening, the Golden Gate (as the narrow entrance to the bay is called). The cold air rushes with considerable force by San Francisco, and is most acutely felt there, and after passing that point it becomes diffused.

The Quicksilver Works and Cinnabar Mines.—After travelling about fifteen miles from San Jose, we arrived at the quicksilver works, which we found situated in the bottom of a beautiful glen, through which a clear stream of water continually flowed. We obtained permission of the Superintendent to witness the process by which quicksilver is extracted from the Cinnabar. In this I found that they had abandoned the old method of using retorts, and adopted a mode by which the process is managed on a more extensive scale, by using a number of large furnaces, each built somewhat in the form of an oven, and having a chamber attached, in which condensation of the mercurial vapour is effected.

We next went to see the mines, one mile and a half distant. The road led up a rather steep ravine, along one side of which it has been cut at very considerable expense. On our way we met a number of mules laden with cinnabar, on pack-saddles, this being found the readiest method of conveyance to the works.

At the head of the road we found a number of men employed in cutting a level into the hill, intended to pass through the vein below the present workings. About 150 feet higher up the hill we could see the present opening to the mine, to which we ascended by a steep, winding path. On a terrace formed in front of the opening a number of men were sorting the ore, while others were employed in carrying it out of the mine in bags suspended on their backs, by means of straps passing across the front of their heads; while in their hands they each carried a stick, which they used in the manner of a long staff, but having a socket fixed on it, near to the lower end, in which they carried a candle to light them through the dark and rocky passage.

The mine is near the top of a mountain, about 1500 feet elevation above the level of the sea. The rock is clay-slate, and the cinnabar is found in a vein with quartz. The vein is vertical, but the slates lean at a considerable angle eastward. In walking across the hill, I found two other quartz-veins with apparently the same metallic character, and I was told afterwards that they had been tested, and found to contain quicksilver, but they were not included in the company's property. The cinnabar is red in colour, different from any I had before seen, though I feel almost satisfied that it is identical with a red mineral that I had frequently seen in Australia, but supposed then to be merely an oxide of iron.

Metalliferous Minerals of California.—Other metals exist in California, but are not thought worth looking for while gold can be got by digging. I was shown a specimen of sulphuret of silver, found up the south branch of the Stanislaus, and which was said to be abundant. It was discovered and identified as silver ore by a South American woman. I was told likewise of the existence of a rich lead-vein in the Coast-range, south of the Cinnabar mines.

4. *On the* Coromandel Gold-diggings *in* New Zealand. By Mr. Charles Heapley. In a Letter to His Excellency Sir George Grey;—communicated by Sir R. I. Murchison, F.G.S.

The gold which was obtained here (Coromandel, near Auckland) during the summer was all dug from either the surface, or from a depth of 18 inches varying to 4 feet below it, and was taken in some instances from the gravel of a stream-bed, or in others from a bed of quartz-grit near the foot of a granite mountain.

Only in one instance had any one sunk a shaft to the bed-rock. At a depth of 33 feet, a shaft, which I dug, fell in from the looseness of the surrounding earth. Mr. Stephenson, a digger, however, came upon the bed-rock at a depth of 27 feet; but there it was on so steep an inclination, that but little gold could have been expected to have been found lodging upon it. Some small pieces, of a more solid nature than any found elsewhere, were, however, washed from its surface. (See fig. p. 323.)

The unusually wet summer induced the diggers, who were chiefly men from Port Philip, men used to a dry climate and firm soil, to abandon the idea of sinking shafts to the bed-rock. The New Zealand diggers contented themselves with digging near the surface, and when the small stratum of quartz-grit, where Coolahan got his gold, was exhausted, they left the district.

It cannot, however, be denied, that the limited extent of the Government district was a source of discouragement to men, who, in Australia and California, look to an unlimited field for exploration. But, had the working been of a systematic nature; had shafts been sunk by each party to a reasonable depth, there is but little doubt that rich deposits would have been brought to light.

On the eastern side of the Dividing Range, gold has been found by various prospecting parties; and in one valley, the Opitonui, which all concurred in declaring rich, one man, a Canadian, has lately reported to me, that in prospecting he "could pick the gold out of a stratum" with the point of his knife. How far this is true, I cannot say. The man says that he merely waits for the valley being thrown open to commence work there. The place is so closely watched by the natives, that it is not practicable for a man to work there now even covertly.

By a map * that I send herewith officially, Your Excellency will perceive the extent of the known gold-field. Beyond this, the Messrs. Ring are reported to have found gold in the direction of the Aroba mountain, to the eastward of the Thames.

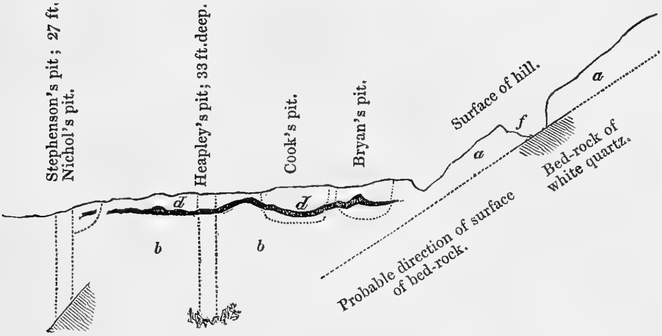
The map only includes such parts of the district as I am personally acquainted with.

By a very recent examination, I have been enabled to discover the surface of the bed-rock immediately over the locality whence Coolahan and others obtained the greater part of their gold last summer; and, from the circumstance of its being of quartz of a similar nature to that to which their gold adhered, I am in great hope of being

* Not accompanying this letter.—Ed. Q. J.

able shortly to find the matrix, or otherwise "pockets" of a rich description. In my last day's prospecting I found some very angular and sharp fragments of quartz, containing gold, within about 25 yards, and below the quartz-rock in question; and, from the entire absence of abrasion on the edges or corners of these fragments, I am induced to believe that they had not been deposited far, perhaps not many yards, from the locality of their original matrix. I send them to you herewith. The annexed is a section of the locality.

Section of the Gold-diggings, at Coromandel, New Zealand.
Length of section about 75 yards.



a, a. Yellow clay.
b, b. Blue and yellow clay, not auriferous, underlying the "dirt-bed."
d, d. Dirt-bed with gold; overlaid by yellow clay.

You will see that, from the position of the denuded bed-rock on the hill-side, it will be easy to carry off the drainage-water from any working commencing at the point "*f*," and hence I purpose tunnelling or "driving" to the right and left from that point, along the surface of the rock, following it also downward, as far as the accumulating water will allow. So long as the rock slants steeply downward, there is no probability of much gold being found on its surface; but should any hollow or edge be found, gold in large quantities is nearly sure to be found also; at least, if the matrix from which the fragments came lay on the hill above.

From examination of the place, it would appear that the "dirt-bed" (*d, d*) was a deposit arising from a slip from the surface of the rock of the hill above; and that, subsequent to its deposit, another slip from a yet higher part of the hill had taken place, covering the dirt-bed over with a yellow clay, in which there is no gold. Coolahan's party, and others, examined this yellow clay, and found in it no gold, but were not aware that it was a more recent, and consequently overlying deposit to that from which they washed their gold, and that it had slid from an upper level, beyond the matrix.

I purpose, if the weather allows, to commence opening out the surface of the rock tomorrow; and, having with me some practical diggers who understand what is termed "driving," I hope to be able soon to find something of a heavier nature than what has yet been washed.

One good nugget of pure gold being found would soon bring back to the place those who have left it; and, the concurrent opinion of Californian and Australian diggers being that the gold is plentiful here, could the bed-rock be reached, I have hopes that by adopting the plan of driving on the hill-sides along the surface, instead of sinking deep shafts, the water will not be found so much an impediment, and the work successfully carried on in all seasons. The prospectors who are now here acquiesce in the opinion, and are prepared to commence tunnelling into the hill immediately.

I am, &c.,

CHARLES HEAPLEY.

Coromandel, May 24th, 1853.

[From Mr. Swainson's * notice of the Coromandel gold district, it appears that the granite of the Dividing Range is flanked by vertical schists, and the range is skirted by conglomerates; that volcanic rocks abound, the whole district having been disturbed by trappean intrusions, and the basalts sometimes capping hills that rival the granitic peaks; that quartz-dykes are reported to exist; that the clayey banks of the Kapanga River are auriferous, as well as its gravelly bed, the lowest parts of the deposits being the richest; and that the auriferous detritus contains quartz-blocks and fragments of granite, slate, and trap-rock.—ED. Q. J.]

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5. *On the* GEOLOGICAL FORMATION *and the* GOLD-BEARING ROCKS *of the* COLONY *of* VICTORIA. By EVAN HOPKINS, Esq., F.G.S.

[Abstract.]

(This communication has been published in full in a pamphlet, entitled "On the Geology of the Gold-bearing Rocks of the World, and the Gold-fields of Victoria." Melbourne, 1853, 8vo. With four Lithograph Plates of Sections.)

WITH this communication, the author laid before the Society, and explained, a geological section of this south-eastern portion of Australia, extending from the Glenelg River, on the west, to beyond Mount Kosciusko, in the Australian Alps, on the east. This section exhibited the structure of this region as formed of great parallel bands of schistose and granitic rocks, having a north and south bearing and a vertical position. Along the line of section first appear the limestone-beds of the Glenelg Valley, resting on the foot of Mount William, in the Grampians, which consists of granite, capped by sandstone formed of the reconsolidated decomposed granite. Mount

* Swainson's New Zealand, 8vo, p. 91.

Cole, in the Pyrenees, next in order, consists of hornblendic schists. The Valley of the Loddon and Forest Creek are on the edges of the great gold band of argillaceous schists, interlaminated with auriferous quartz. These schists constitute the author's "great auriferous band," extending north and south, from the south of Ballarat to the north of Bendigo and Korong. The granite of Mount Alexander succeeds; then the auriferous argillaceous band of the Campaspe Valley and the M'Ivor. This is the "M'Ivor auriferous band." Granite, then the "Goulburn auriferous band," the granite of Violet Town, and the "Ovens River auriferous band," succeed in order to the eastward, and then the great granitic bands of the Australian Alps, occasionally interlaminated with clay-slate, &c. The eastern flanks of the Alps are covered by thick sedimentary beds of sandstone, with thin seams of coal, being the carboniferous formation of New South Wales.

The auriferous deposits were shown to be derived by decomposition from the edges of the auriferous slates and quartz-rock, and to exist under various conditions of depth and material, according to the conformation of the surface and the bearing and structure of the gold-bearing rocks. The richest diggings occur along the north and south extension of the gold-bands. The difference between gold-diggings in the debris *in situ*, and in the debris that has been transported by streams, and so rendered alluvial, was also noticed.

March 22, 1854.

Frederick J. Bigg, Esq., Samuel Minton, Esq., Edward O'Riley, Esq., and Samuel H. Beckles, Esq., were elected Fellows.

The following communications were read:—

1. *On the* Geology *of some parts of* Madeira. By Sir Charles Lyell, F.R.S., F.G.S.

[Extracted from Letters to L. Horner, Esq., F.G.S.]

During a stay of two months in Madeira, Sir C. Lyell had an opportunity of examining a considerable portion of the island, and extracts from his letters to Mr. L. Horner, read at this evening's meeting, contained observations on the geological structure of Madeira and the neighbouring islands of Porto Santo and Baxo. In nearly all his excursions, Sir Charles was favoured by the company of Mr. Hartung, a German naturalist resident at Funchal, who proved a most active fellow-labourer.

Sir Charles agrees with Mr. Smith, of Jordan-hill, in attributing a subaërial origin to the great mass of the volcanic rocks of Madeira. Some of the earlier igneous formations were submarine, and are associated at San Vincente, in the northern part of the island, with deposits containing corals and sea-shells. These marine strata are elevated at least 1200 feet above the sea.

A long and complicated series of volcanic eruptions, for the most part subsequent in date to the above, and which took place in the open air, built up the island. They have given rise to a mountain-chain about thirty miles in length, running east and west. This chain in its middle and loftiest portion rises to the height of 5000, and in some peaks to more than 6000 feet. Its composition is displayed in the precipitous sides of valleys more than 3000 feet deep, and is seen to consist entirely of scoriæ, lapilli, breccias with angular fragments of volcanic rocks, tuff, scoriaceous lava, and some beds of solid lava; the whole being traversed by dikes. None of the fragments of stone in the breccias of the central region have been rounded by water, and no marine remains have been found in them; hence Sir Charles infers that, had there never been any upheaval, Madeira would have acquired a height of between 4000 and 5000 feet by the simple reiteration of volcanic eruptions above the sea-level, or by the heaping up of ejected materials, which have been fissured, and injected by lava in the form of dikes. Large portions of these mountains, constituting the axis of the island, are amorphous and unstratified; but a series of basaltic lavas, separated by tufaceous partings (many of which have probably been ancient soils), are seen to dip away in all directions from the central axis, chiefly towards the north and south, where the island is only twelve miles in diameter, but also towards the east and west, where the chain is highest and most dome-shaped. Under a thickness of about 1200 feet of these lavas, Sir Charles Lyell and Mr. Hartung discovered, in the ravine of San Jorge, a leaf-bed, or argillaceous layer full of fossil leaves, both of Ferns and dicotyledonous plants.

These remains show that the island was clad with a vegetation analogous in many points to that now existing, long before a considerable part of the volcanic eruptions had occurred; confirming the opinion derived from the mechanical structure of the rocks, that the eruptions were supra-marine. The plants, according to Mr. Charles J. F. Bunbury, who visited Madeira with Sir C. Lyell, consist of Ferns of the genera *Sphenopteris*, *Adiantum*?, *Pecopteris*, *Woodwardia*, and others, one of them having the peculiar venation of *Woodwardia radicans*, a species now common in Madeira. There are also a profusion of dicotyledonous leaves, some apparently of the Myrtle family, the larger proportion of them having their surfaces smooth and unwrinkled, with a somewhat rigid and coriaceous texture, and with undivided or entire margins. "These characters," observes Mr. Bunbury, "belong to the Laurel-type, and indicate a certain analogy between the ancient vegetable remains and the modern forests of Madeira. In these last, Laurels and other evergreens abound, with glossy coriaceous and entire-edged leaves, while below them there is an undergrowth of Ferns and other plants."

The lavas and tuffs, which dip away from the central axis, increase in thickness as they recede from it, and become less and less intersected by dikes. Near the axis they are usually but slightly inclined, or only at angles of 3° to 7°, whereas at a distance of two or three miles, they become more tilted, being inclined at angles of 10°, 13°, and even sometimes 20°. When steepest, they sometimes dip inwards, but rarely, the inclination being usually away from the axis. Sir Charles infers that all these lavas issued originally from vents, situated in what is now the central and usually the highest part of Madeira. They formed, together with the cones of eruption, a flattened dome, having a slope varying from 3° to 7° or 8°. They acquired their present steeper inclination during the convulsions attending later eruptions. He agrees, therefore, so far with the *Erhebung* theory of Von Buch, as to admit an expansive movement operating with its greatest intensity along the central axis ; but he supposes this movement not to have been confined to one period. On the contrary, Madeira affords evidence in several regions of great dislocation of the rocks having been accomplished before other lavas and tuffs were in existence. Thus the Picos or Cones of Funchal and Camara de Lobos, with their nearly horizontal lavas and tuffs, about 800 feet thick, cover unconformably the older volcanic rocks of Cape Giram. The newest member of these last consists of alternating lavas and scoriæ, which are tilted at an angle of 30° and 32°, and are overlaid by the Funchal series just alluded to.

Near Porto da Cruz also, a great series of slightly inclined trachytes and tuffs are newer than the central cones of eruption with their steeply-inclined basalts and tuffs, these last having been tilted, and having had deep valleys eroded in them, before the trachytic outpourings took place. Other facts are then adduced to prove that different parts of Madeira have been formed in succession, and a suggestion is thrown out, that the movements accompanying eruptions extend over a much wider area than the superficial ejectamenta and lavas ; also that the subterranean injection of fissures occurs over a wider space below than the effects of eruptions above ground. If so, each series of lavas will most commonly be rent, tilted, and sometimes injected during convulsions accompanying the formation of newer and neighbouring vents and craters ; so that those lavas alone which proceed from the most modern vents will remain wholly undisturbed so as to retain their original position.

Sir Charles remarks that the lavas of Madeira, whether vesicular or compact, do not constitute continuous sheets parallel to each other. When viewed in the sea-cliffs in sections transverse to the direction in which they flowed, they vary greatly in thickness, even if followed for a few hundred feet or yards, and they usually thin out entirely in less than a quarter of a mile. In the ravines which radiate from the centre of the island, the basaltic beds are more persistent, but even here they usually are seen to terminate, if followed for a few miles ; their thickness also being in some cases very variable. Occasionally cones of scoriæ, made up of ejectamenta, inclined at 20° or 30°, are surrounded and buried by the lavas proceeding from the central axis.

The general absence of water-worn pebbles in the tuffs underlying the Madeira lavas is very striking, and contrasts with the frequent occurrence of gravel-beds under lava-currents in Auvergne and elsewhere. Sir Charles supposes that on the flanks of Madeira, as on the slopes of Etna, or Mount Loa in the Sandwich Islands, there were no rivers. At Porto da Cruz, however, there are well-worn pebbles in some comparatively modern tuffs, covered by trachyte; and there are also some partially rounded stones in alluvial tuffs, of relatively modern date, at Camara de Lobos near Funchal. Yet neither here nor elsewhere in the island do the lavas overlying alluvium follow the windings of existing valleys, as in Auvergne. The Curral and other deep valleys are ascribed to aqueous erosion, chiefly fluviatile, assisted by subterranean movements.

In one of the letters the sea-cliff section of Cape Giram, 1600 feet high, was described. Several hundred dikes are there seen, intersecting scoriæ, tuff, and lava. In another letter the volcanic cone of Piedade, near Caniçal, is spoken of. Its structure has been exposed by encroachments of the sea on the coast near the eastern extremity of the island. Near Caniçal also, and in Porto Santo, thirty-five miles N.E. of Madeira, ancient sand-dunes occur, containing fossil land-shells, chiefly of living, but in part of extinct species.

The rocks of Porto Santo are both basaltic and trachytic. Those of the little island of Baxo, south of Porto Santo, are of submarine volcanic origin, covered by supra-marine lavas. In the tuffs of the older series, corals and shells abound, and water-worn pebbles, such as may have been formed on a sea-beach; and these are cemented together by carbonate of lime in the same conglomerate with the organic remains.

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2. *On* Yedmandale, *as illustrating the* Excavation *of some* Valleys *in the* Eastern Part *of* Yorkshire. By H. C. Sorby, Esq., F.G.S.

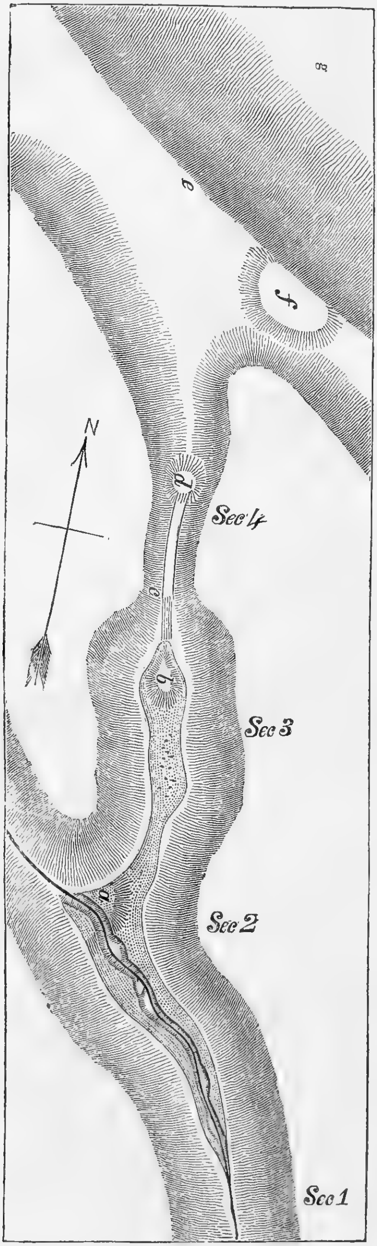
The Tabular Hills of the Eastern Moorlands of Yorkshire in their eastern part, that now under consideration, are very flat-topped; gradually rising from the vale of Pickering, on the south, where the elevation above the sea is about 100 feet, and attaining a height of about 600 feet at the escarpment six miles north of this, overlooking Harewood dale. The surface rock of the southern part is coralline oolite, which, however, has been removed from the northern part, where the calcareous grit is laid bare. Numerous ravine-like valleys, whose sides are inclined at an angle of about 30°, have been excavated in them, chiefly trending N.N.W.; but some are at right angles to that direction, being respectively nearly in the lines of the dip and strike of the beds, which, on the whole, lie nearly parallel to the surface. Many of these have been much modified by the streams now running in them, and present such appearances as might lead one at first to conclude that they had been altogether excavated by their action; and, indeed, there is nothing in their structure to prove decidedly that such was or was not the case. The peculiarity of Yedmandale, however, is, that there appears never to have been any brook or stream of modern drainage in its upper eastern branch, and that it is now in very nearly the same state as when first it emerged from those conditions of submersion which denuded the district. It is situated about four miles west of Scarborough. The lower end opens into the vale of Pickering at Ayton, and it trends to the north-north-west for about two miles. In connexion with the great problems of denudation, formation of valleys, and superficial deposits, it presents a number of facts of such importance in forming a correct theory for this district, that I shall describe them with some degree of minuteness.

At the lower end of the valley the sides are inclined at an angle of about 30° ; and it may be seen that there it has been cut out of the sand and gravel with erratic pebbles found in the vale of Pickering. Here the bottom of the valley is flat, and about fifty yards broad; and there is no indication of a brook having ever run in it. Passing upwards, however, we come to two ravines, trending north, and down them come streams, which, when arriving at the main valley, form an excavated course in its flat bottom, gradually vanishing, the water obviously passing away through the coarse detritus of which it is composed. Above these ravines the flat tract is again entire for some distance, until we arrive at another brook, which also vanishes in a similar manner.

Higher up, however, this brook has cut away and removed the whole of the detritus from the bottom of the valley, and there its sides are inclined at an angle of 30° from the top to the bottom, as shown on the plan (fig. 1), where it is marked *Sec.* 1, and by fig. 2, *Sect.* 1, where the upper dotted line indicates the original surface before the valley was excavated, and the lower, the probable extent of the detritus in it, before it was removed by the action of the brook. Farther up the valley, the brook has not washed away the whole of the detritus, but has formed in it a small ravine and little flat alluvial tracts, as shown on the plan. *Sect.* 2, fig. 3, exhibits the configuration in this part, where the results of the operation of the modern brook, and that of the agent that excavated the valley, are shown by the lower and upper dotted lines.

Here the nature of the detritus at the bottom of the valley is well seen. It is composed of boulders and pebbles, of a size varying up to several feet in diameter, which are but slightly rounded or worn ; and, in some parts, have been cemented together by the infiltration of calcareous water. Though many thousands are exposed, and though I examined them very carefully, I did not find one that could not have been derived from the immediate vicinity northwards, being all composed of harder and softer calcareous grit; and I did not see any of coralline oolite, though it occurs *in situ* only a short distance to the south.

The brook just mentioned comes down the western arm of the valley, as shown on the plan, and has removed from it all the detritus that probably extended up it; and, for the whole of its length, which is about a mile, the section is similar to *Sect.* 1, the ravine becoming less and less. It is, however, the eastern branch that claims the most particular attention. Its form will be best understood from the plan. Except just at the upper end, the sides are inclined at an



Figs. 1 to 6.—*Plan and Sections of Yedmandale.* Scale 6 inches to 1 mile.

Fig. 1.—*Plan of the Valley.*

angle of about 30°, and at the bottom is a small, somewhat undulated tract, composed of the coarse detritus, as shown in *Sect.* 3. As will be seen on the plan, this has been accumulated in the form of a delta at the top, at *b*, and also at *a*, where the ravine joins the valley, though a great part has been removed by the action of the brook that runs down it; whence it would appear that this coarse detritus was brought into the valley down that ravine, and from the part north of the upper eastern end. This is in the form of an amphitheatre, the inclination in the centre being about 14°, passing quickly on each side to 30°. Above it is another small valley, at a level of about 70 feet higher, whose sides are inclined at 30°, and with a flat tract at the bottom, as shown on the plan and by *Sect.* 4, which, however, I think, is not due to deposit at the bottom, but denudation down to a uniform plane of bedding of the rock. At the upper end of this is a very curious absolute depression, as shown at *d*, down to which the sides of the valley pass, whilst north of it they gradually open out into a wider depression, passing into the general denuded top of the hills, as shown on the plan, fig. 1. Still farther north of this is the steep escarpment of the large and deep valley of the Derwent, a portion of which is seen at *g*, and the bottom of which is from 200 to 300 feet lower than that of Yedmandale.

Fig. 6 is a section in the line of the centre of the upper part of the valley, the letters on it corresponding to those on the plan, fig. 1 ; and

Fig. 2. *Sect.* 1.

Fig. 3.
Sect. 2.

Fig. 4.
Sect. 3.

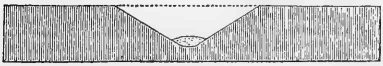


Fig. 5.
Sect. 4.

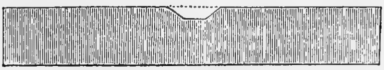
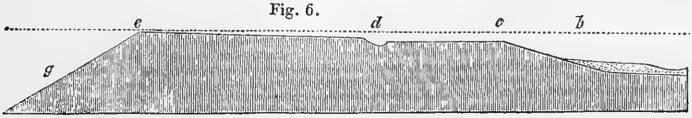


Fig. 6.



Longitudinal section.

the dotted line shows the original level of the surface previous to excavation. At *g e* is the steep upper part of the valley of the Derwent ; from *e* to *d* the inclination is small, but greater than the dip of the beds ; at *d* is the above-mentioned absolute depression, the north side being higher than the south ; from *d* to *c* is the flat bottom of the higher valley, coinciding with the plane of bedding ; and from *c* to *b* is the slope of the centre of the top of the lower ; at the bottom of which, at *b*, is the deltoid accumulation of detritus.

Though there are numerous remains of ancient military works in the vicinity, yet the peculiarities I have described are so connected together, and of such a kind as cannot be other than natural.

Throughout the whole of this upper eastern branch of the valley there is no trace whatever of any brook-course. Why this is so, can easily be understood. The level of the valley of the Derwent being so much lower; there being so small a tract to drain ; the dip of the rocks also having a tendency to carry the water into the ravines in which there are brooks, as previously described ; and the coarse nature of the detritus at the bottom of the valley, easily account for there being no stream of modern drainage in it. As mentioned above, the considerable streams which do enter the valley soon disappear amongst the detritus, and, therefore, one cannot be surprised that the small quantity of water that must enter this branch of it should disappear, without forming any surface-course whatever. Supposing that a stream was to run from *e* towards *b*, there cannot be any doubt that it would cut a ravine course, would fill up the depression at *d*, and, in passing down the steep slope from *c* to *b*, would soon cut deeply into the part at *c*, and, in no long period, produce an evenly-inclined channel for the whole of the distance. There is, however, not the least trace of such an action having ever occurred. The sides of the lower valley pass gradually round at the upper end, without any such irregularity; and, I think, no one examining the valley itself could come to any other conclusion, than that it had been excavated by the same agent which denuded the district, and cut away the whole mass of the Tabular Hills to the north and east of their main escarpment.

Now, if a brook had run down this part of the valley, formed a gradually-sloping channel, and reduced it to the same state as that where one does run; if it had removed the whole of the detritus, and given the valley the form of *Sect.* 1, fig. 2, there would have been no certain evidence whatever to indicate or prove that the whole had not been excavated by it. As it is, however, we must conclude that nearly the whole was due to a cause acting before there was any such surface-drainage, and that the brook has merely cut away some of the detritus left in the valley, which had not been entirely removed by the denuding agent. Though I am far from inferring that such has always been the case, for each particular district ought to be judged of from the facts there seen, and not by any *à priori* reasoning, yet I cannot but observe that we are thus led to form this conclusion for valleys whose form is very much more than ordinarily in accordance with what would be due to the long-continued action of such streams. I might easily fortify this deduction by reference to the phænomena observed in other valleys in the neighbourhood, but will not, for fear of being tedious.

If, then, these valleys in the Tabular Hills were excavated by the same cause that denuded the district, it will be well to examine the facts that may lead to a satisfactory conclusion, with respect to what that agent was. As previously mentioned, the general line of these valleys, in the part under consideration, is north-north-west, being nearly in the line of dip; there being others of a different character at right angles to that direction. Though, in the case of Yedmandale, there is no very decided evidence of any considerable fault, yet I think there is good reason to believe that it and the other valleys are along the lines of this or some other structural weakness.

The deltoid accumulations of detritus in Yedmandale, and the nature of the rock of which it is composed, clearly indicate that it was deposited by a current from the north-north-east. If these valleys were excavated by the denuding agent, we must suppose that the whole surface was submerged. If so, the above fact would prove that there then was a considerable current from the north-north-east. Supposing that a fault extended up the valley, becoming small or ending in the top eastern branch, and that there was such a strong north-north-east current, we must conclude that it cut away the rock on each side of the fault, and gave rise to a ravine-shaped valley, carrying away the detritus to the south into the vale of

Pickering. The configuration of the parts about *e* shows that the top bed has been partly removed, and a small outlier left at *f*. From *d* to *c* a narrower valley was cut down to a uniform plane of bedding, somewhat lower than north of *d*. The absolute depression at *d* may be explained by supposing that, in this change of level of the bottom, an eddy was formed, as would indeed almost necessarily be the case; and the much deeper and larger amphitheatre, at and below *c*, was probably due to a similar cause. Though the mean direction of the valley below this is straight, yet it is curved considerably; but the curves are all situated in parts where, on this supposition, the currents from lateral ravines would have given rise to them. After the valley was excavated, it would appear that the current became less, so that some of the detritus removed from the upper parts could be accumulated in the valley, when the chief part of it would be deposited, in a deltoid form, in the manner and in the places where it is now found.

The north-north-west line of current is very similar to what must have occurred during the deposition of the northern drift of the neighbourhood; and there are some reasons for believing them to be related to one another. A few small erratic boulders and pebbles are found on the higher parts of the hills, but no great deposit of drift, which attains its maximum on the low lands towards the sea-coast. In those valleys that are protected from the north, no erratics are found, except just at their lower ends; but they have been drifted into those opening towards it. This would then lead us to infer that these valleys existed at the period of the Drift. However, as already mentioned, their lower ends have been excavated in drift in such a manner as to show that some currents did pass down them afterwards, so that the surface of the sides and bottom of the valley was rendered uniform and continuous with the parts where none was deposited. If such then be the case, it should appear that both previous to and after the deposition of the drift, northern currents passed over the district. In my paper on the contortions in the drift of the Yorkshire coast (Report of the Geol. and Polyt. Soc. of the W. R. of Yorkshire for 1851, p. 220), I have shown what I consider to be evidence of icebergs having been present during the whole period of the Drift, as well as northern currents; yet not of great intensity, or else one can scarcely suppose that such deposits as it consists of could have been accumulated. Perhaps, therefore, on the whole, the general phænomena of this locality may be best explained by supposing that at first very considerable currents, probably due to movements of elevation, proceeded from some point near to north-north-west, a direction well agreeing with what would be produced by such as have really occurred; that these denuded the district and excavated valleys along lines of weakness; that afterwards the northern drift was accumulated, currents being present that moved in much the same direction, but with very much less intensity, and which subsequently, to a certain extent, denuded and cut valleys in this drift. The whole was then elevated, and the sea, acting at various levels, somewhat modified the surface; and streams of modern drainage, being ultimately formed, filled up some of the original small lakes, and somewhat altered the configuration of the previously existing valleys.

3. *On* Remains *of* Fish *in* Flints. By Capt. Henry Alexander, Royal Staff Corps.

[In a letter to the Secretary of the Geological Society.]

In the year 1850, being in Swaffham, my friend Mr. Rose first called my attention to the existence of fish-scales in flint. A lithographic plate of scales, &c. was afterwards presented to me, which I found to be correctly figured. This plate appears in the Annals of Natural History (No. ix. 1838); and is one of two plates illustrating a paper "On some new Organic Remains in the Flint of Chalk," by the Rev. J. B. Reade, F.R.S. At this period I was residing at Diss in Norfolk, and understood that only solitary scales, teeth, and fragments of bone had been discovered. Having mentioned the circumstance to a friend, Mr. Amyot, also of that town, we commenced to examine very perseveringly the flints of that neighbourhood, more particularly those collected from the fields and placed in heaps by the sides of the roads. Many hundreds of these flint-stones we broke, and at a rough calculation I consider that about one in forty or fifty yielded fragments of fish, from one inch to four, five, and six in length. These fragments consist of scales (cycloid and ctenoid), teeth, fragments of the head, vertebræ, fins, one tail, and various bones. I have found no specimen in which the head or even a portion of it has remained attached to the vertebral column.

The tail above-mentioned is small, but perfect (homocercal), about an inch in length. I have also found the right lower jaw of a fish or reptile; a drawing of which, of the natural size, I enclose. Professor Owen inclines to consider it as belonging to a fish.

This letter accompanies a few specimens of the remains of fishes in flint, which are for the acceptance of the Geological Society, if considered worthy of its notice.

The flints in which I have found the best of my specimens require but a slight blow to break them. Whether this is owing to their long exposure to the atmosphere, or that the flints of the Upper Chalk, to which I presume these belong, are more easily fissured, or from their having been broken up from their original bed, rolled here and there, striking each other, and receiving numerous fractures imperceptible to the naked eye, or from whatever cause, they most certainly (the best of them for producing specimens) break the easiest, and very often in the direction of the enclosed substance, which, however, would be the case, if the hammer fell in the right direction, and when that is the case, it is a fortunate circumstance for the display of the enclosed remains. The specimens require some little patience in their examination; the eye, in fact, requires a little tutoring before the many different objects in a good specimen are wholly displayed to the sight. I possess some specimens that have taken me many weeks before I have discovered that they contain minute teeth, small but perfect vertebræ, scales of various forms and sizes, and some with the lubricating tubes, &c.

Ipswich, Suffolk, Feb. 24th, 1854.

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TO THE

LIBRARY OF THE GEOLOGICAL SOCIETY,

From January 1st, 1854, to March 31st, 1854.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

April 5, 1854.

Robert Etheridge, Esq., was elected a Fellow.

The following communications were read:—

1. *On some* Mammaliferous Deposits *in the* Valley *of the* Nene, *near* Peterborough. By Joshua Trimmer, Esq., F.G.S.

In the collection of the Marchioness of Huntly there are bones of the Elephant and other large mammals, which have been obtained from two gravel-pits near Orton Hall. Some of them have been submitted, I believe, to the inspection of Professor Owen; and through the kindness of the Marchioness I am enabled to exhibit the whole of them* to the Society.

While making, in company with Mr. Bailey Denton, a rapid examination of the geology of the Orton estate in its agricultural relations, I had lately an opportunity of seeing these deposits, which present some interesting features bearing on my communication, published in a late number of the Journal†, "On the Soils which cover the Chalk of Kent."

* The collection comprises remains of *Elephas meridionalis*?, *Bos primigenius*, and *Cervus elaphus*.

† No. 36. vol. ix. p. 286.

I place the Orton gravel on the parallel of the Nar clay and the mammaliferous deposits of the Thames Valley, which I refer to that portion of the Pleistocene epoch which I have called* the second stationary, or second elephantine period, and which I have described as intervening between the elevation of the erratic tertiaries and the distribution of the Warp-drift over their denuded surface.

In the Nar clay the shells are wholly marine, although it is probable that it terminates, on the east, in freshwater deposits similar to those of the parallel valley of Gaytonthorpe†. In the ancient wide-spread alluvium of the Thames the shells are exclusively those of the land and fresh water. The Orton gravel is a fluvio-marine deposit.

These facts accord with the sketch-map which accompanied the paper above-mentioned (*op. cit.* vol. ix. pl. 13, map No. 4.), illustrating the distribution of land and water on the eastern side of England, during the second stationary, or second elephantine period.

In the Valleys of the Nene and Nar we have the elevated coast-line of ramifications from a bay which extended more to the west than the present estuary of the Wash. In the old alluvium of the Thames, on the other hand, we have evidence of the eastern extension of land drained by a river of such volume, that there is no difficulty in supposing it to have extended sufficiently to the east to have been a tributary of the Rhine‡.

The foundation-rock of the Orton Estate is Oxford clay, with beds of impure limestone on its western side; but, from the imperfect sections and the rapidity of my examination, I have not yet been able to satisfy myself whether they belong to the lower part of the Oxford clay or the upper part of the Great Oolite.

The superficial deposits with which these strata are extensively covered, are, taking them in the order of their antiquity,

1. The Boulder-clay of the Lower Erratics.
2. The Orton Gravel, reconstructed from erratic materials.
3. The Warp-drift.

I saw nowhere on the estate, or in its vicinity, any gravel of the upper erratics, in its normal condition, that is, resting on boulder-clay, or resting on other rocks at higher levels than that clay.

The warp-drift on the Oxford clay is, in many parts of the estate, more than 4 feet deep; and, though on that clay it partakes much of the nature of that bed, it contains extraneous fragments to such a depth, that, except at a section afforded by a brick-field, I could not satisfy myself that I had seen it in its native state. Even there, beneath a brown clay-loam, 3 or 4 feet deep and containing detritus not derived from the subjacent stratum, there is a blue clay, containing, to the depth of about 7 feet, decayed roots and other vegetable matter, which not only extend through it vertically, but are interstratified with it in such a manner as to cause suspicion that the clay has been reconstructed to that depth. Without further

* Quart. Journ. Geol. Soc. vol. ix. p. 295.

† *Op. cit.* vol. vii. p. 26.

‡ *Loc. cit.* and Quart. Journ. Geol. Soc. vol. vii. pl. 7.

examination, I should hesitate to affirm that which I believe to be the case, namely that we have here an ancient marshy surface beneath the warp-drift.

The boulder-clay contains a large proportion of chalk and chalk-flints, with other fragments of still more distant origin, imbedded in a base of brown clay. It forms a ridge extending from north to south, and therefore in a direction transverse to this part of the Valley of the Nene. It is based on Oxford clay.

The Orton gravel is spread over the Oxford clay and the oolitic rock in a direction parallel to the valley, and extends to a height of 20 feet above the level of the Nene.

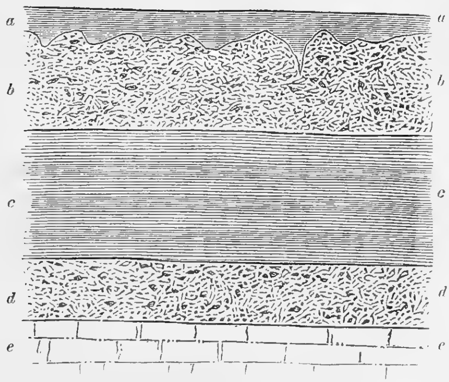
The two gravel-pits which have yielded mammalian remains, associated with terrestrial, marine, and fluviatile shells, are situated near the Hall, and about 176 yards from the road from Peterborough to Northampton. From that nearest to Peterborough, in a pasture-field, bones have been obtained, irregularly dispersed, as I was informed by the workmen, through the gravel. They are more abundant in another pit, in an arable field, distant about 460 yards from the former and about 200 yards from the road.

In the former pit the gravel has been worked to the depth of 10 feet, without reaching the rock.

At the depth of 7 feet, I found *Cardium edule* and *Ostræa edulis*, in the state of large fragments in a very decayed condition.

At the pit in the arable field, the gravel is worked down to the oolitic rock on which it rests; and the total depth of the deposit, of which the following is a section, varies from 12 to 14 feet.

Section of the Mammaliferous Gravel of the Nene Valley; from a gravel-pit near Orton Hall.



a. Warp-drift of brown loam, filling indentations in surface of *b*.
b. Gravel.
c. Alternations of sand with grey and brown clay;—freshwater and land shells.
d. Gravel;—mammalian bones and marine shells, both near the bottom of the bed.
e. Oolitic rock.

I am indebted to Mr. Rupert Jones for the identification of the species, which he describes as

Cardium edule.
Ostræa edulis.
Unio —— ?
Bulimus lackamensis.
Limnæus glaber.
Bithinia tentaculata.
Paludina marginata.
Valvata cristata.
—— piscinalis.

Besides these I found a small *Helix* and a *Planorbis*, which have been unfortunately broken.

From the numerous species of the land and freshwater shells enumerated by Mr. Morris* from a deposit about twelve miles north of this, I have no doubt that the future researches of the Marchioness of Huntly will add several species to the above list.

The marine shells (*Cardium*) from this pit were given me by the men, from a heap of fragments of bones and bouldered oolitic shells, and were evidently freshly detached from their matrix. Their position in the lower part of the gravel rests on their authority.

At the other pit I extracted the marine shells myself, at the depth, as I have stated, of 7 feet from the surface.

The prevalent fragments in the gravel are derived from various oolitic rocks; they are considerably water-worn, and are mixed with chalk-flints. There are also fragments of flinty slate, quartzose sandstone, and other rocks of more distant origin.

This gravel appears to have been formed from the materials of the denuded boulder-clay, with an increased proportion of oolitic materials brought down by the ancient Nene. Chalk, which abounds in the boulder-clay, has nearly, if not entirely, disappeared from the gravel. The only specimens of it which I could find were small rolled pebbles of the very hardest varieties, in the sand interstratified with the clay in the bed *d* of the preceding section.

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2. *On the* Geological Structure *of part of the* Bavarian Alps; *with Remarks on the* Erratic Phænomena. By Dr. Adolphe Schlagintweit.

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

Contents.

* Quart. Journ. Geol. Soc. vol. ix. p. 321.

3. The elevatory relations of the rock-masses.
    A. Structure of the mountain group of the Zugspitze and the Wetterstein.
    B. Structure of the mountains between the Loisach and the Amper.
4. Remarks upon the Diluvial and Erratic Phænomena.
    On Polished Rock-surfaces.

Introduction.—The observations a brief account of which I have now the honour to lay before the Society refer chiefly to that portion of the Bavarian Alps which includes the affluents of the Loisach and Ammer, and partly of the Tsar, to the south of Munich*.

The group of the Zugspitze and the Wetterstein, between the Loisach and the Tsar, forms the greatest elevation in the outer zone of the Alps from the Lake of Constance to the Salzach. It presents a peculiar attraction to the geologist from its very complicated and irregular structure.

The following observations were made in the autumn of 1852 and in the course of the summer of 1853, more particularly during the latter period. In my investigations I was especially guided by the works of Escher von der Linth and Studer, of Schafhaütl, Emmrich, Von Hauer, and by the excellent memoir of Sir Roderick Murchison, which gives such a clear outline of the succession of the sedimentary strata of the Alps, and of the enormous dislocations and disturbances to which they have been subjected.

In the latter part of my paper I have offered some general remarks upon the diluvial and erratic deposits, and upon the polished and striated rocks connected with this subject.

§ General view of the Formations.

I. *Lower Alpine Limestone* (Unterer Alpenkalk)=*Muschelkalk.*

This is the *lowest* of the formations which are found in the upper affluent valleys of the River Loisach. It consists chiefly of grey dolomites, between which, but rarely, occur strata of dark-coloured grey and brown limestones. Fossils were nowhere found in these dolomites, neither in these parts of the Bavarian Alps nor in the eastern portions explored by Prof. Emmrich.

The dolomites of the inferior Alpenkalk, forming the base of the subsequent fossiliferous strata of the lower Lias, may well be considered as an equivalent of a portion of the Trias.

II. *Lower Lias.*

This formation, which covers a great area in this part of the Bavarian Alps, consists generally of dark-coloured marls and marly limestones. In many places very dark slates, not effervescing with acids, are met with. Occasionally there appear masses of lighter

* The author and his brother, Dr. Hermann Schlagintweit, have in preparation a larger Memoir on the subject of this communication, to be illustrated by a geological map and plates. The map and some of the plates were exhibited to the Meeting, and are referred to in this paper.

coloured and harder limestones, which nevertheless are generally characterized by a certain amount of aluminous contents.

In different places there are found in this formation very remarkable and extensive strata of a finely-grained grey sandstone, becoming brown by decomposition; it contains little pieces of mica, and either effervesces but slightly, or not at all, with acids. These sandstones contain few fossils; I found only some indistinct vegetable impressions and fragments of *Avicula* and *Nucula*.

By investigating the superposition and the mutual relations of the strata, I came to the conclusion that these sandstones were to be considered as a part of the Lower Lias formation.

These sandstones seemed to me to be very analogous with those which in the Vorarlberg and in Austria accompany the "alpine coal," according to Escher and Von Hauer. M. Hauer replied to my suggestions, upon making these comparisons, that he also was inclined to admit, after the inspection of the specimens I had sent him, such an analogy, and that in Austria the sandstones accompanying what was termed alpine coal (Alpenkohle) were now also considered as a part of the Lower Lias formation, though with a different *facies*, and in many respects a different fauna.

All the strata here spoken of, I have laid down on the map under the name of "Lower Lias," which was first used by M. Hauer of Vienna, who admits that these strata must be separated from the Cassian beds, which form the uppermost part of the alpine Trias and contain a very different fauna. Other geologists, Emmrich, Escher, and Merian, are inclined to consider these as an equivalent of the Cassian strata. They endeavour to infer this from the mode of superposition in the southern Alps, and from analogy in some palæontological characters.

According to the recent investigations in the Austrian and in the Bavarian Alps, it seems that we must consider as Upper Muschelkalk the strata of Hallstadt, forming an equivalent of the Cassian beds of Münster and Klipstein with *Ammonites Aon*, &c.

The Lower Lias is considered to comprise as *contemporaneous* deposits:

a. The strata of Kössen = Gervillia-strata of Prof. Emmrich = upper Cassian beds of the Swiss geologists.

b. The Dachstein-limestones with *Cardium triquetrum* (=*Megalodus scutatus*, Schafhaütl).

The fossiliferous portions of the alpine Trias not being exposed in that part of the mountains to which I more closely directed my investigations, I could not obtain any proofs of the relation of the Gervillia-beds and their fauna to that of the lower formations.

The strata of the inferior Lias are in many places very rich in organic remains; the following is a list of the most characteristic and generally distributed of these fossils. They have been collected and determined by myself. Fortunately I was enabled to send specimens of all of them to M. Hauer, who has compared them with the beautiful collection of alpine fossils now accumulating at Vienna.

Ammonites Roberti, *Hauer*; very distinctly found in this formation in the Lahnewiesgraben; in Austria it had been met with until now only in the next higher formation,—the Upper Lias.

Avicula inæquiradiata, *Schafhaütl.* Many specimens; this species is found, though rarely, in the strata of Kössen in the Austrian Alps.

Avicula intermedia, *Emmrich*; differing from the very similar forms, *Avicula inæquivalvis* and *A. Munsteri*, by the number of the ribs.

Cardium austriacum, *Hauer.* In some places found in considerable abundance. This is the species designated very often as *Cardita crenata.* Two lateral teeth in the hinge, which M. Hauer could clearly observe in some of the specimens, place this species in the genus *Cardium.* The true *Cardita crenata* of St. Cassian seems to have a very different hinge, although, until now, it has not been quite clearly made out.

Cardium rhæticum, *Merian.*

Gervillia inflata, *Schafhaütl.* In some localities very common, and very characteristic of this formation.

Lima gigantea, *Sow.*

Modiola Schafhautli, *Stur.*=Modiola texta, *Schafh.*

Nucula complanata, *Phill.* In some localities very common.

Ostrea Haidingeriana, *Emmrich.*

Pecten Lugdunensis, *Mich.*, according to a determination by M. Merian; and some other as yet undescribed species of *Pecten.*

Pholadomya lagenalis, *Schafhaütl.*

Pinna Hartmanni, *Zieten.*

Trigonia; similar, according to Von Hauer, to *Trigonia harpa,* Münster, or *Trig. Whateleyæ,* Buch; but differing from it, and probably a new species.

Rhynchonella fissicostata, *Suess.*

Terebratula cornigera, *Schafhaütl.*

Terebratula gregaria, *Suess.*

Terebratula subrimosa, *Schafhaütl.*

Spirifer Emmrichi, *Suess.*

Spirigera oxycolpos, *Emmrich.*

Corals are met with in some parts of this formation, especially in the lower strata, sometimes in great abundance; the species of these corals, principally *Lithodendron* and *Astræa,* have not yet been described.

Only in one locality, on the Katzenstein, some fossils have been found which might seem to indicate a triassic formation; these were *Terebratula trigonella,* Schlotheim, and parts of *Crinoidea* very similar to those of *Dadocrinus gracilis,* H. von Meyer; but with these fossils was associated *Natica alpina,* Merian, belonging very evidently to the Kössen beds; nor does the position of these strata give the least evidence of their being different from the Lower Lias in general.

III. and IV. *Upper Lias and Jura.*

A. *Upper Lias of Ammergau.*—Very well developed and fossiliferous strata of the Upper Lias occur near Ammergau, immediately in the north of my geological map. The blue and grey marly limestones contain numerous and well-preserved specimens of

Ammonites amaltheus, *Schlth.*
Ammonites Nodotianus, *D'Orb.* (also found at Adneth).
Ammonites radians, *Schlth.*
Ammonites Reussi, *Hauer.* Similar to *Am. Humphreysianus,* Sow., but with very different lobes.
Ammonites Partschi, *Stur.*
Ammonites tatricus, *Pusch.*
Inoceramus ventricosus, *Sow.*

These Lias strata dip with very steep angles, being nearly vertical to the south, and are evidently in a very irregular position. They lie conformably on enormous masses of sandy and marly Flysch rocks, which extend to the north, and contain immediately under the Lias strata (which in their mineralogical characters are often scarcely to be distinguished from them) nothing but many specimens of the *Fucus intricatus.*

Above the Lias strata is found a small zone of dolomite, dipping everywhere at 70° and 75° to the south, or south 70° west. Ascending the slopes of the Sonnenberg, we find a thickly-wooded declivity, above which begin the sandstones of the chalk with *Orbitulites,* but dipping with quite an opposite direction to the north.

B. *Lias and Jura on the Hirschbühel and the Wetterstein.* Under the designation of "*Upper Lias and Jura,*" I have laid down on the map two separate zones of strata; the one in the Lahnewiesgraben, the other on the southern foot of the Wetterstein. In both localities are found strata of marl and limestone, in general of a red or of greyish and greenish colour. Amongst the many fragments of fossils I had collected, there could be determined with accuracy only

Ammonites radians, *Schlth.* In small specimens.
Ammonites tatricus, *Pusch.*
Aptychus, similar to *A. lamellosus,* but recently distinguished from it by M. Schafhaütl under the name of *A. subalpinus.* They occur very often in the contorted red marly limestones of the Lahnewiesgraben, but not in the Wetterstein.

According to the order of superposition of the strata, this formation is evidently situated, as seen in the Gaisthal, between the inferior Lias and the upper Alpenkalk.

The above-quoted fossils might indicate them to belong either to the Lias or to a higher Jurassic group. I have comprised these strata on the map under the collective name of "Lias and Jura," since I expect that further investigation may possibly lead to a separation of these strata into two distinct groups.

If we follow out the distribution of these strata on the geological map, we find that in the Lahnewiesgraben their eastern prolongation is stopped by a very remarkable transgressive position of the dolomites of the Kramerberg, of which we shall speak hereafter. On the Wetterstein it is very difficult to trace accurately the limits of the western and eastern prolongation of the band of the Lias and Jura strata. Large masses of debris and the difficulty of traversing the steep declivities made it impossible for me to lay down the eastern and western termination of these strata as distinctly as I could have wished to do.

C. *Red Marble of Graswang and Ettal.*—Very well developed strata of this marble, generally of red, sometimes of white or yellowish colours, are found in the valley of Graswang and at Ettal, a little north from the mountains. Though the structure of the mountains and the position of the strata are here very irregular, as I have endeavoured more fully to describe in my large memoir, it is quite evident, by comparative observations in different localities, that these marbles are generally covered by the white upper Alpine limestone, which dips generally to the north, and contains the same small coral-remains which are so very characteristic of it on the Zugspitze and in other localities. The marbles are clearly underlied by grey and blue marls and limestones, containing in different places *Cardium austriacum, Gervillia inflata, Nucula complanata,* and other fossils characteristic of what we have termed "inferior Lias or Gervillia-strata."

The marbles lying thus between the upper Alpenkalk and the inferior Lias contain very often numerous specimens of *Terebratulæ.* M. Suess at Vienna, who has recently very thoroughly examined the Brachiopoda of the Trias and Lias formations of the Eastern Alps, recognised among the specimens I had collected *Rynchonella Hornesi*, Suess, and *Rhynchonella variabilis*, Schlth.

The Hierlatz-strata of the Austrian Alps, which are characterized by the same fossils, probably form, according to the recent investigations of MM. Hauer and Suess, a part of the Upper Lias (=Adneth strata), though with a very peculiar *facies.*

V. *Upper Alpine Limestone.*

This formation consists, in the mountain ranges under consideration, of a light-coloured, white, or yellowish limestone, which appears in great masses on the Zugspitze, on the Alpspitze, and on the Wetterstein, and forms high and steep escarpments.

These strata here evidently cover all the jurassic deposits; but as yet the investigation of the fossils which they contain is not far enough advanced for determining with perfect accuracy the geological age of this Upper Alpenkalk. In different places, for instance on the summit of the Zugspitze, in the Höllenthalkahr, on the Wetterstein, there occur in this limestone numerous coral-remains. Prof. Schafhaütl has described and figured some of these corals under the name of *Nullipora annulata**.

I have also been able to collect in the Höllenthal, as well as in the upper Bainthal, not far from the end of the Plattacher Glacier, several specimens of *Nerinæa.* According to Von Hauer's comparison of these specimens, they seem to be quite identical with the *Nerinæa* found on the Plassen near Hallstadt.

"The limestone of the Plassen," he writes, "is almost certainly identical with the fossiliferous strata of Stramberg in Moravia, and

* Leonh. and Bronn's Jahrbuch 1853, p. 303, tab. 6. fig. 1.

these latter probably belong, according to the recent investigations of M. Hohenegger, to the Neocomian formation."

In the same stratigraphical relations, and with fossil corals identical with those found in the group of the Zugspitze and the Wetterstein, we find the upper Alpine limestone also in the Kahrwendel range, which extends immediately to the east of the Valley of the Tsar, as well as to the north of my geological map, where it appears again in the environs of Ammergau on the Laberberg, and on the Kofel and Sonnenberg.

VI. *Cretaceous Formations. Orbitulite-sandstones.*

The cretaceous strata, characterized by numerous *Orbitulites*, do not appear within my map, but occur immediately to the north of it, in the environs of Ammergau. They consist of grey sandstones with a calcareous and marly cement. The latter is sometimes very predominant; and the mineralogical composition of the rocks varies very much.

In some strata the quartz and hornstone grains are very predominant, and sometimes attain a considerable size. The rock is then very hard, and the surface becomes very rough and uneven by the effects of weathering.

Among the fossils the most characteristic are numerous *Orbitulites*, of which there are at least two distinct species. There has been also found a well-preserved fragment of an *Ammonite* south of the Rappenkopf, which, according to Von Hauer, agrees with no known species, and is probably undescribed. Different specimens of *Ostræa*, *Nerinæa*, and *Turbo* occurred south of the Rappenkopf and in the Soile-Alpe.

These deposits seem perfectly to agree, as regards their lithological and palæontological characters, with very similar strata observed by Prof. Emmrich in the Urschelau in the Traun Valley. The latter contain more numerous and better-preserved fossils, and belong evidently to the Upper Cretaceous formation.

The cretaceous strata are well developed in the basin of the Soile- and Nebele-Alpe between the Laberköpfen and the Ettales Mändl; they occur also on the southern slope of this mountain range in the Spitzschlaggraben. We find them again on the opposite side of the Amper, on the Rappenkopf, south of the Kofel, and they are prolonged in a westerly direction to the Brunnberg, and probably still farther. The very complicated structure of the Laberberg and the Brunnberg makes it difficult to follow out exactly the distribution of the cretaceous strata. It is evident, by observations on different spots, that they rest immediately upon the Upper Alpine Limestone. Generally speaking they seem to have been deposited not quite conformably upon the older formations, which had in part been previously disturbed.

By a great general upheaval which took place afterwards, and by many powerful contortions and faults, the cretaceous strata have been brought in many places, as in the Rappenkopf and the Soile-

Alpe, into very irregular and puzzling stratigraphical relations to the older formations.

Tertiary Formations.

Proceeding farther to the north in the Valley of the Amper, we find of later formations the Eocene Flysch with *Fucoidea* in great development, and the tertiary strata of Kohlgrub Rottenbuch and the Peissenberg; but these do not belong to the subject of this paper.

The diluvial deposits, which cover to a great thickness the large valleys in the interior of these mountains as well as the elevated plains of Bavaria, will be spoken of in the last part of this paper.

§ The Elevatory Relations of the Rock-masses (*Hebungsverhaltnisse.*)

In the mountain group under consideration, there is a very important and extensive system of joints, which are quite independent of the stratification.

These joints are especially well developed in the hard upper Alpenkalk; but they extend into the liassic marls, as well as into the dolomites. It is evident, 1st, that these joints, which can often be followed to great distances, retain very often in the same district a very regular mean direction; and 2ndly, that in the same district different systems of joints occur, crossing each other at various angles.

I will mention some more special examples of these phænomena in the Höllenthal, where they are particularly well developed. I had here also the opportunity, by the mining operations conducted at different spots, to follow these joints in the interior of the mountain masses. The mean strike of the one predominant system of joints runs from N.E. to S.W. (N. 25°–50° E. to S. 25°–50° W.). They stand almost vertical, and their sides are, generally speaking, smooth and somewhat polished. They can be traced to great distances along the steep escarpments of the mountains, and along the course of different small rivulets, which especially follow the direction of these joints, where they have produced remarkably deep erosions.

Besides this system of joints, I could observe in the Höllenthal another subordinate system, running from W.N.W to E.S.E. They are by far less extensive and regular. In some places where both systems are well developed and exposed, as in the Höllenthalkahr and the surrounding bare ridges, they are seen mutually intersecting at very high, sometimes nearly right angles. By these intersections many derangements of the rocks are produced.

Attentively following these long joints, we are soon aware of a certain connexion which evidently exists between their mean direction and the direction of many valleys and steep mountain escarpments; and we are naturally led to the conclusion that the formation of many valleys, or many ridges and steep escarpments, which can in no way be explained by the strike or the inclination of the strata, are due to the same causes which have produced these long joints and faults.

A. *Structure of the Mountain Group of the Zugspitze and the Wetterstein.*—The light-coloured upper Alpine limestone forms a high continuous escarpment, which is visible from a great distance, and runs from the Wetterstein over the Dreithorspitzen to the western slope of the Zugspitze towards the Eibsee. In the west and in the south the upper Alpine limestone reposes in a regular succession upon the older formations, which dip under it; but on the northern side of this mountain the arrangement of the strata is much more irregular. They have been distorted and broken up by many extensive faults; and isolated portions, comparable to enormous ice-floes in a river or in an arctic sea, have been pressed together by later upheavals and by lateral compressions, in the most extraordinary manner. Very often the upper Alpine limestone dips apparently regularly under the dark marls and limestones of the lower Lias; and these latter are then again covered by the upper Alpine limestone, or even by the dolomites of the lower Alpine limestone.

These abnormal positions of the strata are very well seen, for instance, on the little saddle between the Langenfeld and the Osterfeld. The dolomite which follows farther on in the Bodenlahne, also dipping to the north-east, must be considered as belonging to the lower Alpine limestone, although it seems here to repose upon the Lias; but in its eastern and north-eastern prolongation, at Krün and north of the Barmsee, it is intimately connected with the dolomites of the lower Alpine limestones, which there form quite regularly the base of the lower Lias.

In following a section in a northern direction across the Wetterstein, the complicated structure of these mountains is seen in a very interesting manner.

In the Paiten Valley are laid open the marls of the lower Lias, with an anticlinal dip, covered on both sides by the upper Alpine limestone. On the highest ridge of the Wetterstein these strata dip with an angle of 40° and 50° to the north, 15° west. Along the northern foot of the Wetterstein runs a great fault, and the strata of the lower Lias are then pressed upon and partly over the upper Alpine limestones in a most irregular manner. A very good example of this structure is seen on the Kamithor, where the dark sandy marls, containing many of the characteristic fossils, are very much contorted.

Farther to the north, and separated by another fault, we have the perfectly distinct upper Alpine limestone, followed by a long and regular band of the lower Lias, the whole underlied by an extensive mass of the dolomites.

Another fault, running in the same east and west direction, occurs on the left side of the valley of the Ferchenbach. An observer might at first think here, that the Lias marls must regularly underlie the dolomites; but the great line of fault, entirely separating the two formations, is most distinctly traceable all along the bare escarpments of the Stegreif. The rocks of the lower Lias then cover, with various anticlinal dips, a broad low mountain ridge, and they are underlied in a regular succession, on the right bank of the Valley of the Kankerbach, by the dolomites of the lower Alpine limestone of the Eckenberg. One of the most remarkable of all these faults is this, which extends on the foot of the high escarpments of the Wetterstein, running from east to west, and to the W.S.W. All along this line we find isolated patches of the lower Lias, enclosed in various and most irregular manner between the white limestone strata of the Upper Alpenkalk; I have endeavoured to lay down on the map these Lias patches as accurately as possible. On these lines of dislocation are seen in different points masses of gypsum, and of a cavernous dolomitic breccia and a very cellular and evidently altered limestone (*Cargneuile*). This phænomenon is perfectly analogous to the occurrence of gypsum and cargneuile on the long lines of dislocation in Switzerland, which MM. Studer and Brunner have so well described.

B. *Structure of the Mountains between the Loisach and the Amper.*—The dolomites of the lower Alpenkalk form, on the Brunstelkopf and the Schafkopf, with a dip to the S.S.W., the regular base of the dark marly limestones of the lower Lias. Farther north, and more in the interior of the broad dolomitic range, we find several changes in the dip of the strata, evidently produced by different upheavals and contortions of the rocks. A most striking structure of the mountains is disclosed if we follow the line of section more to the south, through the Lahnewiesgraben, to the Kramerberg. There are seen large masses of well stratified dolomites, reaching the summit of the Kramerberg, at 6085 Fr. feet, which clearly rest upon the strata of the Lias. In examining the environs of the Kramerberg solely, it seems at first impossible not to consider these superposed dolomites as being younger than the underlying marly limestones; but, in following attentively the rocks of the Kramer in their western prolongation, it is quite evident that these strata must be identical with the dolomites which form generally the lower Alpenkalk and the base of all the other formations in this mountain. The dolomitic range, which occupies a considerable breadth on the Kramer, becomes narrower towards the west. The same strata pass on the right bank of the Loisach, and farther still, on the Eibsee and on the Thörlen, they form the base of the Lias and of all the mass of the Zugspitze.

The dolomite of the Kramer has, therefore, been pushed over the younger formations along an extended fault, by a very strong lateral pressure. This supposition is also corroborated by the many violent contortions and modifications in the strike and dip of the red lias strata, near the line of junction with the dolomites. The former stand at very steep angles, often nearly vertical, whilst the dolomites which follow above them are inclined at angles of only from 30° to 47°.

By the dolomites having been pushed over in so irregular a manner on the younger formations, we may also account for another remarkable phænomenon. It is seen on the map that the upper Lias and Jura formations, which occur on the Hirschbühel, become more and more narrow as we follow their eastern prolongation, whilst the dolomites have been advancing farther to the north. I nowhere succeeded, in the lower parts of the Lahnewiesgraben, in finding the characteristic red marly limestones of the upper Lias and Jura, or the fossil remains which accompany them. The dark fossiliferous marls of the lower Lias are here continued to the limits of the dolomite, which is seen immediately resting upon them.

§ Remarks upon the Diluvial and Erratic Phænomena.

The diluvial and the alluvial deposits could not be indicated by different colours on the map. Mere alluvial and detrital accumulations in the higher parts of the mountains were not separately marked.

It may be of some interest to advert to the two diluvial terraces in the valleys of the Loisach and of the Tsar. They consist of hard conglomerates, containing pebbles of the different sedimentary rocks of the Alps, mixed with erratic pebbles, which go down to the very lowest visible beds. The terraces attain a height of 120 and 180 feet above the level of the rivers. They show us the great thickness of the diluvial beds with which the Alpine valleys had been covered before the denudations by the present rivers took place.

One of the most interesting phænomena which occur in the study of the Alpine diluvium is offered by the erratic blocks. I have endeavoured to indicate on the map the highest points on which the erratic rocks are found, and to ascertain the heights by direct barometric observations.

In the lower parts of these mountains, below 4000 and 3500 feet, the erratic rocks are seen everywhere scattered about in more or less abundance.

I may be allowed to mention some points which seem to me of importance for forming an estimate of the way in which these remarkable erratic rocks have been transported.

The erratic pebbles in the mountain chains under consideration generally reach an elevation of 4000 and 4400 Fr. feet, in some cases even 4600! Even on these highest limits we generally find rounded pebbles of 5 to 20 centimetres diameter. Hornblende rocks, with many massive and schistose varieties, are prevalent; there are also found mica-schist and gneiss, as well as some fragments of granite.

Even on the isolated summit of the Peissenberg, nine English miles distant from the Alps, at an elevation of 3005 Fr. ft., thick layers of diluvial boulders occur, with rolled erratic rocks. Further it is to be remarked, that the erratic rocks are not only deposited on the surface of the older diluvial boulder beds, but that they are also disseminated in their interior, and that they are found in their very lowest beds, down to the surface of the miocene tertiary deposits.

The deep valleys which have been cut through the thick boulder beds of the Bavarian plateau by the greater rivers, for instance by the Tsar, afford very excellent opportunities for the study of these phænomena. In the Valley of the Tsar, in the environs of Munich, the erratic pebbles in the lower beds are all rounded, and do not generally exceed the size of the fist. Erratic blocks of very considerable dimensions are not very common on the plateau around the Tsar and the Ammer, which I have more especially examined. In those localities where blocks of larger size appear in greater number, they are sometimes more numerous, especially in the upper parts; but they are always imbedded between the other diluvial boulders, and are in part rounded, and in part they have preserved fresh angles. But it would be quite erroneous to suppose that these larger blocks are necessarily only limited to the upper beds; I have convinced myself by repeated careful examinations that they also occur, though generally less numerous, in the lower beds, and I have seen very large blocks which have sometimes been brought up from considerable depths in the excavation of wells.

The occurrence and the distribution of the erratic rocks on this part of the Bavarian Alps, and plateau bordering them to the north, seem evidently to show that here at least they must have been transported, and deposited in the same mode and at the same time as all the rest of the diluvial limestone and sandstone boulders amongst which they lie, and which cover to so great an extent and with so great a thickness the Bavarian plateau.

I need scarcely add, that the facts and the remarks which I have now brought forward relate only to that part of the Bavarian Alps which forms the subject of this paper. The erratic and diluvial phænomena all around the Alps are so extended, and they present such remarkable differences in various parts of this chain, that they must, in my opinion, be studied minutely in different districts before we can venture on general conclusions. But I may be allowed to say, that, generally speaking, the erratic rocks which occur on the plains all around the Alps have been too much regarded as merely a superficial deposit; and that, by examining different good sections, erratic pebbles are found to descend more or less deeply into the interior of the diluvial boulder beds.

The occurrence and the distribution of the erratic blocks on the extensive diluvial formations of the basin of the Lake of Constance, are, according to the minute observations of Prof. Fromherz*, very analogous to the phænomena which I observed on the Bavarian plateau.

These very remarkable heaps of enormous and angular erratic blocks principally occur in Switzerland and on the slopes of the Jura. Every one who has studied the present physical conditions of glaciers, and who has seen the great oscillations to which these ice-masses have been often subjected, even in historical times, will perfectly agree, that in former geological periods,—when the Alps were surrounded by large masses of water, when there was a greater amount of moisture in the atmosphere, and a greater quantity of snow-fall,—the glaciers may very probably have undergone most considerable changes of extension. The transport of debris from the central crystalline portions of the Alps may have been in some places, as in the valleys of the Rhone, of the Aar, of the Inn, &c., particularly favoured by that greater extension of the glaciers.

It is further very essential to recollect the importance of large

* Leonhard und Bronn's Jahrbuch für Geognosie, 1850, p. 641–656.

masses of ice floating about in rivers, or on the surface of lakes, in the transport of great angular rocks. Even in the present time large rocks are transported on the shores of the Arctic seas from one point to another; and the great masses of fine granite blocks which cover the plains of northern Germany, up to the foot of the Harz and the Silesian mountains, came very probably on similar icebergs and ice-floes from the Scandinavian peninsula.

On Polished Rock-Surfaces.

In relation to the erratic phænomena and their connexion with ancient glaciers, I propose to add a few remarks upon the polished and striated rocks, which have been considered, I think in some instances with too little hesitation, as general evidences of the presence of ancient glaciers.

There can be no doubt whatever, that the glaciers have the faculty of extensively producing by their movement polished and striated rock-surfaces on their borders. These interesting phænomena can be traced sometimes at very great distances from the present glaciers. They are seen very well developed in the environs of the glaciers of Macugnaga and of Gorner, especially on the lower termination of the Gorner glacier*.

But there are still many other agencies which can produce similar phænomena in a very deceptive way. I will not dwell on the polished and striated rocks produced by land-slips, so very common in the Alps; or on the striæ resulting from a small amount of sliding of sedimentary strata one along the other, which I clearly observed in several quarries: but I will merely call the attention of the Society to the fact, that the gneiss as well as the granite of the Alps very often shows a concentric exfoliation; and that all these concentric laminæ, having very different dimensions and very various degrees of curvature, offer on their surfaces a fine polish and fine parallel striæ, which are not limited to the superficial surface, but are repeated on all the laminæ in the interior of the rock.

It is quite evident that in such a case the polish and the striæ of the rocks cannot be attributed to the action of glaciers, which could but have affected the very surface of the mountains, never the interior laminæ of the rock. It seems that these phænomena are here intimately connected with the process of the concentric exfoliation itself; and that a limited sliding and displacement of the different folia or laminæ have taken place, which produced the fine parallel striæ and scratches so generally observed in these instances.

Leopold von Buch† was the first to show the importance of these polished concentric laminæ in Sweden and in the Alps: guided by his directions, I have endeavoured more fully to work out the subject in the Alps, and to represent some of the most characteristic forms of these concentric exfoliations on the three plates now exhibited to the Society.

* Lithographic illustrations of these phænomena (prepared for the Author's larger Memoir) were laid before the Meeting.

† Ueber Granit und Gneiss; Abhandlungen der Berliner Akademie für 1842.

In the vicinity of the Aar glacier, in the Bernese Alps, the rocks of granite and gneiss offer a curious and instructive exemplification of these phænomena.

On the mountains on the left side of this glacier are seen numerous small systems of these concentric foliations; the mountains being covered with little rounded bosses (*roches moutonnées*). In this instance these *roches moutonnées* cannot have been produced, as is indeed the case in other places, by the action of glaciers; for, by investigating their structure more closely, and by following the different ravines which disclose the interior of the rocks, we clearly see that these rounded bosses are produced by concentric exfoliations, and that the lowest visible laminæ are equally well polished as those on the very surface of the rocks. An additional proof of this conclusion is seen in the higher parts of the Aar glacier. We have there the limits between the granite and gneiss rocks and the stratified chlorite and mica slates, which latter do not show any of the concentric exfoliations. As soon as the granite appears, we find these very remarkable rounded bosses, which are wanting farther east in the schists. Had the glacier produced these rounded rock-surfaces, both formations would equally have been rounded and smoothed.

In comparing well-preserved polished rock-surfaces resulting from the action of glaciers, with the polished surfaces due merely to the process of the concentric exfoliation of gneiss and granite, it is quite possible to find some distinctive characters. On the polished surfaces produced by glaciers the striæ run generally pretty parallel to the longitudinal axis of the valley; whilst on the surface of the concentric layers the striæ follow generally the line of the maximum of the inclination of the laminæ. It is also very often to be observed that the polished concentric surfaces have a somewhat greater lustre, which may probably have been produced by small exudations of siliceous matter during the process of concentric exfoliation. These few remarks will be sufficient to show how desirable it is that the interior structure of rocks should be examined with the greatest care, and at different places; so that we may not confound, in all the extensive gneiss and granite districts of the Alps, the striæ and polishings of glaciers with other phænomena, very similar at first sight, but which have been produced by quite different causes.

May 3, 1854.

John Petherick, Esq., and John Coode, Esq., C.E., were elected Fellows; and M. Joachim Barrande was elected a Foreign Member.

The following communications were read:—

1. *On some* Intrusive Igneous Rocks *in* Cawsand Bay, *near* Plymouth. By Leonard Horner, Esq., F.R.S., F.G.S.

Several of the principal features in this locality are described by Sir Henry De la Beche, in his "Report on the Geology of Cornwall, Devon, and West Somerset;" but the plan of that work was, of necessity, limited in a great degree to general views. To have entered into detailed descriptions of local phænomena, in so large a field, would have required the labour for many years of several observers in the investigations, and the results would have filled many volumes of description. The author of that Report has however dwelt upon many of the more remarkable places where the phænomena throw light upon important questions of theory; but, in these days, when geological researches demand far more minute observation, when, as our President has on more than one occasion inculcated, the ground must in many cases be gone over inch by inch, ample opportunities will long remain for diligent observers to fill-in details in the masterly outlines of the geology of the West of England, which have been drawn by the skilful and practised hands of De la Beche, Sedgwick, and Murchison. A short residence in the neighbourhood of Plymouth enabled me to examine with some care the portion of the coast I am about to describe; and believing that an account of the somewhat uncommon appearances which the rocks exhibit may not be without interest, and may be the means of calling the attention of geologists to a more close investigation of them, I venture to lay before the Society the results of my observations*.

In Cawsand Bay, on the western side of Plymouth Sound, there occurs an association of igneous and sedimentary rocks which present phænomena illustrative of some of the great questions of geological theory. The portion of the coast I am about to describe extends from Penlee Point on the south-west to Redding Point on the north-east, a distance of about three miles, in a semicircular line, the shore being bounded by vertical cliffs, except in a few places near the fishing villages of Kingsand and Cawsand.

The prevailing rocks are red slates, sandstones, and conglomerates, belonging to the Old Red Sandstone or Devonian system. These sedimentary deposits are associated with a red porphyritic rock, which presents itself under a variety of aspects.

Near the eastern end of Kingsand, argillaceous schistose rocks stand out on the shore, bearing W.N.W., with a S.S.W. dip. They exhibit many varieties of colour, purple, red, green, and yellow; and, in a face of the rock on which the houses of Cawsand are built, all this diversity of tint is well exhibited. Interstratified with shining argillaceous slate are some hard arenaceous beds, undistinguishable in colour and mineral structure from many found both in the Old and the New Red Sandstone formations, and, like them on many occasions, they have stripes and spots of a greyish-white and bluish-green colour.

Proceeding eastward, we come upon a red porphyry, occupying a considerable portion of the shore over which the tide flows. When

* These observations were made as far back as the year 1841, and this paper, so far as concerns the descriptions, was drawn up shortly afterwards, while the impressions I had received were still fresh, and my notes could with safety be extended. It was laid aside for revision, but other pressing engagements interfered, and in changes of my residence the paper and the specimens I had collected were mislaid, and have only recently been recovered.

examined at low water, and looking over its broad surface, the porphyry is seen to be traversed in all directions by joints, which divide the rock into wedge-shaped and polygonal masses of various dimensions. A prevailing series of the joints have a W.N.W. direction, corresponding with that of the slates on the west, giving the porphyry the appearance of being composed of highly inclined beds. On measuring it by walking in a line perpendicular to its western side, I counted 1100 paces until I again came to slate eastward, so that this mass of igneous rock cannot be less than half a mile wide, and I found it identical in nature on both sides*. In some places it presents a perfectly flat surface of great extent, which in one part I estimated to include not less than 2000 square yards.

The base of this porphyry is a purplish-red felspar, interspersed with minute dark green crystals of hornblende and some specks of mica. Steatite appears to form a constituent of the base, and it is disseminated through it in white and coloured spots, and seems also to coat the joints. Under the blowpipe the reddish base changes to greenish-white, similar to the spots, and is fused with great difficulty. One of the most striking peculiarities of this porphyry, and which at first sight gives it the appearance of a red sandstone, is the predominance of white and bluish-green stripes, patches, and spots in every part†; but all these have a much greener aspect in the rock than they preserve in hand specimens, after a little while; which may arise from humidity when in the rock. The surfaces of the joints are very generally greenish-white; sometimes it is a mere film, at other times the change of colour has a depth of three or four inches. So much do the stripes and patches of the lighter colour give the rock the appearance of a red sandstone, that it is not until it is struck with the hammer that we discover that it is not a sedimentary deposit.

It is well known that the rocks of Cornwall are traversed by numerous porphyritic dykes, provincially called 'Elvans.' They are often very narrow, but have been seen as much as 400 feet wide; many of them may be followed for several miles, and one extends from the neighbourhood of Marazion to Camborne, a distance of twelve miles‡. They consist of a felspatho-quartzose base, including crystals of quartz and felspar, and occasionally specks of mica and hornblende or schorl. As the constituents are mixed, as in other igneous rocks, in a great variety of proportions, the rocks have many different aspects, but still they have a common mineral character.

I have examined the extensive series of specimens of Elvans in the Museum of Practical Geology, but have not found any exactly corresponding to the porphyry of Cawsand Bay; those most resembling it are the felspar porphyries of Creegbroaze Quarry, Chacewater, of Pentewan St. Austell, and of Tremore near Bodmin.

The slate rocks on the western side of the porphyry are in many places very much disturbed and contorted; sometimes they are vertical

* Specimen No. 1, from the eastern side. That from the western side has been unfortunately lost. [The specimens are in the Museum of the Society.]

† Specimen No. 2, western side. ‡ Report on Cornwall and Devon, p. 174.

or dip at a high angle to the N.E., that is, towards the porphyry and opposite to the general dip; and as they come nearer to the igneous rock, both dip and direction are frequently and considerably changed, their colour becoming more intensely red, and they include numerous subordinate arenaceous beds of various dimensions, of a much harder texture, and chiefly composed of quartz*. An actual junction of the slate with the porphyry I could not find, but close by the latter there is a conglomerate rock in which the fragments are rounded. These last consist of the same materials as the hard quartzose beds in the slate above-mentioned, but they appear to be mixed up in some degree with the porphyritic matter, and the rock has some resemblance to the trappean conglomerate found near Exeter, and at Dunchideock, north of Chudleigh†.

On its western side, the porphyry rises up from the shore like a wall, facing the S.W.; on its eastern side it also rises up with a mural face, and here looking to the N.E. Immediately adjoining this eastern side we find a conglomerate similar to that on the western side‡. On the west it is of greater thickness than on the east, and contains more fragments of slate. On the eastern side the conglomerate has an indistinctly-marked bedded structure. It is succeeded, that is eastward, by red slaty arenaceous beds, very much mottled and striped with green, similar in appearance to the light patches in the red porphyry. Frequently there are alternate stripes of red and green slate in the direction of the laminæ, but these green stains occur in all forms, sometimes shading off, at others bounded by a sharp well-defined line§.

These last slate rocks are succeeded eastward by others having a more decidedly argillaceous and shining structure; still ranging W.N.W., and dipping at various angles S.W. by W., that is, having the same direction and dip as the slates westward of the porphyry, and very much traversed by quartz veins.

I traced the porphyry into the interior of the country; first in some quarries not far distant from the shore in the road from Kingsand to Millbrook‖. It has there the same apparently bedded structure, the beds being from 15 to 30 inches thick, and bearing W.N.W. I again found it *in situ* two miles distant, near the farm of Trewinnow, presenting the same aspect and with green spots as on the shore, and in the same line of bearing, with slate at no great distance on each side of it, so that there is every probability of its being a prolongation of the great mass on the shore.

Interstratified with the ordinary slate, and traversed, in common with it, by quartz veins, I found on the shore, under high-water mark, on the east of the porphyry and very near to it, a schistose

* Specimens No. 3, the red slate; 4 and 5, the hard arenaceous portions; from the western side of the porphyry and near the eastern end of Kingsand.

† Specimens No. 6, 7, 8; from the western side of the porphyry.

‡ Specimens Nos. 9 & 10, from the eastern side of the porphyry.

§ Specimen No. 11, variegated slate from the eastern side; No. 12, a hard quartzose bed, interstratified with 11, and similar to Nos. 4 & 5 from the western side.

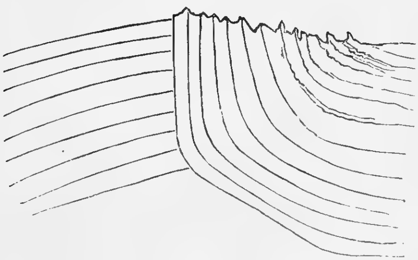
‖ Specimens Nos. 13 & 14.

rock of a purple colour, and containing some hard nodular concretions which effervesce slightly with acid*; and in the vertical cliff near this spot, there is an interruption to the continuity of the ordinary stratification by a mass so much resembling a dyke that I expected to find it to be porphyry, but it proved to be a schistose rock resembling that on the shore above, mentioned as being interstratified with the true slate†. It has, however, a cleavage fracture at a considerable angle to the plane of stratification of the adjoining slate, and which does not extend into the slate.

The Rev. D. Williams read a paper to the Geological Section of the Meeting of the British Association at Plymouth, in 1841‡, in which he refers to the part of the coast now under consideration, stating that "from Redding Point to the great mass of porphyry near the fishing houses, there is one uninterrupted series of varieties of *volcanic ash*, sometimes passing into clay-slate, interstratified among the thick red sandstone beds seen in the east and west cliffs of the Sound." The schistose rock above described may possibly be what Mr. Williams calls Volcanic Ash, but the term would be altogether inapplicable to the far greater proportion of the rocks in this locality§.

Farther east the slates and associated arenaceous beds are in a very disturbed state, both as to direction and dip; highly inclined beds, dipping S.S.W., abut against others that are vertical, and these last bend round into a stratification inclined not more than 10° and toward N.N.W.|| I tried, but without success, to make a correct drawing of this singular and not very intelligible disturbance; the following rude sketch will, however, give a better idea of it than mere words can do.

Diagram of the disturbed Slates in Cawsand Bay, near Plymouth.



The nearly horizontal beds are very hard, have greenish-grey spots and stripes, and divide into sharp angular blocks, both sides of the

* Specimens Nos. 15, 16, & 17. † Specimen No. 18.

‡ Report for 1841, Transactions of the Sections, p. 62.

§ Mr. Williams, in the same paper, goes so far as to say that in his opinion the killas or clay-slates of Devon and Cornwall are volcanic products in a stratified condition.

|| Sir Henry De la Beche evidently refers to this part of the cliff, and ascribes the disturbance of the stratification to a fault.

joints being coated with green. In external appearance these beds strongly resemble the adjoining porphyry, but a stroke of the hammer reveals their true nature*.

Still farther east, these same hard and nearly horizontal sandstone beds are cut by a dyke of porphyry (A) six feet wide, but unaccompanied by any disturbance of the stratification. This porphyritic rock has a schistose structure†, which near the sides becomes more distinct‡. Sir Henry de la Beche, in his Report before referred to, when speaking of the porphyry in Cawsand Bay, says—"The porphyry has a coarsely laminated structure towards the east, becoming as much laminated as the slates among which it runs in veins, where the latter are small; in such cases changing its common red colonr for a light brown stained by oxide of iron§."

Not many yards distant, a second dyke (B), about five feet wide, cuts across the same beds, and immediately adjoining there is a great disturbance of the stratification. This dyke|| resembles in mineral structure very closely not only the dyke A, but even more so the rock (Specimen No. 15) which I have described as interrupting the continuity of the strata of slate and as resembling a dyke.

Again, farther eastward, another dyke (C) of somewhat wider dimensions cuts the same sandstones, and in one part of it presents a most remarkable schistose structure¶, at right angles to the sides of the dyke, so as to make it hardly distinguishable from the quartzose sandstone beds, Nos. 19, 20, & 21**, and the long-continued action of the blowpipe on a minute fragment does not produce even a partial fusion††. This is probably the dyke figured in Sir Henry De la Beche's Report, p. 279, describing the laminated structure as cleavage planes.

The dyke C is shortly afterwards succeeded by another (D) about five feet wide, having a very distinct slaty cleavage‡‡. A suite of specimens, from the great porphyry mass to this fissile rock, might easily be made, showing the passage from the one structure into the other, a gradation which may indeed be traced even by the specimens that accompany this paper, although they were not collected with that view§§. It is more than probable that the smaller veins are

* Specimens Nos. 19, 20, & 21.

† Specimens Nos. 22 & 23.

‡ Specimen No. 24.

§ Report, p. 211.

|| Specimens Nos. 25 & 26.

¶ Specimens Nos. 27 & 28.

** "At Newham quarry, near Truro, at the termination of a long dyke, extending about nine miles from the westward of Penstruthal, where it cuts through granite, even the porphyritic character becomes lost, *and we have a substance not unlike some arenaceous rocks.* It is white and rather friable—a fine-grained compound of quartz and felspar. A short distance west, however, the elvan is a well-characterized porphyry."—De la Beche, Report on Cornwall, &c., p. 177.

†† "In some experiments on the fusibility of rocks, made jointly with Mr. L. Llewelyn Dillwyn, at the Cambrian Pottery, Swansea, we found that the Cornish granites and elvans were melted at a temperature about equal to that required for fusing malleable iron. The heat required for the fusion of malleable iron is the greatest which can be obtained in a smith's forge."—De la Beche, Report on Cornwall, &c., p. 191.

‡‡ Specimen No. 29.

§§ Compare the Specimens in the following gradation of their respective numbers, 1, 13, 31, 30, 22, 23, 24, 29, 25, 18, and 26.

branches from the great mass, and that the variety of aspect arises from the different conditions of their cooling. The igneous rock composing the dyke D appears to have been injected into several cracks and fissures of the strata, and portions of the sandstone and slate are enveloped by it; without however causing any alteration in their structure, and without any indication of metamorphic action. It presents different aspects, as will be seen by the accompanying specimens*. In one place it closely resembles the dyke A.

Farther eastward, the sandstones and slates are heaved up on the shore in a dome-shaped mass, the upper part of which has fallen in, and the beds may be seen dipping to all points from N.N.E. round by W. to the S., and a little E. of S., presenting a miniature crater of elevation.

From this part of the coast to Redding Point, there is a succession of the sandstones and slates, exhibiting great variety in the stratification, there being frequent changes in the direction and dip, and several instances of curvatures and arch-formed elevations.

Having thus described the facts as I observed them, I will now hazard some suggestions as to the theory of this association of igneous and sedimentary rocks. That the porphyry is an igneous rock which has issued in a molten state from the interior of the earth, and as a submarine outburst, scarcely admits of a doubt. Such rocks are either spread in a sheet over the sea-bottom and are afterwards covered by sedimentary deposits, or they have been thrust into openings between the beds of sedimentary rocks, or into rents that cross their lines of stratification. The occurrence of a conglomerate adjoining the porphyry on the eastern and western sides, so nearly alike as to be almost identical, would not, of itself, contradict the hypothesis of a sheet of molten rock poured out on the sea-bottom; because the outpouring and consolidation might occupy so short a time that the same causes which collected the lower bed of conglomerate might have continued in operation. But while it is conceivable and even probable that the melted matter might insinuate itself among the pebbles and sand over which it flowed, it is not so conceivable how it could be mixed with those that would be deposited over it, as that surface would be cooled and consolidated by the water in which it was poured out before any sand or gravel could be thrown down upon it. The disturbed state of the stratified rocks on both sides of the mass is also adverse to such an explanation. Judging from that disturbance, and from the identity of mineral structure and of the general dip of the strata on the east and west of the porphyry, it seems to be most probable that the igneous rock was poured into a vast irregular cavity parallel to the plane of stratification, and into smaller lateral rents, both caused by the force which raised the sedimentary rocks from their original horizontality into their now highly-inclined position.

* Specimens Nos. 30 & 31. Specimen No. 32 is a detached and rounded fragment included in Nos. 30 & 31. Specimen No. 33 is from a bed interstratified with the sandstone and slate in the vicinity of the dyke 30 & 31.

As in numerous instances of dykes of igneous rocks, even of moderate dimensions, we see that they have so acted on the rocks they traverse as to change a soft sandstone into a compact flinty slate, and an earthy limestone into a crystalline marble, so we might have expected that a mass nearly half a mile in width would certainly have produced similar effects; but I did not discover any signs of metamorphic action, unless some slight induration of the slate in one or two places may be so considered.

I would particularly call the attention of geologists who may hereafter visit this spot to the phænomenon of the laminated structure or slaty cleavage of some of the smaller dykes in the cliff, and especially that indicated by the letter c in the above description, in which the lamination is at right angles to the sides of the dyke, and the stone is scarcely to be distinguished from a quartzose arenaceous rock.

I would also call attention to the existence in the great porphyry dyke of greyish-green spots and stripes, similar to those so commonly met with in red sandstones, arising probably from the iron in both parts being in different states of oxidation. The change from red to the grey or greenish tint has been ascribed to the presence of decomposed vegetable matter*; but it is evident that such an explanation will not apply in the case of an igneous rock.

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2. *On the* May-Hill Sandstone, *and the* Palæozoic System *of the* British Isles. By the Rev. Professor Sedgwick, F.R.S., F.G.S., &c.

[Abstract.]

In a former communication† the author and Professor M'Coy had shown that the sandstone of May-Hill contains a group of fossils of the true Wenlock type, and that it must therefore be cut off from the Caradoc sandstone, and arranged with the base of the Wenlock group; also that on the western flank of the Malverns, the upper portion of what had been called Caradoc sandstone is the equivalent of the May-Hill sandstone. In the present paper Professor Sedgwick treated of the Mathyrafal and Glyn Ceiriog sections, on the east side of the Berwyns, and sections on the western side, together with the sections of the Pentamerus limestone of Norbury and Linley, on the flanks of the Longmynd; the sections of Horderley, the Onny, and of Caer Caradoc; and lastly, the sections of Builth, Llandovery, and Llandeilo.

From the examination and consideration of these sections, and of their fossil evidences, the author concludes that in those great physical regions there is not so much as one continuous unbroken section throughout which we can ascend in the way of passage from the

* "On the Colouring-matter of Red Sandstones and of Greyish-white Beds associated with them," by John William Dawson.—Quarterly Journal of the Geological Society, vol. v. p. 25.

† Quart. Journ. Geol. Soc. vol. ix. p. 215.

Cambrian to the overlying Silurian groups;—that there is a physical break between them exactly on the horizon of the May-Hill sandstone;—and that, in exact co-ordination with that break (often distinctly marked by a discordancy in the position of the beds), there is a great change in the fossil species;—thus pointing out the true physical and palæontological base of a Silurian system. Professor Sedgwick appended a corrected tabular arrangement of the Palæozoic rocks*, in accordance with the above; and concluded with some remarks on the nomenclature of British geology.

May 10, 1854.

The following communications were read:—

1. Postscript *to* Palichthyologic Note, No. 4†. By Sir P. de M. Grey Egerton, Bart., M.P., F.R.S., F.G.S.

It having been shown, that, in accordance with the established rule of priority in scientific nomenclature, the generic prefix *Tetragonolepis* is applicable solely to those species which coincide in generic character with the typical species originally described by Bronn, which has been proved to belong to the Pycnodont family, it becomes necessary to make some provision for the remainder of the species hitherto classed under that title, but which undoubtedly belong to the Lepidoid family. These fishes have been distinguished from those of the genus *Dapedius* mainly by the character of their teeth; and, although that character is shown to have been subject to occasional variations, nevertheless on taking a comprehensive view of all the Dapedioid species, it seems to have been sufficiently constant to warrant the continuance of the separation of the group into the unicuspid and bicuspid species. With this view, and with the sanction of Professor Agassiz, I now propose the generic prefix Æchmodus (from *αἰχμὴ, a point*, and *ὀδοὺς, a tooth*) for the unicuspid species, the bicuspid species continuing as formerly under the genus *Dapedius*.

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2. Palichthyologic Notes. No. 6. *On a* Fossil Fish *from the* Upper Beds *of the* New Red Sandstone *at* Bromsgrove. By Sir P. de M. Grey Egerton, Bart., M.P., F.R.S., F.G.S.

[Plate XI.]

The second division of the Lepidoid family of fossil fishes, the *Ganoidei homocerci*, is distinguished from the first, or *Ganoidei heterocerci*, by having the more or less symmetrical form of tail common to the generality of existing bony fishes, and to those fossil species (with rare exceptions) found in strata more recent than the Trias.

Although this character, derived from the organization of the

* See also Report Brit. Assoc. 1853, Transact. Sect. p. 55.

† Quart. Journ. Geol. Soc. vol. ix. p. 274.

caudal fin, is one of great value and significance in the determination of various genera of fossil fishes, it is nevertheless necessary, in drawing general conclusions, to be careful not to assign to it more importance than it is strictly entitled to; for we find, by the comparison of several genera, that it is not one of those well-defined trenchant characters which can be affirmed to exist or not, as the case may be, but that it is variable in amount, passing from extreme *heterocercy* to absolute *homocercy* by a sliding-scale so gradual, that it is (at all events in fossil examples) most difficult to define a positive line of demarcation between the two forms.

The researches of one of the most distinguished naturalists in Europe, Professor Müller, tend to show that as much difficulty prevails in determining this point in recent fishes; and in his valuable paper on the structure and characters of the *Ganoidei*, communicated to the Academy of Sciences at Berlin in December 1844, he comes to the conclusion that *heterocercy*, anatomically considered, passes insensibly into *homocercy*. As a proof of this fact, he instances the Sturgeon among Ganoid fish; which, although considered to be *heterocerque*, is shown nevertheless, on dissection, to have a series of inarticulate cylindrical spines in the upper lobe of the tail attached to other unarticulated spines, placed upon, or on the upper surface of, the chorda dorsalis, of similar structure to those given off from the under surface. So also in *Plagiostomi* he finds, on dissecting a heterocercal Shark, a small rudimental fin above the vertebral column, corresponding in structure to, although of shorter dimensions than, that proceeding from the lower portion of the column.

As, however, these appearances may be classed with numerous other anatomical facts now attributed to an arrest or interruption at various stages of fœtal development, attention has naturally been directed to the evidences afforded by a close investigation of embryological phænomena with reference to the organization of the distal extremity of the vertebral column and its appendages. One of the most elaborate works hitherto published on this subject is that undertaken by M. Vogt, at the instigation and with the advice of Professor Agassiz, on the embryology of the *Coregoni*, in which it is clearly demonstrated that the tail of the fœtal fish, in passing from the embryonic to the perfect state, undergoes a gradual transition from the heterocerque to the homocerque condition.

In addition to the facts so beautifully detailed and figured in this publication, I am informed in a letter recently received from Professor Agassiz, that he has ascertained some further points of high importance in the investigation of the embryology of the genus *Lepidotus*, which I trust may soon be made public.

These remarks have been instigated by the examination of a most singular fossil fish lately discovered by the active and intelligent collector of the Geological Survey in the upper strata of the New Red Sandstone at Bromsgrove, and which I now proceed to describe.

Dipteronotus cyphus. (From the Bunter of Bromsgrove.)

Gen. char. Head diminutive; body short and deep; back steeply vaulted; two dorsal fins; tail homocerque; scales ganoid.

The singular features (not to say deformities) of this remarkable fish are so striking and uncommon, that, while on the one hand they designate it as a new generic form, on the other they leave it in doubt to what family it belongs. Affinities it has none with any fossil fish hitherto known. It is difficult for mere words to convey any idea of its peculiarities. To conceive a small *Platysomus* with a diminutive head, and a back exalted into a dome proportionately as large or larger than the hump of a Camel, with an angular fin perched on its summit, and a second fin of similar form behind it, is a considerable stretch of imagination, but yet is inadequate to portray all the eccentricities of this curious fossil. Unless I am mistaken, its character is still further complicated by a caudal fin, almost if not quite homocercal! and this in a fish of the age of the Bunter Sandstone! Whether this be so or not, the peculiar characters of the double dorsal fin will at once arrest the attention of ichthyologists, as of unusual occurrence in the fishes of the mesozoic strata. Among the earlier races of fishes of the families *Sauroidei-dipterini* and *Cœlacanthi*, the occurrence of the double dorsal is the rule and not the exception; but it is generally associated with a double anal, and is one of those embryonic features rendered permanent, which we also recognize in the persistence of the notochord and the various gradations of ossification in the vertebral elements. The Acanthodeian genus *Diplacanthus*, it is true, exhibits two distinct dorsal fins, but the fins of this family, with the exception of the abnormal genus *Cheirolepis*, are membranous, and supported by ichthyodorulites, not jointed at the base, as in the spines of all bony fishes, but plunged into the integuments, as in *Spinax* and other Placoid genera. In the remaining families of the Ganoids, there is no instance of a double dorsal, as far as is yet known, in the *Sauroidei* and *Pycnodonti*; and only two small genera in the *Lepidoidei*, viz. *Notagogus* and *Propterus*, from the upper Oolites of Kelheim, in which this peculiarity obtains.

The occurrence, in an older deposit than the Lias, of a Ganoid fish having a homocerque tail, forms an exception to the ordinary rule founded by Agassiz as the result of his past experience in the study of fossil ichthyology. One single instance came under his notice of a heterocerque genus above the Lias, but no case of a homocerque fish beneath that formation. The remarkable genus *Dorypterus*, found in the Kupfer-Schiefer of Mansfeld, is described by Prof. Germar as having a homocerque tail, but there is some doubt of the fact from the imperfect condition of the only specimen he had examined.

Description.—This fish measures 3 inches in length from the point of the nose to the fork of the tail, and $1\frac{7}{8}$ inch in depth from the base of the anterior dorsal fin to the insertion of the ventral fin. The head is very diminutive, and measures only $\frac{3}{4}$ of an inch in length by $\frac{5}{8}$ in depth. It projects in a remarkable manner from the general contour of the body, reminding one somewhat of the head of a Tortoise exserted below a high-backed carapace. In form it is not unlike the head of a *Leuciscus* of the present day. The mouth is small, and to all appearance edentulous, but of this fact there is not sufficient evidence, from the imperfect condition of this part of the specimen. The orbit is proportionately large. The preoperculum is broad, of a semilunar outline and rough exterior. The operculum and suboperculum are comparatively small.

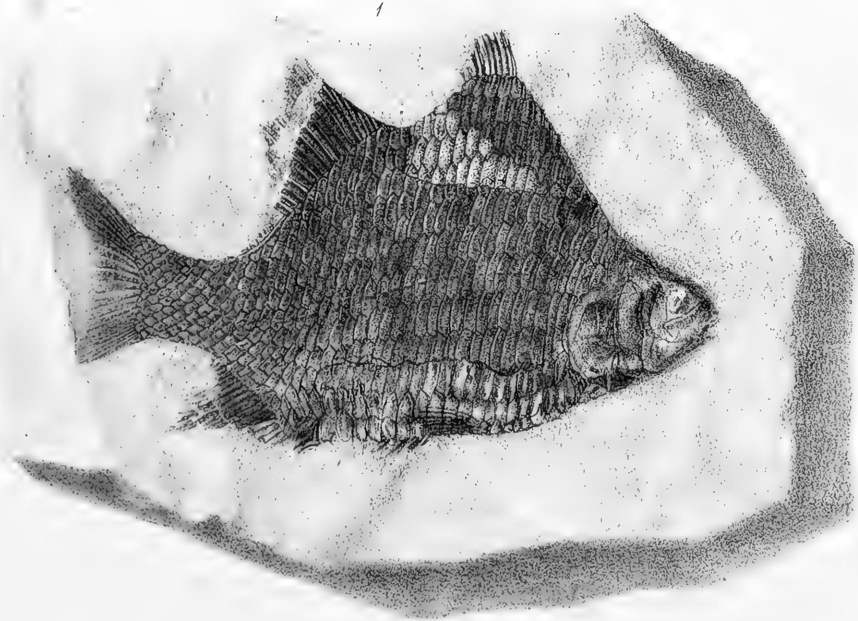
The junction of the head and neck describes an obtuse angle, from which point the back rises abruptly for more than an inch, and then slopes backwards and downwards to the base of the tail. The ventral line forms a gentle curve from the lower jaw to the tail. No parts of the internal skeleton are preserved.

The pectoral fins are deficient. The ventral fins are indistinct, but their position is clearly shown, exactly at the middle distance between the nose and the tail.

The first dorsal fin is rather mutilated. It contains six or seven rays, of which the fourth is the longest, the anterior ones being of graduated lengths. The second dorsal fin is composed of at least twenty rays, the sixth being the longest. The anterior rays or spines of both fins are composed of a hard lustrous ganoine, similar to the outer layer of the scales, and are sharpened at the points. The succeeding rays are flattened laterally, and are coated with similar ganoine; they appear consequently outwardly to be single and entire, but on close inspection traces of the transverse articulations are visible beneath the superficial layer. Their extremities appear to have been dichotomous, but, in consequence of their more delicate and perishable structure, the only remaining trace of these parts is a stain on the matrix in which they reposed. The base only of the anal fin remains. It contains about eight rays, of similar structure and arrangement to those of the dorsal fin. It is situated nearer the tail than to the ventral fins.

The caudal fin is forked, and is composed of two very distinct lobes, connected by a few distant rays, forming the centre of this organ. The upper lobe consists of twelve rays, with frequent transverse articulations and fimbriated extremities. They converge at the base, and appear to have been supported by a process or processes given off from the upper surface of the vertebral column. In the lower lobe I count eleven similar rays, apparently similarly divergent from the under surface of the column. The central portion of the fin is filled up by five or six weak rays, which subdivide at a short distance from their bases. The scales project slightly over each lobe of the tail, the extreme ones being in the centre of the upper lobe, and not on the upper margin, as in a true heterocerque tail.

The dermal investment is of great strength and solidity. The scales are numerous, and provided with a thick coat of ganoine. They are also firmly interlocked and strengthened by an unusually large overlap. The exposed parts, in consequence of the latter provision, are high and narrow, except in the vicinity of the tail, where they are more lozenge-shaped. The surface of the enamel is very uneven,



Jos. Dinkel, lith. Ford & West imp.

DIPTERONOTUS CYPHUS (Egerton)

and the free edges of the scales are rudely and irregularly notched. The mode of articulation is not very well seen, but it appears to have been by means of a broad central rib, somewhat resembling this arrangement in the genus *Aspidorhynchus*, and not by means of a marginal rib, as in the Pycnodonts. There are fourteen rows in the dorso-ventral series, and thirty-four in the longitudinal direction. The lateral duct pierces a row of broad scales extending from the upper margin of the opercular apparatus to the centre of the tail.

The characters described in the foregoing details show *Dipteronotus* to be a member of the Lepidoid family of Ganoids. Its position in that family cannot be assigned with any degree of certainty; but it may at all events be provisionally arranged near the genus *Eurynotus*.

I may add that, having forwarded to Professor Agassiz a drawing of the tail, together with my reasons for considering it a homocerque form, he has kindly replied to me as follows:—"I see no sort of reason to place it anywhere except among homocerques; it is not even as much heterocerque as some I have previously referred to that [homocerque] division."

DESCRIPTION OF PLATE XI.

Fig. 1. Dipteronotus cyphus, nat. size.
Fig. 2. Caudal extremity, magnified.

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3. Palichthyologic Notes. No. 7. *On* Two new Species *of* Lepidotus *from the* Deccan. By Sir P. de M. Grey Egerton, Bart., M.P., F.R.S., F.G.S.

[Plate XII.]

The discovery of remains of fossil fishes in the table-land of the Deccan was first brought under the notice of the Geological Society in 1851 by Colonel Sykes*. The only specimen he had then received sufficiently perfect for description, proved to be a new species of the genus *Lepidotus*. In the course of last year† further specimens were received from the same district, but apparently from a different bed, which indicated a new species of the genus *Tetragonolepis* of Agassiz, now *Æchmodus* (*vide supra*, p. 367).

The specimens described in this memoir were sent to me a few days since by Colonel Sykes. They are bedded in a similar bituminous shale to that containing *Lepidotus Deccanensis*, and are stated to have been found in the same locality. They are both clearly distinct from that species and from each other, although they all possess in common the characteristics of the Liassic section of the genus *Lepidotus*.

Lepidotus longiceps, Egerton. Plate XII. fig. 1.

There are two specimens assignable to this species; one much mutilated, the other very perfect, with the exception of the tail. The

* Quart. Journ. Geol. Soc. vol. vii. p. 272. † See *ibid.* vol. ix. p. 351.

length of the latter fish is $9\frac{1}{2}$ inches; of this the head occupies within a fraction of $3\frac{1}{2}$ inches, or more than one-third. The greatest depth of the body is 3 inches. The form of the head is elongated, and the rostral portion is more acutely produced than is usual in this genus. The lower jaw is of equal length with the upper jaw, and they are both armed with similarly proportioned teeth, of a conical form; those in the anterior portion of the jaws being more elongated than the more remote ones.

The cranial and opercular bones are of considerable thickness, and are invested with a very compact enamelled casing. Small isolated granules of shining ganoine are irregularly scattered over their surface. The preoperculum differs from the other opercular plates in having a more rugged and uneven surface.

The bones constituting the thoracic arch are of considerable substance, more especially the coracoid bone, which is very strong and flattened out at its posterior margin. Immediately behind the humeral bones two or three broad irregularly-shaped scales occur, coarsely notched on their hinder margins, and covered with an unusually thick coating of ganoine.

The pectoral fins are about 2 inches in length. The rays composing them are numerous, but not remarkably strong. The ventral fins are inserted about half-way between the pectoral and anal fins. The latter fin is situated near the tail. It is composed of ten rays, the anterior one being fringed with a set of oblique osselets along its border. The rays have frequent transverse articulations, and are much subdivided in the expanded portion of the fin.

The dorsal fin, as generally happens in this genus, occupies a remote position, commencing at a point behind the insertion of the ventral fins, and extending beyond the anterior rays of the anal fin. It contains twelve rays, corresponding very closely in form and dimensions with those of the anal fin. A similar bordure of fulcral osselets characterizes the anterior ray. Nothing remains of the caudal fin save two or three of the elongated scales, indicating the commencement of its superior lobe.

The scales are for the most part smaller and more rectangular than those of *Lepidotus Deccanensis*. The dorso-ventral series contain about twenty, the longitudinal series about thirty. On receding from the head they gradually lose their rectangular outline and become more and more rhomboidal. A few scales in the vicinity of the coracoid bone are considerably larger than those in any other region of the body. Where the outer surface of the scale is preserved, it is seen to be distinctly radiated, and pectinated on the posterior margin.

In general appearance this species, although belonging to the more elongated group of the genus, is not so slender as *Lepidotus pectinatus* or *Lepidotus Deccanensis*. Its most striking feature is the unusually large proportion of the head to the total length. This peculiarity serves to distinguish it from all the species hitherto described, and has suggested the propriety of the specific appellation.

LEPIDOTUS BREVICEPS, Egerton. Plate XII. fig. 2.

The evidence of a second species of *Lepidotus* among the ichthyo-

lites recently received by Colonel Sykes is pretty clear, although the specimens affording it are deficient in many details. One specimen and its counterpart contain a head and a small portion of the body; another specimen shows the impression of the trunk as far as the base of the tail; and its mutilated counterpart contains the base of the skull and the scales of the anterior and middle portion of the body. With the exception of a few scattered rays, all the fins are wanting.

The length of the fish, from the nose to the base of the tail, is 7 inches, the greatest depth being $2\frac{1}{2}$ inches. The head measures $2\frac{1}{4}$ inches, or less than one-third of the entire length. It will be seen, on comparing these dimensions with those of other species of *Lepidotus,* that this is one of the smaller species of the genus.

In general form it very much resembles the American genus *Ischypterus*; and indeed in size it corresponds pretty nearly with the larger specimens of *Ischypterus fultus*. The muzzle is pointed, but not so acutely as that of the species last described; the maxillary and facial bones are shorter, but the opercular bones are proportionately larger. The form of the trunk is remarkable for the vaulted outline of the back, in front of the position of the dorsal fin. The opercular bones are more profusely ornamented than those of *Lepidotus longiceps*. Although a few similarly isolated granules occur here and there, these are associated with a surface-ornament of larger grains, which in some places become confluent. The preoperculum has, nevertheless, a more even surface than in that species. The maxillary bones are shorter, and the teeth less elongated. The frontal bones have a coarsely corrugated exterior, beset with pustuliform grains of larger size than those on the surface of the opercular bones. The coracoid bone is less flattened than in the former species. The scales are small in size, and are entirely devoid of pattern on their surface; nor have they any serrations on the posterior margin. In these respects they afford a good distinctive character from those of *Lepidotus longiceps*.

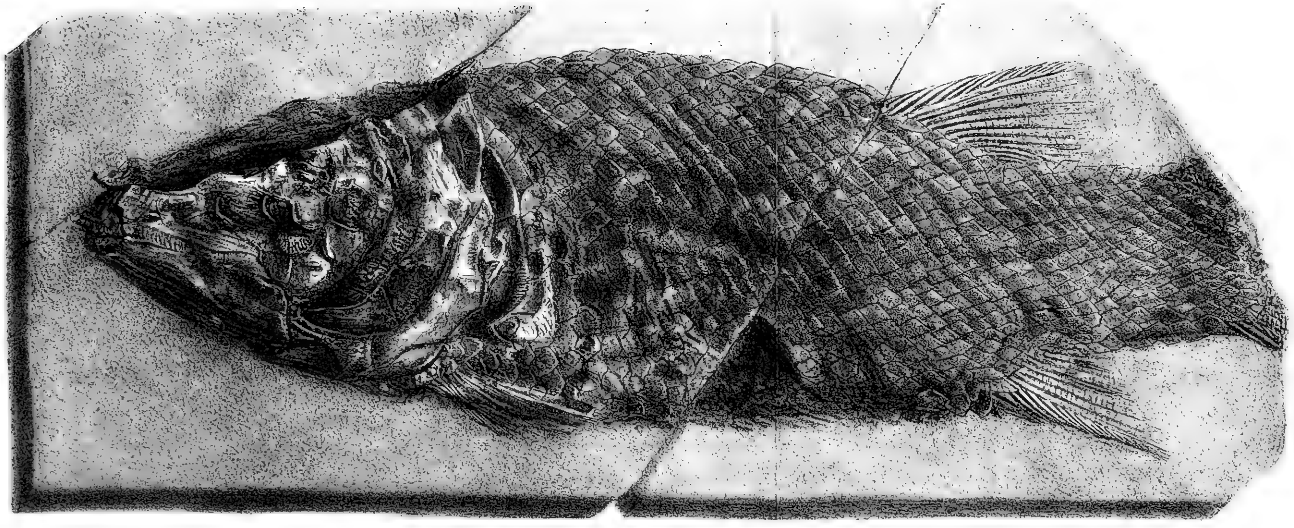
In addition to the specimens enumerated above, from the bituminous schist, the collection contains a fragment of a large *Lepidotus*, apparently from a bed of compact argillaceous limestone, similar to that containing the specimen of *Æchmodus Egertoni* described last year*. This may possibly indicate another species.

It may be worthy of remark that the genus *Lepidotus* has the most extensive geographical range of any genus of fossil fish with which we are acquainted. It has representatives from England, several localities in France and Germany, from Switzerland, the Tyrol, Lombardy, Naples, Greece, the Brazils, and from Central India. Its stratigraphical range is also extensive, viz. from the Lias to the Calcaire Grossier, both inclusive.

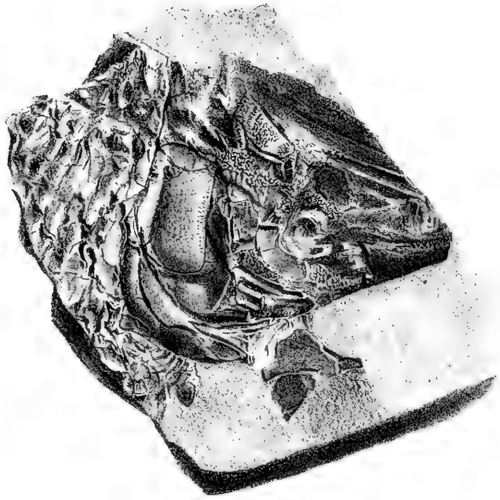
DESCRIPTION OF PLATE XII.

Fig. 1. Lepidotus longiceps, nat. size.
Fig. 2. Lepidotus breviceps, nat. size.

* *Tetragonolepis Egertoni,* Sykes; Quart. Journ. Geol. Soc. vol. ix. p. 351.



Lepidotus longiceps



L. breviceps

FOSSIL FISH FROM THE DECCAN

Jos. Dinkel, lith.

Ford & West, Imp.

NOTE *on the* FOSSILS *from* KOTAH, DECCAN.

THE ichthyolites above-described were forwarded to Col. Sykes by Dr. T. L. Bell, in the summer of 1853; and in a letter dated July 12th, 1853, Dr. Bell states that these specimens were taken from the same spot at Kotah* from which those previously sent were obtained.

The specimens of bituminous shale contain, besides the fish-remains, some coprolites and some traces of plants. There are also four specimens of impure limestone with fish-remains (*Lepidotus* and *Æchmodus*).

Some small pieces of a reddish, friable, coarse sandstone or grit, containing obscure traces of wood, accompany the above, and are mentioned as having been obtained about 200 yards further up the river, where this is the surface-rock, and rests upon limestone. The specimen sent of the latter is similar to the limestone with fish-remains above-mentioned, and to that referred to in the former notices†.

Dr. Bell also forwarded with the above several fragments of dark clay-slates, and of a black micaceous quartzy schist with a coarsely wrinkled surface and obscure vermiform markings. These specimens, he observes, "were collected fifteen miles N.E. from Kotah, at the foot of a range of hills, 400 feet high, whose general direction is parallel to the other hills at Kotah and in the surrounding country, but with an underlying stratum of clay-slate, which has a dip directly opposite to that of the underlying strata at Kotah. This clay-slate is very extensive; I traced it until it was lost beneath the sandstone range. The layers composing it are extremely fissile and break up into rhomboidal masses soon after exposure. I observed, while tracing it, evidence of disturbance in the form of a fault in one case, and a bend in another, separated from each other by about 800 yards."

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4. PALICHTHYOLOGIC NOTES. No. 8. *On some* ICHTHYOLITES *from the* NUMMULITIC LIMESTONE *of the* MOKATTAM HILLS, *near* CAIRO. By Sir PHILIP DE M. GREY EGERTON, Bart., M.P., F.R.S., F.G.S.

[PLATE XIII.]

THE fish-remains contained in the six specimens submitted to me by Mr. Horner for examination are derived from not fewer than sixteen individuals.

With the exception of one mutilated tail, the posterior portions of all are deficient. The cranial bones are for the most part in good preservation; some of the fins are also well shown, more especially those parts composed of hard spines. The teeth and scales are also in

* See Quart. Journ. Geol. Soc. vol. vii. p. 272, vol. viii. p. 230, and vol. ix. p. 351.

† *Loc. cit.*

perfect condition. The anterior portion of the endo-skeleton is displayed in several of the specimens, together with the dermal apparatus for supporting the dorsal and anal fins. Unfortunately the precise character of the dorsal fin is not recognizable, nor can the soft rays of any of the fins be counted with accuracy. The branchiostegous rays are also indefinable, both as to form and number; and the vomer and palatine bones are not visible.

These deficiencies render doubtful the determination of the family or genus to which the species is to be referred. Enough, however, is preserved to afford, if not conclusive evidence, at all events an approximation to the truth.

There is no question but that all the specimens belong to one and the same species, and the crowded position of their remains warrants the conclusion that it was a gregarious species. The characters of the scales and fin-rays determine it to be a true Ctenoid of Agassiz, or Acanthopteroid of Müller, and belonging to one of the most typical families of the Order.

In the absence of the materials above alluded to, the preoperculum, which is well seen in several of the specimens, is a feature of some consequence. This bone, as in the true Perches and the Sciænoids, is serrated on its outer margin; a character which is not found in any of the Sparoid family. These serrations on the posterior border are very decided and regular, and have their points directed upwards. At the angle of the bone are five or six strong diverging spurs, forming a powerful armature to this portion of the opercular flap. These are succeeded on the lower margin by a series of sharp points directed forwards, and diminishing in size until they become obsolete at the anterior angles.

I have been unable to discover a similarly constructed preoperculum in any genus of the Percoid family. In *Perca* the strongest spurs are at the anterior angle of the lower border, and the serrations on the posterior angle are small and irregular. In *Cyclopoma* and *Labrax*, the same. *Lates* and *Holocentrum* have a single spur at the posterior angle. *Enoplosus* has fine serrations on the posterior margin, and those on the lower margin, although stronger, are directed backwards. In *Serranus* the serrations are fine and uniform.

In the Sciænoid family the preoperculum is serrated, but not so strongly as in the Perches. The Labroids have no serrations on the opercular bones.

It appears hence that the preoperculum in the Egyptian fish, although more nearly resembling the forms of that bone prevailing in the family of the Perches than in the Labroids and Sciænoids, has nevertheless an appropriate form, differing from that found in any known genus of that family. The operculum seems to have had a similar outline to that of our common *Perca fluviatilis*; but, as the margin is imperfect, it is uncertain whether the posterior angle was so much produced.

Assuming then that the fossil as regards the preoperculum is more nearly allied to the Percoids than to any other family, we must consider how far the other details will bear out that assumption. The dorsal fin is unfortunately incomplete. There is evidence to prove, however, that it was a *continuous* fin, the anterior or spiny portion containing not less than ten rays, and the hinder portion at least eleven, probably more (fig. 4). The interapophysial plates supporting the spines are broad and equidistant, with the exception of the three anterior, which are slender and not bladed. Of these one is unarmed between the occiput and the fin, and the succeeding two contribute to the support of the anterior spine. The osselets bearing the hinder portion of the fin are more closely set. The spines are compressed laterally, having a sharp edge to the front. The third from the front is the longest and strongest, and the second and fourth are recessed to accommodate its expanded base. They are all more or less irregularly grooved or striated in the longitudinal direction. The fin, when fully expanded, had a forward inclination. In many of the preceding details we find a much nearer approach to the dorsal fin of the Sciænoids, and especially to the genus *Pristipoma*, than to any of the Percoid genera.

The pectoral fins are nowhere preserved. The ventral fins are thoracic. They consist of one long sharp spine and about eight rays, supported on pelvic bones of considerable size. The coracoids have a roughly corrugated surface, but are devoid of the transverse plate so largely developed in the genus *Perca*.

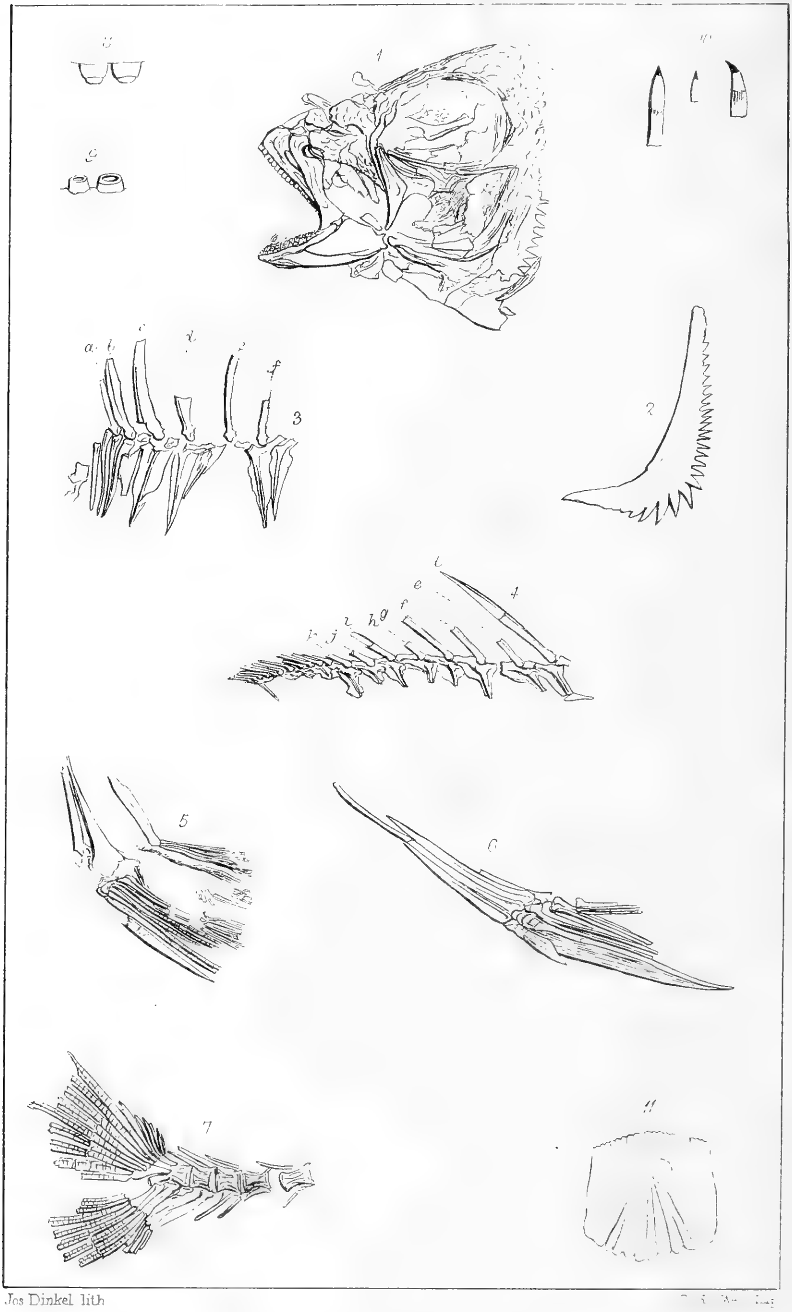
The anal fin is one of a formidable character. It has a short strong fulcral spur at its base, succeeded by a powerful spine of great strength, backed up by a second spine of inferior size. These are succeeded by a few soft rays. The bones giving support to this fin are of corresponding strength. The Percoid genus *Holocentrum* and the Sciænoid *Pristipoma* are the only examples I am acquainted with having anal fins so powerfully armed.

The tail had nine principal rays in the upper lobe and eight in the lower. The extremities are deficient.

The coincidences between the characters of the dorsal fin with the Pristipomes are fully carried out in the other locomotive organs.

We come now to the most remarkable feature of this fossil, namely the dentition. The dentigerous bones visible are the premaxillary and submaxillary. These are furnished with an outer range of closely set, regular, strong, conical teeth, with sharp recurved points and expanded bases, succeeded by ranks of similarly formed, though smaller teeth. Those of the principal range near the symphysis, although rather larger than the others, do not project as in *Dentex*, *Pagrus*, and *Lethrinus*; nor are larger teeth intercalated as in the *Serrani*. Whether the vomer, palatines, and pterygoids were dentigerous or not, there is no evidence to determine; but the branchial arches were decidedly so. In most of the specimens, the osselets composing this apparatus are seen, owing to the absence of the opercular flap, and in each case they are confusedly mingled with multitudes of conical teeth, of analogous form to those constituting the true dental series. The form of these teeth is not unlike a miniature representation of the canine teeth in *Ursus*.

On comparing the dentition of this curious fish with analogous



Jos Dinkel lith.

FISH REMAINS FROM THE NUMMULITIC [illegible]
MOKATTAM, EGYP[illegible]

forms, it appears that in this respect it differs materially from the family of the Percoids; one of the leading characters of that family being the having *dents en brosse*, or, as Professor Owen expresses it, "small, numerous, and closely aggregated teeth, resembling the plush or pile of velvet." The teeth of some of the Sparoids have a strong resemblance to the fossil; but the serrated preoperculum forbids its approach to that family. The dentition of the Sciænoids varies much in character, almost to the two extremes of *dents en pavé* and *dents en velours*, so that, on the whole, the dentition of the fossil is such as might exist in a Sciænoid genus. But one of the main characteristics of the Sciænoids is the prevalence of numerous mucous ducts traversing the bones of the face and jaws, and in this respect the fossil is irreconcileable with this family. Neither does it appear that the opercular apparatus was invested with scales, as in the Sciænidæ.

I abstain from entering upon a detailed description of the cranial osteology of the fossil, since the foregoing remarks have rather reference to the family affinities than to specific differences. I will only, therefore, further notice, that the lower jaws were shorter and deeper, the premaxillary bones also shorter and stronger, and the maxillary bones thicker and broader, than in the Perches. These variations are in strict accordance with the altered character of the dentition. The edges of the scales are very finely serrated, their bases are large and fluted, and the overlap considerable.

Briefly to recapitulate, it appears that the Mokattam fish had a close resemblance to the Sciænoids, and particularly to the genus *Pristipoma*, in the characters of the organs of locomotion, and in the general form of the trunk; but that in the opercular apparatus and osteology of the cranium it more nearly approaches the Percoids. The dentition differs from both, and recalls that of some of the Sparoids.

Professor Hermann von Meyer has described a fish from the same locality under the name of *Perca Lorenti*. Although the specimen figured is much smaller and less perfect than Mr. Horner's specimens, I incline to believe it is one of the same kind, from the following expression used in describing the teeth—"der Fisch mit kleinen *spitz-konischen* Zähnchen bewaffnet war*."

DESCRIPTION OF PLATE XIII.

Fig. 1. Head, showing the dentition.
Fig. 2. Preoperculum.
Fig. 3. Anterior part of the dorsal fin.
Fig. 4. Middle part of the dorsal fin.
Fig. 5. Ventral fins.
Fig. 6. Anal fin.
Fig. 7. Caudal extremity.
Fig. 8. Premaxillary teeth, magnified.
Fig. 9. Lower maxillary teeth, magnified.
Fig. 10. Branchiostegous teeth, magnified.
Fig. 11. Scale, magnified.

Note by Mr. Horner.—Being engaged in an inquiry into the geological structure of the Nile Valley in Lower Egypt, I wrote to my friend Mr. Jesse, then engaged with the construction of the rail-

* Palæontographica, vol. i. page 105.

road between Alexandria and Cairo, requesting him to procure for me as many organic remains as he could from the Nummulite Limestone of the Mokattam range, at the foot of which Cairo is situated. He kindly complied with my request, and among other specimens which he sent there were some Ichthyolites. These I was anxious to have examined by my friend Sir Philip Egerton, our highest authority in this country in that branch of Palæontology. With his usual readiness, he has given me the benefit of his opinion; and I was desirous that his valuable communication should at once be made known to the Geological Society.—LEONARD HORNER.

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5. CONTRIBUTIONS *to* FOSSIL ENTOMOLOGY. By J. O. WESTWOOD, Esq., F.L.S. &c.

[Communicated by the Rev. P. B. Brodie, F.G.S.]

[PLATES XIV. XV. XVI. XVII. XVIII.]

CONTENTS.

Note.—For the generic and specific appellations, see "Explanation of Plates."

THE valuable contributions to our knowledge of fossil entomology recently published on the Continent, and more especially the admirable work of M. Heer of Zurich, appear to have led several of our English geologists to take up that branch of Palæontology with more energy than at any previous period; the result of which has been shown not only in the large collections of Lias insects made by the Rev. P. B. Brodie, which formed the groundwork of his 'History of the Fossil Insects in the Secondary Rocks of England,' published nearly ten years ago, but also in the discovery of some traces of fossil insects in the Hastings series of the Isle of Wight by Professor Edward Forbes,—a large number of insects in the Wealden rocks of Hastings and its neighbourhood by Messrs. W. and H. Binfield *,—

* Quart. Journ. Geol. Soc. vol. x. p. 171. A rich collection of fossil insects, from the Lias of Gloucestershire, &c., has been made by W. R. Binfield, Esq., to whom also the Museum of the Geological Society is indebted for a suite of insect

a few doubtful specimens by W. R. Brodie, Esq., in the Wealden series of Punfield Bay (Swanage), and in the Tertiaries of Studland Bay,—and by still larger collections of fossil insects from the Middle and Lower Purbecks by the Geological Surveyors, the Rev. Mr. Fisher, Messrs. W. R. Brodie and C. Willcox, Capt. Woodley, and especially by the Rev. P. B. Brodie*, who, from his attention having been especially directed to this branch of the subject, has been highly successful in detecting minute fragments of insect remains in small slabs of stone, which would to a less educated eye have been passed over as destitute of any traces of ancient animal life.

Several of these collections having been placed in my hands for examination and description, I have endeavoured in the five accompanying Plates (Pl. XIV.–XVIII.) to give a general idea of the chief remains contained therein; but the very fragmentary nature of the specimens (of which, it will be observed, there is not one entire, and not a single leg, antenna, or any trophi,—the majority, in fact, consisting only of elytra or fragments of wings and elytra) will prevent me from giving more than a very general description. This is the more to be regretted, since amongst the fragments of wings there are evidently portions belonging to forms distinct from any with which we are now acquainted, and which from their analogy would lead to the inference that they belonged to some forms of Neuropterous insects allied to *Sialis*, *Semblis*, &c., genera which are more or less aquatic in their natural habits;—an inference more strengthened by the prevalence of great numbers of Libellulideous wings in these collections (the early states of the insects of which family, I need scarcely observe, are also entirely aquatic), and by the many and great blanks now existing in the series of the Order *Neuroptera*, doubtlessly attributable to the extinction of some of the connecting links.

In the following observations it will, perhaps, be most convenient to describe the collections according to their localities and owners; reserving the general observations which are suggested by their review, including a comparison of the Middle with the Lower Purbeck insects, as well as of the Purbeck insects of Dorset with those of the Wiltshire Purbecks †, to the end of the communication.

The reader will bear in mind that in the Plates the lines drawn by the side of the different figures represent their natural length; the majority of the specimens being of minute size.

I. Fossil Beetle from the Stonesfield Slate ‡. Pl. XIV. fig. 13.

A fragment of a large fossil Beetle, discovered in the Stonesfield Slate by Lord Enniskillen, has been kindly placed in my hands for

remains from the Lias of Lyme Regis. A fossil insect has been lately met with in the Great Oolite of Lincolnshire by Mr. Morris, F.G.S. See also 'Catalogue of British Fossils,' new edit. p. 116, for fossil insects found in Britain.

* In the Quart. Journ. Geol. Soc. vol. ix. p. 51, Mr. Brodie has also recorded his discovery of a coleopterous wing-case in the Kimmeridge Clay of Ringstead Bay, Dorsetshire.

† Termed 'Wealden' in 'History of Fossil Insects,' &c.

‡ Four species and numerous relics of insects from the Great Oolite of Stonesfield, &c. are noticed in 'Morris's Catalogue,' 2nd edit.

description by Sir Philip Egerton, and is figured in Plate XIV. fig. 13. This represents the mesosternum, metasternum, and ventral surface of the abdomen of an insect, which, from its structure, must have been of heavy aspect and most probably of slow motion, and which must have lived in dark and obscure situations.

This I infer from the circumstance that the elytra are deflexed at the sides, forming a groove for the lateral margins of the abdomen, a peculiarity which implies—1st, that the elytra, if separate, could only be raised with difficulty; 2ndly, that they were more probably soldered together along their dorsal suture; and, 3rdly, that the wings were wanting. These are characteristics of several groups of beetles, amongst which are the Darkling Beetles (*Blapsidæ*) and the larger species of the Ground Beetles (*Carabidæ*). In these families short broad forms occur in the genera *Blaps* and *Pimelia*, and in *Cychrus*.

As to the decided affinities and position of this fossil beetle, we must take into consideration the form of the two sterna and the form and number of the segments of the abdomen. The recent investigations of Coleopterists have proved that these characters, and especially the latter, are among the best and safest clues to the natural classification of the Order. In the fossil before us, the mesosternum is advanced in a triangle between the cavities for the insertion of the middle legs; the metasternum is very short, and is extended slightly backwards, and divided into two small lobes by an impressed line; and its hinder notched edge meets the advanced wide lobe of the short basal segment of the abdomen. The second, third, and fourth segments of the abdomen are of nearly equal width; but the extremity of the fourth and the remainder of the ventral surface are abraded. Now the relative size of the sterna agrees better with the *Blapsidæ* than with the *Carabidæ*; but the short basal segment of the abdomen occurs in *Cychrus*, only it is soldered to the next segment, so as to be but little distinct.

From the appearance of the fossil, I should conceive that the lost extremity of the abdomen comprised only a single segment; if so, it would be even longer than the preceding, whereas in the *Blapsidæ*, owing to the large size of the basal segment, the two terminal segments are very short. The fossil beetle differs, therefore, from both these tribes, and it is much to be regretted that its fragmentary condition will not allow of its relations being more satisfactorily determined.

A small spiral univalve shell is imbedded in the same slab with the beetle.

II. Large fossil Dragon-fly from the Stonesfield Slate. Pl. XVII. fig. 20.

A pair of large wings of a Dragon-fly found in the Stonesfield Slate*, at Eyeford, on the Cotswolds, by the Rev. P. B. Brodie, are represented

* For an account of the Stonesfield Slate of Gloucestershire, see a paper by Messrs. Brodie and Buckman, Proc. Geol. Soc. vol. iv. p. 437, 1844; see also Brodie's 'Fossil Insects,' p. 39, &c.

in Pl. XVII. fig. 20. Two slabs, containing the fossil and its cast, were found, but unfortunately the surface of the stone is in both so much abraded that the precise form of the "cells" cannot be determined. This, together with the fact of only one pair of wings, apparently the anterior, being preserved, will prevent its relations being determined, as the form of the anal angle of the several wings (unfortunately lost in the specimen before me), and other minute characters presented in the structure of the head, eyes, and ocelli, are the chief characters adopted for generic distinction in this family.

The discovery of this and many other fine fossil wings of Dragonflies, in the Lias, Oolite, and Purbeck formations, is interesting in several respects, both geological and zoological. Their presence in the winged state in a form so identical with those of the existing races of these insects, implies, of course, an abundance of winged, and, for the most part, herbivorous insects; whilst the aquatic condition of their larvæ implies a condition of the water identical with that which is now in existence, as it must have been similarly acted upon chemically by the curious respiratory apparatus of these larvæ. Moreover, whilst the remarkable fact obtains in the present physical condition of the insect world, that many of the largest aquatic insects occur in temperate climates (the gigantic *Nepidæ* forming the only exception), we find only amongst these fossil insects traces of the *Libellulidæ*, the great Water-beetles of the families *Dyticidæ* and *Hydrophilidæ* never appearing, as far as hitherto ascertained, amongst these fossil remains.

III. Supposed Insect from the Lias. Pl. XVIII. fig. 2.

In Pl. XVIII. fig. 2 is represented a dark-coloured obscure object, about $\frac{1}{4}$ inch long, which was found in the Lias by the Rev. P. B. Brodie. This exhibits a triangular space in front, which has the appearance of a scutellum together with the closed wing-covers of one of the *Pentatomidæ*. It is preceded by a small dark space, which may represent the advanced pronotum; but I dare not pronounce upon its character with any attempt at precision.

IV. Insect Remains from the Corfe Clay*. Pl. XVI. figs. 34, 35.

Four small slabs of white tertiary clay, from the Leaf-beds at Creech, near Corfe and Wareham, have been forwarded to me by the Rev. P. B. Brodie, from the collection of W. R. Brodie, Esq., of Swanage. Each little slab contains an elytron of a distinct species of Beetle.

The most characteristic, represented in Pl. XVI. fig. 34, is 4 lines long; very narrow; flattened, and gradually attenuated to the tip; with eight distinct, punctated, longitudinal striæ, and a short one near the base of the suture. This was probably the elytron of some narrow beetle allied to *Agrilus*, amongst the *Buprestidæ*.

The second elytron is 6 lines long; of nearly equal width for two-

* These specimens were noticed in Quart. Journ. Geol. Soc. vol. ix. p. 51.

thirds of its length, and then gradually attenuated; the surface is now nearly smooth, but it may probably have been originally punctured and subsequently abraded. This specimen may belong to the *Helopidæ.*

The third elytron, represented in Pl. XVI. fig. 35, is 3 lines long; oval; very convex; marked with seven rows of very deep round punctures, the lateral rows rubbed down, and bearing a subsutural row of small tubercles. This belonged most probably to one of the *Curculionidæ.*

A fourth object, which may possibly not be an insect remain, is 2 lines long, very oval and convex, with a granulated surface, partly abraded. It has, however, somewhat the appearance of the elytron of a very gibbose beetle of the family of *Chrysomelidæ* or *Curculionidæ.*

V. Insect? Remains from the Hastings Sands.

The Rev. Mr. Brodie has forwarded me four specimens, found by Mr. W. R. Brodie in the Hastings Sands of Swanage Bay, which are of doubtful character. The first has the appearance of an elytron, ½ inch long, and nearly 3 lines wide for three-fifths of its length, and then gradually attenuated; the surface smooth, but with a deep longitudinal, possibly accidental, impression from the base. The second and third are small dark patches of membrane upon the surface of the stone, which are traversed by straight longitudinal veins emitting parallel branches; but as in the larger specimen the veins radiate nearly from a point, somewhat like the ribs of a fan, I should rather regard them as vegetable. The fourth has the appearance of a small semi-oval elytron, 2 lines long; but the surface is irregularly longitudinally rugose, like that of the hard seed-vessels of some fruits.

VI. Fossil Insects from the Middle Purbecks of Dorset*. Pl. XV. figs. 6 to 26.

A large collection of Insect-remains, consisting of 118 small slabs, of various sizes, some containing many specimens, has been made by the Rev. Mr. Brodie from the top of the Middle Purbecks of Durdlestone Bay, Dorset. They are chiefly from the "Pecten and Corbula bed," No. 31 of the stratigraphical list in Mr. Austen's 'Guide to the Geology of the Isle of Purbeck'; but a few are from the bed No. 58. They are of a hard blue slaty calcareous rock.

The most remarkable of these Insect-remains are represented in Plate XV. figs. 6–26.

Elytra and Bodies.—The greater portion of these remains consist of small elytra, perfect or fragmentary, or of entire bodies or parts of bodies of insects.

The following are the chief specimens:—

Pl. XV. Fig. 6. Right-hand figure—the abdomen of a small flat beetle.

* Collected by the Rev. P. B. Brodie.

Pl. XV. Fig. 8. Left-hand figure—possibly the segment of the body of an elongated insect.

Fig. 9. Abdomen of a very small broad beetle;—*Coccinellidæ?*

Fig. 10. Abdomen of a small beetle.

Fig. 11. Metasternum and abdomen of a small beetle.

Fig. 12. Mesonotum and abdomen of a small beetle;—very obscure.

Fig. 13. Larger figure—mesosternum of a beetle; probably one of the small *Dyticidæ.*

Right-hand figure—abdomen of a small beetle.

In addition to these, there are—the thorax and elytra (in place, but crushed) of a small beetle; one and a third of a line long; of a broadly ovate form:—the abdominal portion, 3 lines long, of a beetle, without its elytra, but covered apparently with the wings folded up:—and two small flattened insects, each a line and a half long, which look like little beetles, or *Cimicidæ,* without wings; the limbs and the elytra are wanting, and the articulations very indistinct.

A great number of elytra (of which the majority of these fossils consist) are of very small size, not being more than $1\frac{1}{2}$ or 2 inches in length, varying from the narrow form of an *Agrilus* to the oval form of a *Chrysomela,* and with the surface plain, simply striated, punctate-striated, or deeply punctured.

Pl. XV. fig. 8, right-hand figure, and fig. 13, two upper figures, represent several of these small elytra.

The finest pair of elytra is represented in Pl. XV. fig. 7, of the natural size. The base and apex in these elytra are unfortunately wanting, both in the specimen and its cast. The surface is abraded; it has, however, evidently been finely punctured, and bears several plain narrow longitudinal costæ. It may have belonged to a broad species of *Prionus* or *Buprestis,* both of them lignivorous beetles.

Wings.—The wings, although numerous, and presenting many distinct types, are, like the foregoing, unfortunately in general only fragments of single wings, and unaccompanied by any portions of the bodies to which they belonged; so that we can judge only by analogy as to whether these insects possessed one or two pairs of these organs.

It is remarkable that there is only one fragment of the wing of a Dragon-fly; this is the middle portion of a wing quite similar to that from the Lower Purbecks figured in Pl. XV. fig. 5.

The chief types exhibited by the other wings are given in the following figures:—

Pl. XV. Fig. 6. Upper figure—the small wing-cover apparently of one of the *Cicadellinæ.*

Lower left-hand figure—the extremity of the upper surface of the closed wing-cover of a *Reduvius?*

Fig. 14. A slab containing a number of fragments of wings, and magnified figures of five of them beneath. Of these, * and ⊙ are probably por-

tions of wings of small *Trichoptera*; ⁂ is the upper wing of one of the *Cercopidæ*; † is part of the wing-cover of a small Blattideous insect; and ‡ is part of the wing of a Grass-hopper.

Pl. XV. Fig. 15. The wing of a small Dipterous insect, apparently allied to *Simulium*.

Figs. 16 & 17. Portions of the wings of Neuropterous insects, apparently allied to *Corydalis*.

Fig. 18. The lower wing of a species of the *Cicadellinæ*.

Figs. 19, 20, 23, 26. Apparently portions of wing-covers of various species of *Blattidæ*.

Fig. 21. Wing of a small Dipterous insect, allied to *Chironomus* or *Cecidomyia*.

Figs. 22 & 24. Portions of wings of Neuropterous insects of doubtful family.

Fig. 25. A remarkable spotted wing-cover, apparently of some curious Cimicideous insect.

Among other fragments of wings, there is also one, 4¾ lines long, with a few slight longitudinal veins, one of them next the costa being forked: this may perhaps be a portion of the under wing of a small Nepideous insect.

VII. Fossil Insects from the Dorchester Quarries§. Pl. XVI. fig. 3. Pl. XVIII. figs. 9 & 14.

Twelve specimens of fossil insects from the Ridgway Quarries near Dorchester, from the bed No. 106 of the Rev. O. Fisher's Section||, have been forwarded to me by the Rev. Mr. Brodie; and, being from a distinct bed, it has been thought advisable that they should be noticed separately.

Pl. XVIII. Fig. 9 represents a small insect, destitute of legs, antennæ, or wings, and which may possibly be the immature state of a *Naucoris*, or an allied Nepideous insect. The centre of the abdomen is longitudinally impressed; and there is a slight depression on either side, parallel with the lateral margin.

Fig. 14 may possibly be an insect closely allied to fig. 9; it is, however, far less clearly defined, especially in the anterior half of the body.

There is another insect similar in size to the two preceding, but so slightly indicated that it cannot be described.

Pl. XVI. Fig. 3 represents a portion of one of the slabs, in which it will be seen that a great mass of elytra, of different sizes and forms, have been deposited; and it is to be observed, that in the original the large dark-coloured elytron has ten, very

§ Collected by the Rev. O. Fisher, F.G.S.

|| Large Sheet. 1852, Dorchester, Foster.

fine, longitudinal, plain striæ; and that the striæ of the large central elytron are punctured.

Several of the other slabs also contain a great number of small elytra, of different sizes, and sculptured variously; but few of these are well defined. One, however, of larger size than the rest, is of a broad semi-oval form, $3\frac{1}{2}$ lines long, with a narrow, plain, lateral, dilated margin, and with nine longitudinal striæ, and one short, subscutellar, punctured stria.

In a few of the specimens of elytra, it is also to be observed that a portion of the original tegument of the elytra still exists, black and shining in appearance, and extremely brittle and friable in texture.

The only fragment of a wing amongst these Dorchester fossils is one, $\frac{1}{2}$ inch long, which is a part of a rather narrow delicate Neuropterous wing; the narrow costal portion of which has short oblique veinlets; and the disc has a submarginal straight vein, emitting straight, oblique, longitudinal veins, similar to the extremity of fig. 33 in Plate XVIII.

VIII. Fossil Elytron from Durdlestone Bay. Pl. XIV. fig. 11.

Plate XIV. fig. 11 represents, of the natural size, a very fine elytron found in the Lower Purbecks, Durdlestone Bay, Dorset, and kindly sent to me by Captain Woodley for examination. It is broad and flat, very finely punctured, of a brown colour, with part of the sutural edge finely reticulated with black, each reticulation being punctured; and it has three, smooth, plain, narrow, longitudinal costæ on the disc.

This specimen appears to be very nearly related to the fossil elytra from the Middle Purbecks represented in Pl. XV. fig. 7, above-described.

IX. Fossil Insects and Isopods from the Lower Purbecks*. Pl. XIV. figs. 9, 10, 12, 14–21. Pl. XV. figs, 1, 2, 4, 5. Pl. XVII. figs. 1–19, 21.

An extensive suite of fossil insects, amongst which are some of the finest I have hitherto examined, has been forwarded to me, through the Rev. Mr. Brodie, by Mr. Willcox, by whom they were collected from the Purbeck insect-beds near Swanage. They consist of sixty small slabs of various sizes, some containing a considerable number of insect remains. The most remarkable specimens are represented in the lower part of Plate XIV. by figs. 9, 10, 12, 14–21, and in Plate XV. by figs. 1, 2, 4, 5, and by the whole of Plate XVII., excepting fig. 20.

Isopods.—Pl. XIV. fig. 12. This is the most interesting of the whole of the series of fossils from the Lower Purbecks, not only on account of its being so far perfect as to show the general form of the

* Collected by C. Willcox, Esq.

body, but also from its belonging to the Crustacean order, *Isopoda*, which are very rare in the fossil state, and from its close relationship with the species of Isopod discovered in the "Insect limestone" of Wiltshire by Mr. Brodie, and figured in his work upon the Insects found in the Secondary Rocks of England, pl. 1. figs. 6–10, under the name of *Archæoniscus Brodiei*, applied to it by M. Milne-Edwards.

Two specimens, of one of which a cast is also preserved, were found by Mr. Willcox; and, as they are represented, in Pl. XIV. fig. 12, of the natural size, it will be seen that they are larger than the ordinary specimens of *A. Brodiei*, although the individual figured in Hist. Foss. Insects, pl. 1. fig. 7, is of equal size.

The tegument of the body, which remains in a few parts of the fossil, appears to have been a thin shell, somewhat like that of a shrimp. Neither antennæ nor legs are visible; and I cannot detect any trace of the eyes. There appears to have been an elevated ridge down the middle of the body, terminating at the base of the large, transversely oval, anal plate; and several of the articulations preceding the latter are much shorter and less distinct than the anterior segments; the terminal plate, moreover, exhibits no traces of the lateral caudal appendages, except a slight thickening and elevation of the basal lateral angles.

Insects.—Of entire insects or portions of their bodies there are but very slight traces to be found in this collection. Pl. XV. fig. 1 represents a part of the articulated elongate abdomen of a small insect, which seems most like a part of some Tipulideous specimen; and Pl. XVII. figs. 8 & 18 represent two small abdomens, which seem more like those of Hemipterous or Homopterous, than Coleopterous insects.

Of the elytra of *Coleoptera* there is a very extensive series, consisting generally of single detached specimens, but occasionally of the two elytra conjoined. Pl. XIV. figs. 14 & 15 are pairs of elytra of two small beetles, which were about $\frac{1}{3}$ inch long.

Pl. XIV. figs. 16–21 and Pl. XVII. figs. 1–6 represent single elytra belonging to insects of different families. Of these the largest, Pl. XIV. fig. 17, must have been part of a beetle about 1 inch long. Several of these are also remarkable for the very distinct manner in which they are spotted and striped, especially the striato-punctate forms in Pl. XIV. fig. 19 and Pl. XVII. figs. 3 & 5; the first and last of which seem to have belonged to the *Buprestidæ*, and the other to the *Harpalidæ*.

I will not, however, pretend to assign all these elytra to their families; the forms and markings vary so infinitely in every Coleopterous family of any extent (many of the families containing several thousand distinct species in each), that the attempt would be very hazardous.

Pl. XVII. fig. 1, as well as fig. 7, and possibly fig. 9, seem to me to have rather doubtful claims to be considered as insect remains. It is possible that they may be of vegetable origin; but the first looks like an elytron, the irregularity of the surface of which may have been caused by abrasion; and fig. 9 may be a strongly granulated or tuberculated elytron, of which a portion of the inner margin has been abraded; but I know of no insect to which fig. 7, if belonging to an Annulose animal, can satisfactorily be referred.

Of naked-winged insects there is a considerable collection of interesting fragments, amongst which those belonging to the *Libellulidæ* are pre-eminent, as usual, for their size. Pl. XV. fig. 4 represents a portion (near the extremity) of one of the wings of a *Libellula* of very large size. Fig. 5 is one of the wings of a Dragon-fly with very small meshes, and with the characteristic triangle occupying a higher position than in the typical *Libellulæ*. Pl. XVII. fig. 21 is a portion of a wing, drawn of the natural size, which, from its general character, is evidently Libellulideous; but I know no species with such an arrangement of veins; and, compared with the ordinary types of the family, this fossil insect must have been quite gigantic in size.

Pl. XVII. Fig. 12 represents one of the wings of a Neuropterous insect, allied to *Sialis* or *Panorpa*; and fig. 16, one allied to *Raphidia*.

Fig. 19 appears to be one of the narrow elongate tegmina of a Grasshopper; and figs. 10 and 13, tegmina of *Blattidæ*.

Fig. 11 seems to be a portion of one of the upper wings of a Homopterous insect.

Figs. 14 and 15 are a wing and wing-cover of a small Cimicideous insect.

Pl. XV. Fig. 2 appears to be a portion of a wing of a Tipulideous species.

Pl. XVII. Fig. 17 represents a number of fragments of delicate tegument covered with minute punctures and traversed by straight and somewhat radiating veins, which appear like portions of the hind-wing of some species of Butterfly, entirely denuded of scales. A fragment of larger size will be noticed amongst the Rev. Mr. Brodie's Lower Purbeck insects.

X. Fossil Insects from the Lower Purbecks, Durdlestone Bay, Dorset *. Pl. XIV. figs. 1–8.

A small collection of insect-remains, 22 in number, collected by W. R. Brodie, Esq., of Swanage, Dorset, has been communicated to me through his cousin the Rev. P. B. Brodie. A few of the more interesting of these are represented in the upper part of Pl. XIV. As in the other collections, the greater portion consist of single elytra.

Pl. XIV. figs. 1, 2, 3, are three of the best-marked specimens, the others being of small size. The first of them appears to belong to one of the *Elateridæ*; the second is Helopideous; and the third is Curculionideous.

Pl. XIV. fig. 4 appears to me to belong doubtfully to an insect:

* Collected by W. R. Brodie, Esq.

it may indeed possibly represent a spotted elytron, with a fragment of a wing; but I cannot regard it as such with any degree of certainty. Fig. 6 seems to be the short coriaceous upper wing, or wing-cover, of some Cercopideous insect among the *Homoptera*. Figs. 5 & 7 may also be portions of the wing-cover and wing of a Grasshopper. But all these (figs. 4, 5, 6, 7) have somewhat of a vegetable character.

Pl. XIV. fig. 8. This is the most interesting specimen of all the insect-remains yet discovered amongst the Lower Purbeck series. It is, in fact, the wing of a gigantic Ant, which, in its perfect state, must have measured at least 2 inches across the expanded wings; and it is most nearly allied to some of the exotic forms of which *Myrmica* is the type in our temperate regions.

The discovery of such an insect is of the highest importance in respect to the question of the geographical range of the insects imbedded in the Lower Purbeck series.

The wing of a second species of Ant (Pl. XVIII. fig. 21), closely allied to the foregoing, but differing from it generically, occurs in the Rev. Mr. Brodie's collection, and will be subsequently noticed.

Mr. W. R. Brodie has also sent me a slight sketch of an insect with four wings of equal size, which he found in the stratum marked No. 116 in the list in Mr. Austen's 'Guide.' This is about the size, and has somewhat the appearance, of the common *Panorpa*. It is now, I believe, in the Museum at Cambridge.

XI. Fossil Insects from the Lower Purbecks of Durdlestone Bay*. Pl. XV. fig. 3; Pl. XVI. figs. 1, 2, 4–33, 36–38; Pl. XVIII. figs. 1, 3–8, 10–13, 15–43.

By far the largest collection of insect-remains from the Lower Purbecks is that formed by the Rev. P. B. Brodie, who has placed in my hands his entire series, consisting of 350 small slabs of stone, of various sizes. Upon many of these only a single fragment of an insect occurs; but upon a considerable number the remains are very numerous, the fragments being crowded together, and often lying upon one another. Of this condition a slight idea may be obtained from Pl. XV. fig. 14, and Pl. XVI. fig. 3.

The representation of the more interesting of these fossil remains is given in Pl. XV. fig. 3, Pl. XVI. figs. 1, 2, 4–33, 36–38, and Pl. XVIII. figs. 1, 3–8, 10–13, 15–43.

With the exception of the Dragon-flies, of which there are as many as thirty-four fragments of single wings (from which, however, it is impossible to affirm either a moderate or tropical climate and geographical range), and of the large Ant wing, Pl. XVIII. fig. 21, it is worthy of remark, that the whole of these remains, not fewer in number than 700 or 800, are those of minute insects not more than a fourth or a third of an inch in length.

A few of the more remarkable elytra, which I have selected for illustration, belong to Beetles half an inch long or thereabouts; and

* Collected by the Rev. P. B. Brodie, F.G.S.

there are half a dozen, at the most, of Beetles which were not more than an inch or 15 lines long.

Bodies of Insects.—Mr. P. B. Brodie's collection of Lower Purbeck fossils presents to us very few specimens of the entire bodies of insects; none, in fact, in which the antennæ and limbs are preserved. The bodies or abdomens of a few minute insects alone occur, the most perfect of which are represented in the upper part of Pl. XVIII. Of these, fig. 1 represents the under side of the thorax and abdomen of a beetle, probably Carabideous: fig. 12, the head and body of a minute *Haltica* or other Chrysomelideous beetle: fig. 16 appears to be the prothorax of some small beetle: figs. 6, 10, 18, & 19 appear to be the abdomens of minute beetles: fig. 17, the abdomen of a small Cimicideous or Homopterous insect: fig. 11 may be the scutellum and closed wings of a beetle deprived of elytra, or those of a Cimicideous insect: figs. 7, 8, 13, & 15 appear to be portions of the thorax of various insects: there are several specimens like fig. 7; it appears indeed to be reproduced in the front part of fig. 13.

In addition to the above, there are the bodies of three minute insects of an oval flattened form, about one-eighth of an inch long, resembling Pl. XVIII. fig. 12. There is also a small object, 1 line long, which looks like the head of a beetle with the two excavations for the base of the antennæ and the transverse labrum. There are several mesonotums and metanotums of minute beetles, and a few minute abdomens of beetles, and several objects that appear like the articulations of small annulose animals in a greater or less state of dislocation.

Elytra.—As above stated, elytra, generally of minute size, and rarely appearing in pairs, constitute the greater portion of this suite of insect-remains. The most interesting and best defined of these are represented in Pl. XVI., which, with the exception of figs. 3, 34, & 35, is entirely occupied with them.

Pl. XVI. fig. 1 represents one of the commonest occurrence. The extremity, which terminates in an obtuse point, is here broken off. This specimen is about 4 lines long, and is marked with ten plain fine striæ. I presume it to be Carabideous. Pl. XVI. fig. 2 is a small object, which may possibly be an elytron; it is convex and smooth. Figs. 8 & 9, although approaching fig. 2 in form, are, on the other hand, evidently elytra of some short and very convex beetle, such as *Coccinella* or *Scymnus*. Fig. 4 is a minute elytron, interesting on account of the fossil still retaining a small black portion of the original tegument of the beetle: it seems to have belonged to a small *Elater*. Fig. 5 is the largest elytron of the series, and appears to have belonged to the same family as fig. 4. Figs. 6, 23, 29, & 32 represent elongated elytra, pointed at the tip, with the outer margin slightly serrated, and the disc marked with dark cloudy spots: these appear to have belonged to species of *Agrilus* among the *Buprestidæ*. Figs. 11, 22, 31, 36, 37, 38 are interesting on account of the original light-coloured spottings on a dark ground being still visible. Figs. 15 & 24 are pale coloured, with small dark spots on the interstices of the striæ. Fig. 13 is also one of the commonest elytra; it has a flattened lateral margin, and as many as eighteen very fine longitudinal plain striæ; it may have belonged to a Helopideous or Diaperideous beetle. Figs. 10, 12, 17, 30, & 33 deserve notice on account of the deep punctures or other rugosities which are still retained in the specimens; figs. 10 & 30 may be Carabideous, and fig. 33, Curculionideous. Fig. 19 is a fragment of a very fine elytron, remarkable for having the deep lateral impression similar to that of the elytra which are so common in the Stonesfield Slate, upon the relations of which I commented in Mr. Brodie's work, p. 122. The other elytra do not appear to merit any particular mention.

Wings.—The remains of insect-wings likewise constitute a very large portion of the series of Mr. P. B. Brodie's specimens. Of these the finest and largest are the remains of wings of Dragon-flies, of which there are thirty-four fragments. In no instance is there a perfect wing.

In the arrangement of the veins, especially those of the characteristic triangle, they agree with that in Pl. XV. fig. 5. In one specimen, however, the outer side of the triangle, instead of being vertical, or nearly so, as in that figure, is very oblique, so that the outer angle is very acute, as in *Æschna* (Quart. Journ. Geol. Soc. vol. v. pl. II. fig. B). There is also considerable difference in the size of the cells of the wings; in some specimens these are very small, whilst in one they are very large and quadrangular: this specimen must, I apprehend, have belonged to a very large species of *Agrion.*

Other Neuropterous wings occur also, but always fragmentary. Pl. XVIII. fig. 24 represents a wing of an insect allied to *Sialis*; to which also figs. 35 & 37 may be allied. Figs. 25, 28, 31 are probably portions of wings of insects allied to *Phryganea.* Figs. 22, 23, 26, 32, 33, 34, 38, 40, 41, 42, & 43 appear to be Orthopterous; some of them, as figs. 22, 32, & 43 (of which there are a great number of specimens), being probably the wing-covers of *Blattidæ*; as well as figs. 23, 26, & 33. Fig. 21 is a wing of a gigantic species of Ant, closely allied to, but differing from, fig. 8 of Pl. XIV. in the position of the cells.

Pl. XVIII. figs. 27 & 30 appear to be portions of the hind-wings of some species of Butterfly; still they have very much of a vegetable aspect. The surface is covered with minute punctures, which may be the cells for the insertion of the quills of the coloured scales which are all removed, supposing the specimens to be Lepidopterous. If such should prove to be really the case, by the discovery of more characteristic specimens, it will form an interesting addition to our knowledge of fossil entomology. M. Boisduval has, however, described, in the *Annales de la Société Entomologique de France*, a fossil Butterfly under the name of *Cyllo sepulta*, which has given rise to a remarkable controversy between himself and M. Alex. Lefebvre, published in the same work.

Pl. XVIII. figs. 4 & 29 may possibly be the wing-covers of Cimicideous insects much abraded. Figs. 3, 5, 36, and Pl. XV. fig. 3, are portions of the wing-covers and wings of Cercopideous insects. Pl. XVIII. fig. 20 is the wing of a Tipulideous insect.

The Museum of Practical Geology in Jermyn-street also possesses a fine series of fossil insects from the Purbecks. This series agrees in general characters with the Rev. Mr. Brodie's collection, but comprises several specimens of Dipterous insects in a much more perfect condition.

In the British Museum also there are a few fossil insects from the same formation; and there are several other specimens in the Cambridge and Dorchester Museums.

Summary.

The microscopical examination which I have been compelled to make of so many hundreds of fossil insect-remains, for the most part in a fragmentary condition, from the Lower Purbecks of Dorset, although beyond measure tedious from the unsatisfactory results afforded by the nature of the specimens, has still enabled me to arrive at some results, and to form a general comparison of these insect-deposits with those which I similarly investigated whilst preparing the plates of Mr. P. B. Brodie's work on the fossil insects of the Wiltshire Purbecks, &c.

If we take into consideration the small, and even minute size of the great majority of the insects, and indeed of the whole of the *Coleoptera*, which have been passed under review, the idea, that we have before us the wreck of an Insect Fauna of a temperate region, is at once raised; for although it would be rash to assert that a mass of remains of the existing tropical insects might not be accumulated in which a large quantity of minute beetles and flies would not be present, yet I cannot conceive any process, either arising from currents of water, or chemical dissolution of insect matter, which would carry off or destroy the many gigantic forms of insect life always occurring in the tropics.

The fossils before us show abundant evidence of the presence of numbers of Lignivorous species, such as the *Elateridæ* and *Buprestidæ*; but we nowhere find amongst them traces of the great Lamellicorn and Longicorn beetles. Herbivorous insects also occur in considerable numbers; but we do not meet with the gigantic Grasshoppers and Locusts of tropical climates. It has indeed been suggested that the remains may be those of insects living in a temperate climate and carried by currents to a tropical region; and Prof. E. Forbes has instanced the fact that he found shells of a temperate type, natives of the upper parts of the great range of the Atlas Mountains in Africa, brought down by currents and resting in the lower regions among shells of a tropical character. But, in order that the analogy should hold good, it seems to me necessary that we should find amongst the remains, not a single specimen or two (as in the case of the wings of the large Ants above-mentioned), but the remains of a great majority of tropical species mixed up with a smaller number of temperate forms. I must leave geologists to discover or to suggest the action which could have brought together and deposited such great masses of insect-remains as we find in many of the slabs of stone in these collections, and of which Pl. XVI. fig. 3 will afford an idea. Entomologists, however, are perfectly well aware that sudden inundations or the rapid rising of rivers are sure to bring with them the most abundant entomological harvest, insects being floated down such currents in vast numbers, and congregated together in masses on the banks, as thick as bees in a hive, or ants in an ant-hill.

The circumstance also that such vast numbers of elytra have been preserved, whilst the equally hard thorax, head, antennæ, and legs have entirely disappeared, is worthy of remark. I must admit that I can offer no solution of so curious a fact, especially as the wings, notwithstanding their great delicacy, have left their impress on the stone as clearly as any of the harder elytra. We here, however, see another instance in which nature had from the earliest time adopted processes which we look upon when first applied in art or manufactures as wonderful novelties. We see, in fact, that the modern discovery of "natural printing," as it has been termed, whereby the most delicate objects leave their mark upon the hardest materials, when in contact under heavy pressure, has been anticipated in these fossil imprints of wings of some of the smallest and most delicate insects.

It has been suggested that the discovery of quantities of detached elytra in a small slab might possibly be accounted for on the supposition that the insects to which they had belonged had been devoured by some bird or other insectivorous animal, and had passed through the stomach undissolved, owing to the presence of an asserted chemical substance in the elytra, which has been termed "elytrine." I believe, however, that the term in question does not imply a distinct substance in the elytra of beetles, but was given in consequence of the experiments in which it was developed having been made upon elytra. All the parts of the outer integument of a beetle have, in fact, the same chemical composition, and consist of the substance now known by the name of "chitine," which is analogous in composition to horn. Moreover entomologists are well aware of the fact that other parts of a beetle are of as solid a nature as elytra; they know, for example, that one of the best beetle-traps is a toad, the excrement of which generally contains *entire* specimens of some of the rarest ground-beetles.

With the exception, then, of the winged giant Ants, and of some of the fragments of gigantic Dragon-flies' wings, there seems to be such a general conformity with the Purbeck insects of Wilts*, that I may almost reiterate the whole of my observations published in the introductory part of Mr. Brodie's work. But, if the general conditions of insect-life were so similar in the two districts, as indicated by the remains in the Wilts and Dorset Purbeck formations, the mode of destruction of such insect-life must have been very different; since we found abundance of specimens of insects in a tolerably entire state of preservation in the former, whilst in the latter scarcely anything but fragments of wings or elytra, or a few segments of the abdomen, occur. This indeed is the more remarkable, because, from the tubular horny structure both of the leg-joints and antennæ, it would have been quite reasonable to have expected to have found them lying detached amongst the masses of elytra, &c. of the beetles and other insects to which they belonged. This dislocation and partial de-

* The discovery of closely allied fossil *Isopoda* in both the localities is especially to be noticed.

struction of the insects appear to be so general, that we may almost renounce the idea of any chance discovery of perfect insects, even of fragments sufficiently distinct to allow us to form a satisfactory opinion on the general entomology of the Dorset Purbeck period.

In like manner, there is also so great a general coincidence between the insects of the Lower and those of the Middle Purbecks, including those from the Ridgway quarries (judging, as well as I am able, from the comparative paucity of materials which I have examined), that I can come to no other conclusion, than that the insects discovered in all these different strata belong to one general insectal fauna.

EXPLANATION OF PLATES XIV. XV. XVI. XVII. XVIII.

Plate XIV.

Fig.		*Probable relations.*	*Formations and Localities.*	*Collected by*	*Page.*
1.	Elytron	Elateridæ	} Lower Purbecks, Durdlestone Bay.	W. R. Brodie, Esq.	387
2.	Elytron	Helopideous			
3.	Elytron	Curculionideous			
4.	Elytron ?	—— ?			
5.	Wing-cover and wing ?	Grasshopper ?			
6.	Wing-cover ?	Cercopideous ?			
7.	Wings ?	Grasshopper ?			
8.	Wing	Giant Ant			
9.	Elytron ?	......	} Lower Purbecks, Durdlestone Bay.	C. Willcox, Esq.	385
10.	Elytron ?	......			
11.	Elytron	Buprestidæ	Lower Purbecks, Durdlestone Bay.	Capt. Woodley.	385
12.	Body	Archæoniscus	Lower Purbecks, Durdlestone Bay.	C. Willcox, Esq.	385
13.	Part of body	Beetle	Stonesfield Slate	Earl of Enniskillen.	379
14.	Elytra, united	......	} Lower Purbecks, Durdlestone Bay.	C. Willcox, Esq.	386
15.	Elytra, united	......			
16.	Elytron	......			
17.	Elytron	......			
18.	Elytron	......			
19.	Elytron	Buprestidæ			
20.	Elytron	Harpalidæ			
21.	Elytron	Tentyridæ			

Specific names.

Fig. 1. Elaterium Pronæus, *W.*
2. Helopium Agabus, *W.*
3. Curculium Syrichthus, *W.*
8. Formicium Brodiei, *W.*

Fig. 11. Buprestium Woodlei, *W.*
12. Archæoniscus Edwardsii, *W.*
13. Blapsium Egertoni, *W.*

Fig. 19. Buprestium Teleas, *W.*
20. Harpalidium Anactus, *W.*
21. Tentyridium Peleus, *W.*

Plate XV.

Fig.		*Probable relations.*	*Formations and Localities.*	*Collected by*	*Page.*
1.	Abdomen	Tipulideous	......	} C. Willcox, Esq.	386
2.	Wing	Tipulideous	......		387
3.	Wing-cover	Cercopideous	} Lower Purbecks, Durdlestone Bay.	Rev. P. B. Brodie.	390
4.	Wing	Libellulidæ		} C. Willcox, Esq.	387
5.	Wing	Dragon-fly	......		
6.	Upper left-hand figure—wing-cover.	Cicadellinæ	} Middle Purbecks, Durdlestone Bay.	Rev. P. B. Brodie.	382
	Right-hand figure—abdomen.	Beetle			
	Lower left-hand figure—wing-cover.	Reduvius ?			

PLATE XV. (*continued*).

Fig.		*Probable relations.*	*Formations and Localities.*	*Collected by*	*Page.*
7.	Elytra, united ...	Buprestidæ........			
8.	Right-hand figure —elytron.	Diaperidæ			
	Left-hand figure segment of body of insect ?	....			
9.	Abdomen	Coccinellidæ ?......			
10.	Abdomen	Beetles			
11.	Part of body	Beetles			
12.	Part of body	Beetles			
13.	Two upper figures —elytra.	Beetles			
	Large figure— part of body.	Dyticidæ ?			
	Right-hand figure —abdomen.	Beetle...............	Middle Purbecks, Durdlestone Bay.	Rev. P. B. Brodie.	382
14.	* Wing	Trichoptera			
	⊙ Wing	Trichoptera			
	⁑ Wing	Cercopidæ			
	† Wing-cover ...	Blattidæ			
	‡ Wing	Grasshopper			
15.	Wing	Dipterous			
16.	Wing	Neuropterous......			
17.	Wing	Neuropterous......			
18.	Lower wing	Cicadellinæ.........			
19.	Wing-cover	Blattidæ			
20.	Wing-cover ?	Blattidæ			
21.	Wing	Dipterous			
22.	Wing	Neuropterous......			
23.	Wing-cover	Blattidæ			
24.	Wing	Neuropterous......			
25.	Wing	Cimicideous			
26.	Wing-cover	Blattidæ			

Specific names.

Fig. 2. Corethrium Pertinax, *W.*
3. Cercopidium Mimas, *W.*
4. Libellulium Agrias, *W.*
5. Æschnidium Bubas, *W.*
6. (Upper left-hand figure) Cicadellium Dipsas, *W.*
7. Buprestium Gorgus, *W.*

Fig. 8. (Right-hand figure) Diaperidium Mithrax, *W.*
14⁑ Cercopidium Telesphorus, *W.*
15. Simulidium priscum, *W.*
16. Termitidium ignotum, *W.*

Fig. 17. Panorpidium tessellatum, *W.*
18. Cicadellium Psocus, *W.*
21. Cecidomium grandævum, *W.*
26. Blattidium Molossus, *W.*

PLATE XVI.

Fig.		Probable relations	Formations and Localities	Collected by	Page
1.	Elytron	Carabideous	Lower Purbecks, Durdlestone Bay.	Rev. P. B. Brodie.	389
2.	Elytron ?	....	Lower Purbecks, Durdlestone Bay.		384 & 388
3.	Slab with insect-remains.	....	Lower Purbecks, Ridgway.	Rev. O. Fisher.	384 & 388
4.	Elytron	Elateridæ			
5.	Elytron	Elateridæ			
6.	Elytron	Buprestidæ.........			
7.	Elytron	....			
8.	Elytron	Coccinellidæ ?......	Lower Purbecks, Durdlestone Bay.	Rev. P. B. Brodie.	388
9.	Elytron	Coccinellidæ ?......			
10.	Elytron	Carabideous			
11.	Elytron	Buprestidæ			

PLATE XVI. (*continued*).

Fig.		*Probable relations.*	*Formations and Localities.*	*Collected by*	*Page.*
12.	Elytron...........	....	Lower Purbecks, Durdlestone Bay.	Rev. P. B. Brodie.	388
13.	Elytron...........	Helopideous			
14.	Elytron...........	....			
15.	Elytron...........	....			
16.	Elytron...........	....			
17.	Elytron...........	....			
18.	Elytron...........	....			
19.	Elytron...........	....			
20.	Elytron...........	....			
21.	Elytron...........	....			
22.	Elytron...........	Buprestidæ.........			
23.	Elytron...........	Buprestidæ.........			
24.	Elytron...........	....			
25.	Elytron...........	....			
26.	Elytra, united....	....			
27.	Elytron...........	....			
28.	Elytron...........	....			
29.	Elytron...........	Buprestidæ.........			
30.	Elytron...........	Carabideous ?			
31.	Elytron...........	Buprestidæ.........			
32.	Elytron...........	Buprestidæ.........			
33.	Elytron...........	Curculionidæ			
34.	Elytron...........	Buprestidæ.........	Tertiary, near Corfe.	W. R. Brodie, Esq.	381
35.	Elytron...........	Curculionidæ			
36.	Elytron...........	Elateridæ	Lower Purbecks, Durdlestone Bay.	Rev. P. B. Brodie.	389
37.	Elytron...........	Elateridæ			
38.	Elytron...........	Buprestidæ.........			

Specific names.

Fig. 4. Elaterium Triopas, *W.*
5. Elaterium Barypus, *W.*
6. Agrilium Strombus, *W.*
11. Buprestium Stygnus, *W.*
13. Helopidium Neoridas, *W.*

Fig. 22. Buprestium Stygnus, var.?, *W.*
23. Agrilium Stomphax, *W.*
29. Agrilium Cyllarus, *W.*

Fig. 31. Buprestium Valgus, *W.*
32. Agrilium Cyllabacus, *W.*
36. Ctenicerium Blissus, *W.*
37. Ctenicerium Hylastes, *W.*
38. Buprestium Dardanus, *W.*

PLATE XVII.

Fig.		*Probable relations.*	*Formations and Localities.*	*Collected by*	*Page.*
1.	Elytron ?	....	Lower Purbecks, Durdlestone Bay.	C. Willcox, Esq.	386 & 387
2.	Elytron ?	....			
3.	Elytron	Harpalidæ			
4.	Elytron	Telephoridæ			
5.	Elytron	Buprestidæ.........			
6.	Elytron	....			
7.	Wing ?	....			
8.	Abdomen	Hemipterous ? ...			
9.	Elytron ?	....			
10.	Wing-cover	Blattidæ			
11.	Upper wing	Homopterous ...			
12.	Wing	Neuropterous			
13.	Wing-cover	Blattidæ............			
14.	Wing	Cimicideous			
15.	Wing-cover	Cimicideous			
16.	Wing	Raphidiidæ.........			
17.	Wing	Lepidopterous ...			
18.	Abdomen	Hemipterous ? ...			
19.	Wing-cover	Grasshopper	[Eyeford.		
20.	Wings	Dragon-fly	Stonesfield Slate,	Rev. P. B. Brodie.	380
21.	Wing	Libellulidæ.........	Lower Purbecks, Durdlestone Bay.	C. Willcox, Esq.	387

Specific names.

Fig. 3. Harpalidium Nothrus, *W.*
4. Telephorium Abgarus, *W.*
5. Buprestium Bolbus, *W.*

Fig. 12. Panorpidium tessellatum, var.?, *W.*
15. Cimicidium Dallasii, *W.*
16. Raphidium Brephos, *W.*

Fig. 17. Cyllonium Boisduvalianum, *W.*
19. Gryllidium Oweni, *W.*
21. Libellulium Kaupii, *W.*

Plate XVIII.

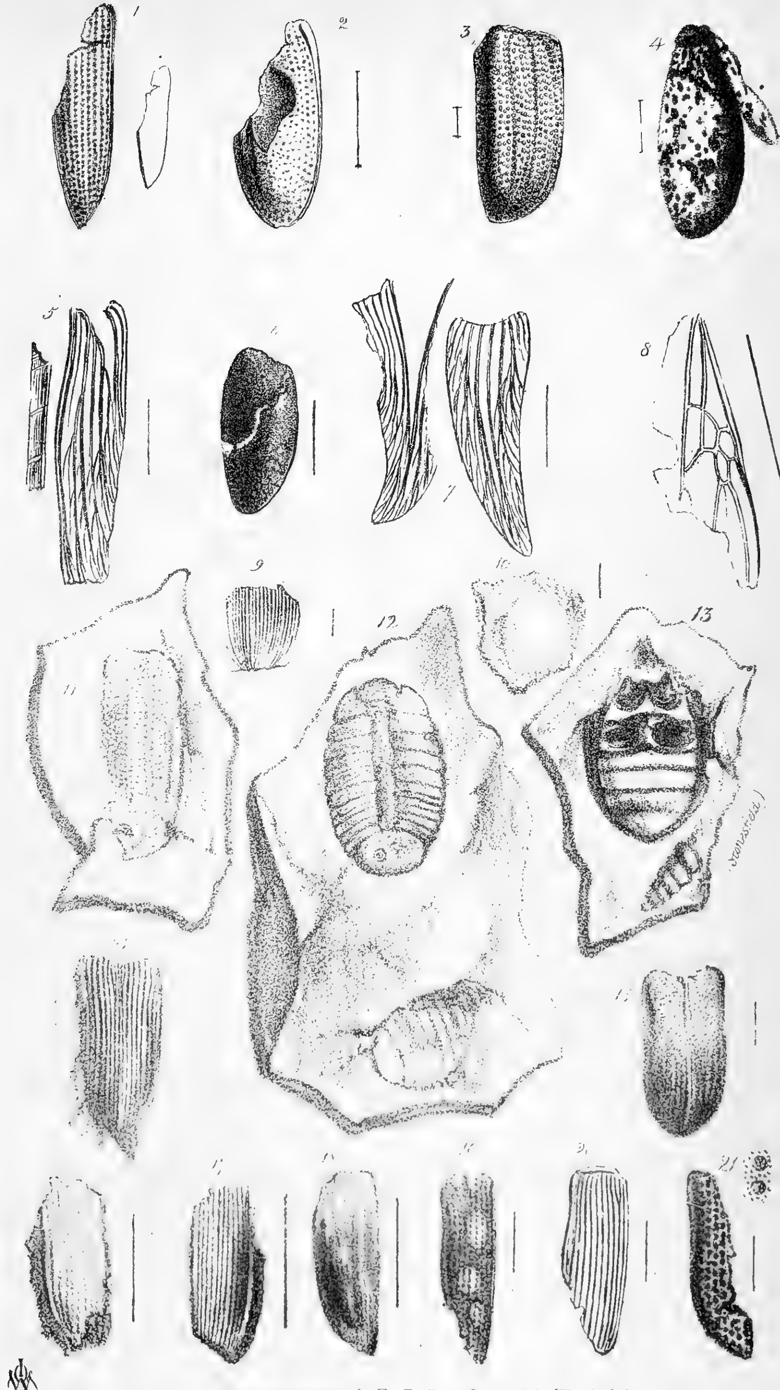
Fig.		*Probable relations.*	*Formations and Localities.*	*Collected by*	*Page.*
1.	Part of body	Carabideous	Lower Purbecks, Durdlestone Bay.	Rev. P. B. Brodie.	389
2.	Part of body ? ...	Pentatomidæ ? ...	Lias	Rev. P. B. Brodie.	381
3.	Wing	Cercopideous			
4.	Wing-cover	Cimicideous			
5.	Wing	Cercopideous	Lower Purbecks, Durdlestone Bay. (3–8)	Rev. P. B. Brodie.	389
6.	Abdomen	Beetle			
7.	Thorax	....			
8.	Thorax	....			
9.	Body	Nepideous	Lower Purbecks, Ridgway.	Rev. O. Fisher.	384
10.	Abdomen	Beetle			
11.	Part of body and wings.	Cimicideous ?	Lower Purbecks, Durdlestone Bay. (10–13)	Rev. P. B. Brodie.	389
12.	Body	Chrysomelideous ..			
13.	Thorax	....			
14.	Body	Nepideous	Lower Purbecks, Ridgway.	Rev. O. Fisher.	384
15.	Thorax	....			
16.	Prothorax	Beetle			
17.	Abdomen	Cimicideous			
18.	Abdomen	Beetle			
19.	Abdomen	Beetle			
20.	Wing	Tipulideous			
21.	Wing	Giant Ant			
22.	Wing-cover	Blattidæ			
23.	Wing-cover	Blattidæ			
24.	Wing	Neuropterous			
25.	Wing	Phryganeidæ			
26.	Wing-cover	Blattidæ			
27.	Hind-wing ?	Lepidopterous ...			
28.	Wing	Phryganeidæ			
29.	Wing-cover	Cimicideous	Lower Purbecks, Durdlestone Bay. (15–43)	Rev. P. B. Brodie.	389 & 390
30.	Hind-wing ?	Lepidopterous ? ...			
31.	Wing	Phryganeidæ			
32.	Wing-cover	Blattidæ			
33.	Wing-cover	Blattidæ			
34.	Wing	Orthopterous			
35.	Wing	Neuropterous			
36.	Wing	Cercopideous			
37.	Wing	Neuropterous			
38.	Wing	Orthopterous			
39.	Wing	Neuropterous			
40.	Wing	Orthopterous			
41.	Wing	Orthopterous			
42.	Wing	Orthopterous			
43.	Wing-cover	Blattidæ			

Specific names.

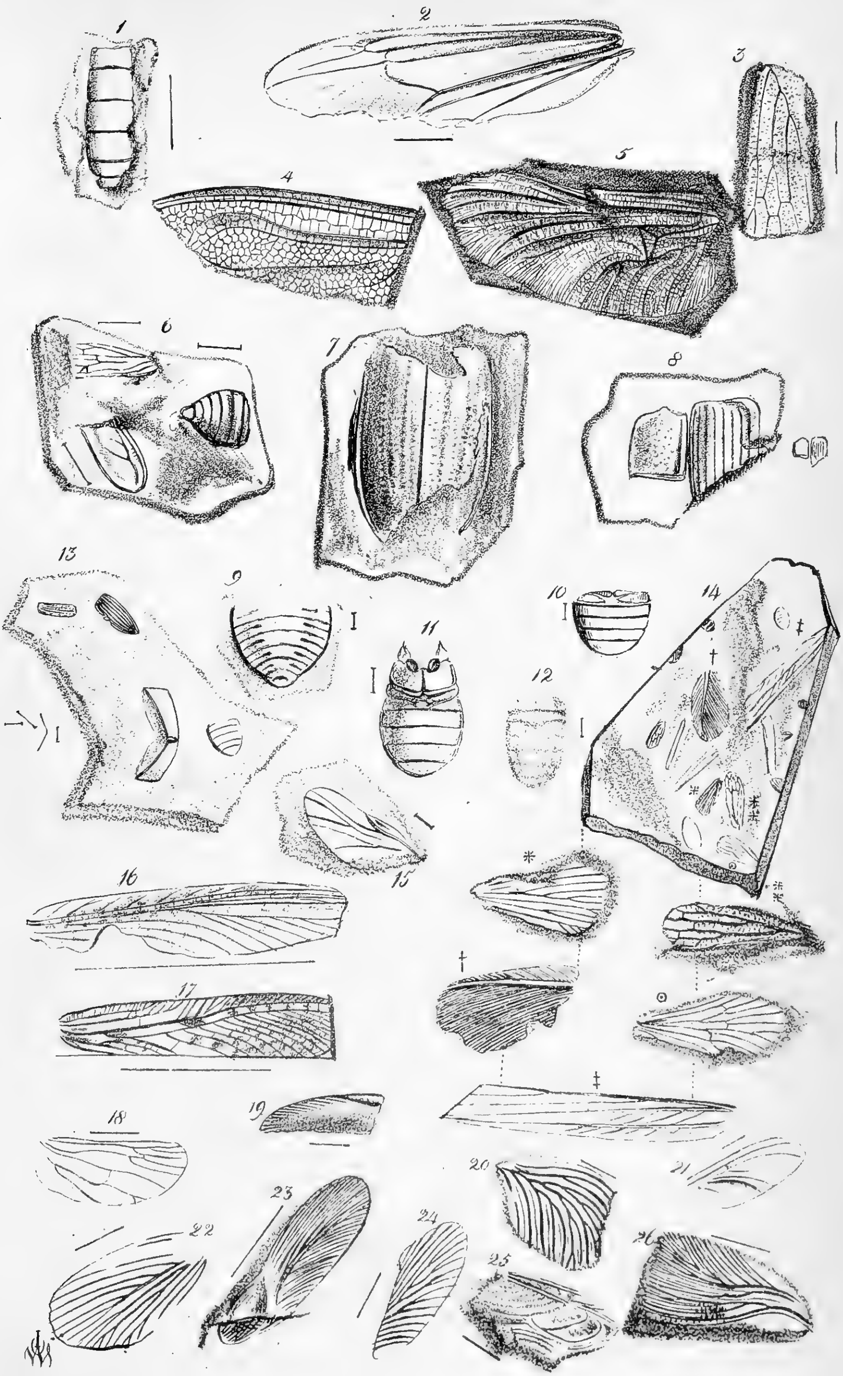
Fig. 1. Carabidium Dejeanianum, *W.*
3. Cercopidium Hahnii, *W.*
5. Cercopidium Schæfferi, *W.*
9. Nepidium Stolones, *W.*
21. Myrmicium Heerii, *W.*

Fig. 23. Blattidium Nogaus, *W.*
24. Sialium Sipylus, *W.*
26. Blattidium Achelous, *W.*
27. Cyllonium Hewitsonianum, *W.*

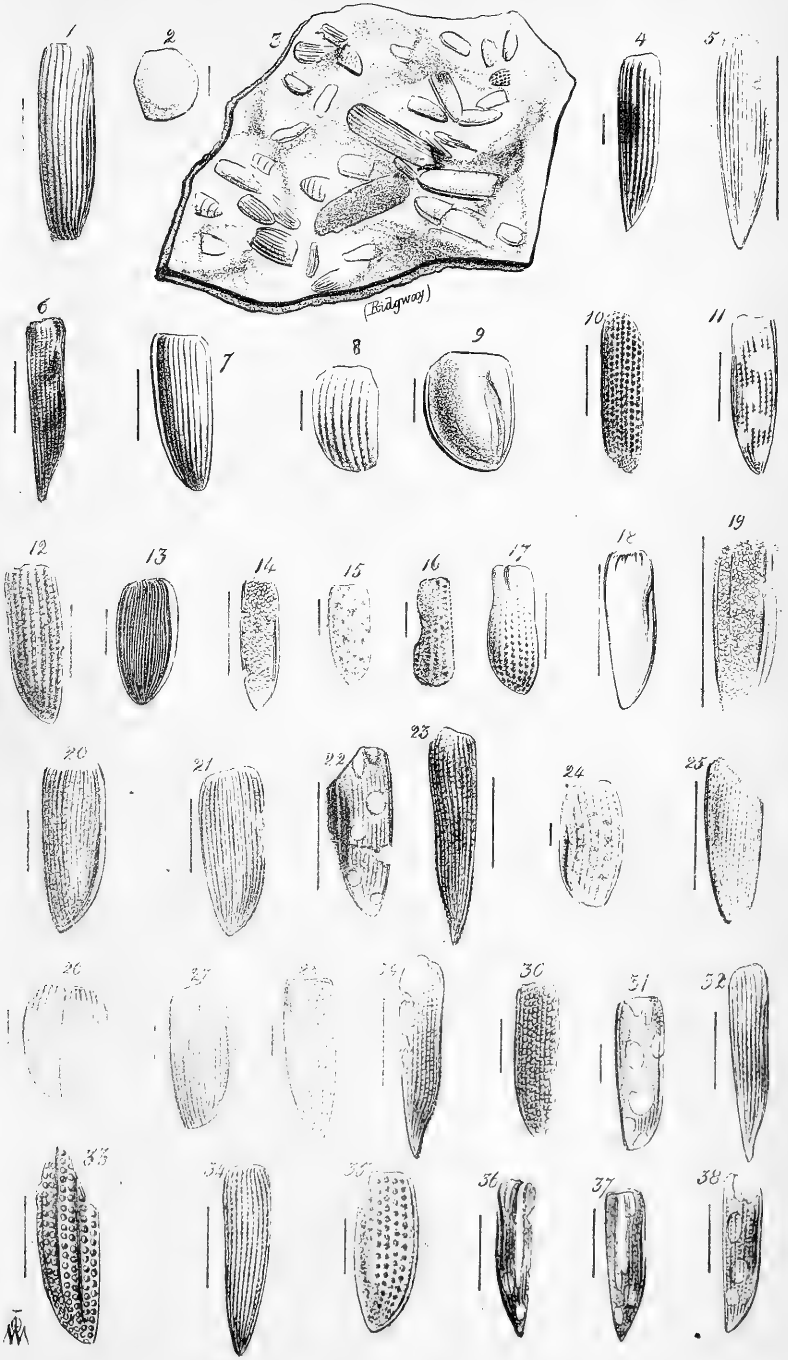
Fig. 31. Phryganeidium Pytho, *W.*
33. Blattidium Symyrus, *W.*
36. Cercopidium Signoretii, *W.*
39. Agrionidium Ætna, *W.*



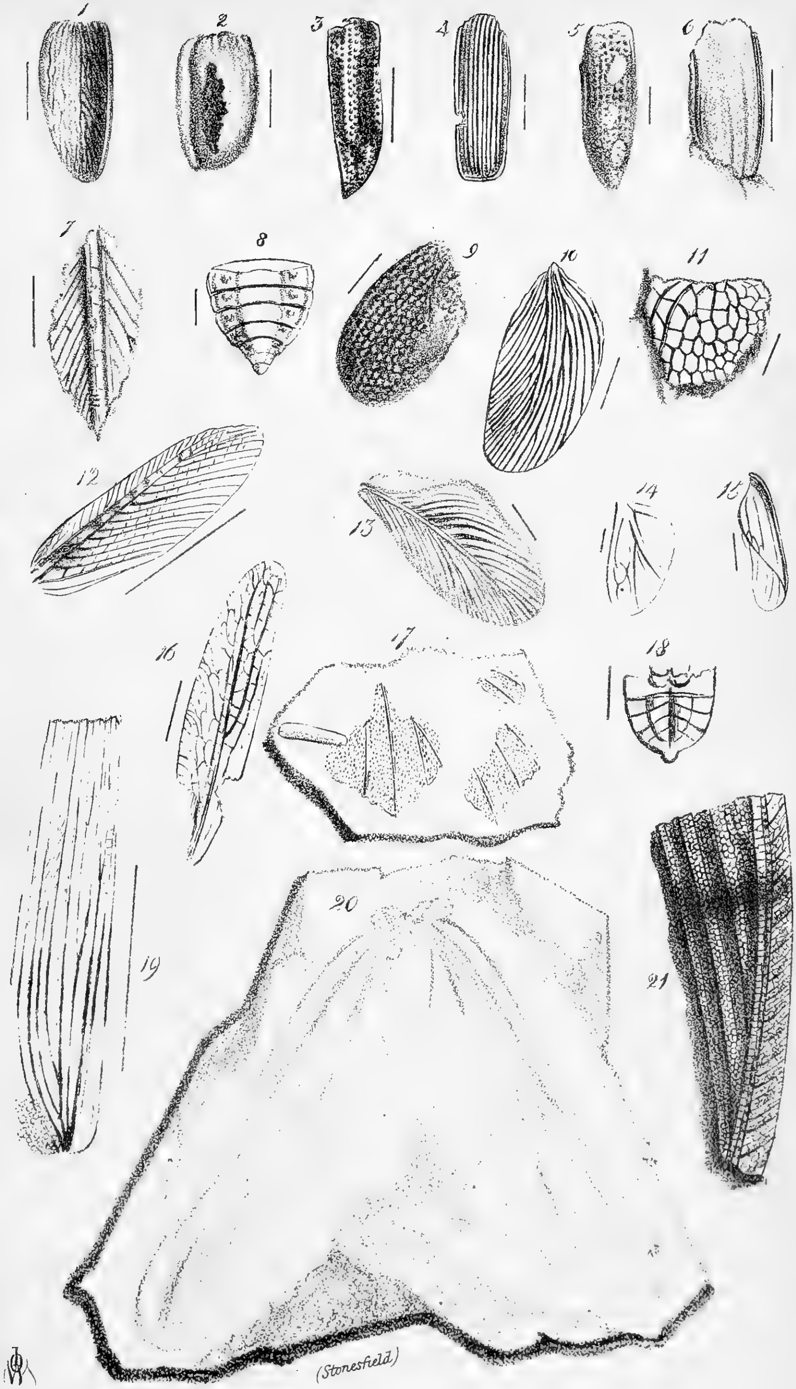
Fossil Insects (Purbeck & Stonesfield [Fig 13])



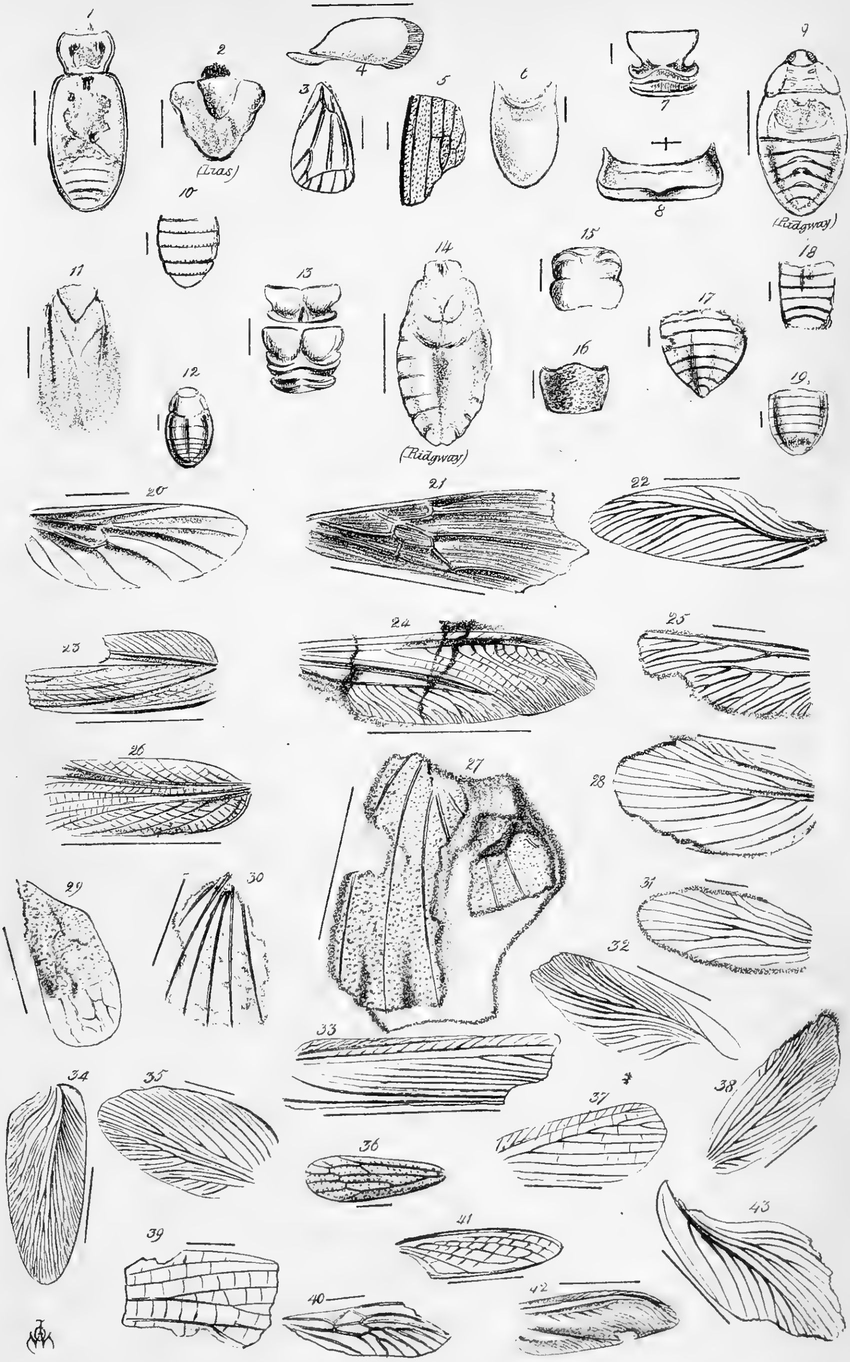
Fossil Insects (*Purbeck*)



Fossil Insects (*Tertiary* [34. 35.] & *Purbeck.*)



Fossil Insects. (*Purbeck & Stonesfield.* [Fig 20])



Fossil Insects (*Purbeck & Lias* [Fig 2].)

6. *On the* Pegmatite *of* Ireland. By M. A. Delesse.

[Abstract*.]

The author observes that the Pegmatite of the Mountain of Mourne in Ireland is very remarkable for its cavernous structure. This structure is especially found in pegmatites which contain topazes; it is therefore probable that the cavities in the pegmatite are owing to the separation of fluoric gases, the fluor of which is subsequently fixed in the topaz and mica.

The Irish pegmatite is also very remarkable for the presence of fayalite and of ferruginous peridote; for peridote is the characteristic mineral of rocks of igneous origin which have not an excess of quartz.

M. Delesse remarks, in conclusion, that cavernous pegmatite is formed under circumstances markedly different from those under which granite properly so called is produced.

May 24, 1854.

SPECIAL GENERAL MEETING.

Sir R. I. Murchison, Vice-President, in the Chair.

1. The President announced that Prof. E. Forbes, in consequence of his appointment to the duties of Professor of Natural History at Edinburgh, had been compelled to resign the Office of President of the Society, and that the Society was now called upon to elect a President in his room; also to elect a Member of Council in the room of the Rev. Mr. De la Condamine, deceased.

2. Scrutineers were appointed, who, after the Ballot, reported that William John Hamilton, Esq. was unanimously elected President; and that Joseph Prestwich, Jun., Esq. was unanimously elected a Member of Council.

3. Resolved, that the thanks of the Society be given to Prof. E. Forbes, retiring from the office of President.

[It was also resolved, that Mr. Prestwich be requested to undertake the duties of Secretary until the next General Meeting.]

ORDINARY MEETING.

Edward Bretherton, Esq. and William Ferguson, Esq. were elected Fellows.

The following communications were read:—

1. *On the* Structure *and* Affinities *of the* Hippuritidæ. By S. P. Woodward, Esq., F.G.S.

[Abstract.]

[The publication of this paper is postponed.]

These fossils were regarded by the author as bivalve shells, forming

* This communication is printed in full in the *Bulletin de la Société Géologique de France*, 2 ser. vol. x. p. 568.

a distinct family, related most nearly to the *Chamidæ* and the *Cardiadæ*.

The Hippurite was shown to have its valves articulated by a hinge essentially like that of the Radiolite. The internal ligament or cartilage is divided into two portions, situated at the sides of the first or most anterior of the three inflections of the outer shell-wall; this ligamental inflection is very prominent in the *Hippurites cornu-vaccinum*, but obsolete in *H. bioculatus*. Two prominent straight teeth are developed from the upper valve, parallel with the hinge-margin, in *H. bioculatus* and *H. radiosus*, transverse to it in *H. cornu-vaccinum*. The anterior tooth supports a curved horizontal muscular apophysis, shaped like the adductor impression in the lower valve; the posterior tooth has a long vertical process, sometimes more prominent than itself, which is received by the cavity between the first (or ligamental) and second (muscular) inflection, which corresponds to the muscular ridge in *Diceras* and *Cardilia*. The third ridge in the lower valve of the Hippurite, which meets a corresponding inflection of the upper valve, was compared to the siphonal ridge of certain bivalves, which divides the inhalent from the exhalent current of water.

In a series of specimens of *Radiolites Hœninghausii*, presented by Mr. Pratt to the British Museum, there was evidence that the *umbo* of the upper valve was marginal when young; and the ligamental inflection, though obsolete externally, was always manifest inside the upper valves which had lost their inner shell-layer.

The *Radiolites Mortoni* (Mantell) was shown, by specimens from the chalk of Kent, exhibited by Mr. M. Wright, to have possessed a thin internal layer with grooves, rather than sockets, for the teeth and muscular process close to the side, there being no projecting ligamental plate; the interior (of the lower valve) was divided into water-chambers by thin concave plates, as in the various foreign species.

The difference between the shell-structure of the upper valves of *Hippurites* and *Radiolites* was compared to the difference between *Rhynchonella* and *Terebratula*, and held to be, in this case, only of generic importance.

The genus *Caprotina*, D'Orbigny, was shown to include certain species (*e. g. C. 4-partita*) which could be compared to *Radiolites*, the hinge-teeth supporting plates for the attachment of the shell-muscles; the anterior tooth being further connected with a plate which divides the umbonal cavity of the upper valve in two. The first and fourth lobes of *Caprotina* were held to represent the internal cartilage ("accessory apparatus") of *Radiolites*.

Evidence was adduced to show that the fixed (or dorsal) valve of *Caprinella* and *Caprinula* was always turned away from the spiral valve, with more or less of a sigmoid flexure, and not as in the restoration given by M. d'Orbigny.

The genera *Requienia* (*R. Lonsdalei*) and *Monopleura* (*M. imbricata*) were considered to be more nearly related to *Diceras* and *Chama*.

———

2. Geological Notices *of the* Isle of Sheppey, *and of its* Outlier *of* Bagshot Sand. By Charles Henry Weston, Esq., B.A. Cantab., F.G.S., and Barrister at Law.

(Received January 2, 1849.)

[Abridged.]

The north-western and southern parts of the Isle of Sheppey are low and marshy, as well as a portion of the north-eastern coast from Sheerness to Scrap Gate. From this point the cliff begins to rise, and from Minster to Warden attains a considerable height. The highest points must be at least 200 feet above the level of the sea.

The elevated coast-line shelves off towards the interior of the Isle, leaving such parts low and marshy; but from some circumstances connected with the cliffs near Warden and the inclination of the strata near Scrap Gate, I strongly suspect that this depression toward Elmley Isle is rather the result of an actual sinking of the strata in that direction, than the effect of mere denudation. I had not time, however, to substantiate this as a fact.

The extent of the marsh and low ground on the north side from Sheerness to Scrap Gate is about two miles. At Scrap Gate there is a kiln for the manufacture of draining tiles, showing the existence of clay intermingled with sand, as well as the absence of lime. To these points we shall have occasion to refer.

From Scrap Gate the coast-line begins to elevate itself towards the S.E., and attains its greatest height at a point about $1\frac{1}{2}$ mile distant. On its first emergence it is composed of a stratum of ferruginous-coloured clay; but before reaching East End Lane Preventive station, another stratum of blue clay is seen coming out from under the superincumbent ferruginous clay rising in the same direction. At the termination of the cliff at Warden (the southernmost extremity), this bed of blue clay forms the floor of the sea*.

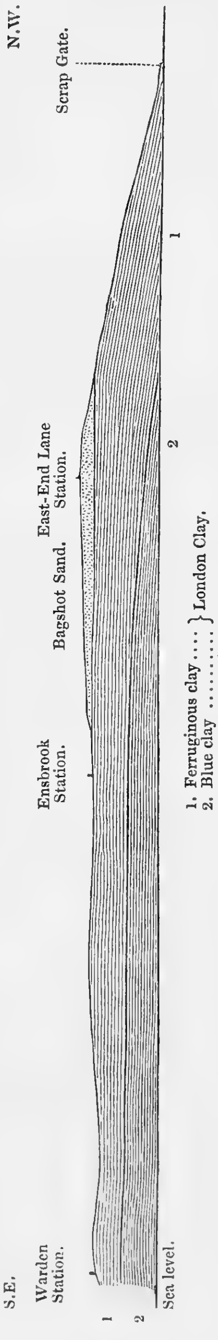
After examining the coast-line, I proceeded on the following day along a great part of the edge of the cliff, and examined its upper surface. I commenced at Scrap Gate, and before reaching the East End Preventive station, I found, to my great surprise, the commencement of a bed of ferruginous sands (see fig. p. 400). This bed extended itself towards the S.E. for about $1\frac{1}{2}$ mile, crowning the highest parts of the cliffs. It lay conformably upon the stratum of ferruginous clay, but its limits I did not trace beyond the Ensbrook Preventive station†.

I was not before aware that this development of ferruginous sand existed in the Isle of Sheppey; and yet, in analogy with various other elevated portions of the London Clay on whose tops outliers of the Bagshot Sand are confessedly found, this deposit might have been expected in this locality, which forms part of the highest ground of the Isle, and where the upper portion of the London Clay has also evidently been attained.

* The clay of the cliffs sometimes separates in conchoidal forms, and sometimes, while stratified and divisible into laminæ, it exhibits a sort of cleavage at right angles to the laminæ, pointing to the monohedral symmetry of slaty structure.

† I visited the Isle of Sheppey in April 1848, and then first saw this bed of sand.

Section of part of the N.E. Coast of the Isle of Sheppey, showing the supposed Outlier of Bagshot Sand on the London Clay.



Thus on the high ridge of London Clay at Highgate we have an outlier of the Bagshot Sand, and the same formation is also to be seen at Hampstead, and particularly on the sides of the road descending towards Hendon.

Thus also, when upon the London Clay at Edgeware, if we ascend to Harrow Weald, we first find brick-kilns upon the higher level, showing the commencement of a superjacent arenaceous deposit, and then afterwards, fully developed upon the high summit of Harrow-on-the-Hill, we find another acknowledged outlier of the Bagshot Sand*.

The discovery of this ferruginous bed of sand leads to an interesting inference when considered in connexion with the distinction of colour, which has been previously noticed as existing between the upper and under portions of the subjacent argillaceous formation. Two causes, apparently distinct and unconnected, seem to have been simultaneously in operation—the one producing an earthy, and the other a metalliferous deposit. Thus, while aluminous matter was being precipitated, there was an outpouring of iron, dissolved most probably in water containing carbonic acid gas. But this ferruginous solution was not simply coextensive with the formation of the aluminous stratum; it continued in operation even when the alumina had given place to silex, although a substance chemically and essentially so diverse. The origin of the ferruginous impregnation was therefore independent of those causes which produced the earthy deposits.

The same circumstances occur in other places. Thus near Bath they are to be seen in the transition of the clay of the Upper Lias into the sand of the overlying Inferior Oolite; while near Weymouth they are equally to be noticed in the passage (*e contrario*) from the Oxford Oolite into the superjacent Kimmeridge Clay.

* The geognostic position of these kilns and that at Scrap Gate in the Isle of Sheppey appears to be identical.

That at some former period the ferruginous sand of Sheppey, though now limited in extent, was *coextensive with the London Clay beneath,* seems evident from the existence of the kilns at Scrap Gate, and of others which appeared to me to be on the Warden end of the cliffs. These clearly show, that although the arenaceous deposit does not exist in such localities as a distinct mass, yet there is, in the necessary loamy state of the brick clay, evidence of a transition state between the London Clay below and the commencement of some sandy bed above.

I do not attempt to prove the identity of the Sheppey sand with that of Bagshot. My wish is to bring those facts which I observed under the notice of others, who may have an opportunity of minutely investigating the subject. The discovery of fossils, or of lithological characteristics, or actual sequence, must be added to the present order of superposition before we can really prove that the high lands of Sheppey bear an outlier of the Bagshot Sand formation, in common with the other elevated portions of the London Clay.

The accompanying woodcut gives an approximate section of the cliffs on the N.E. coast of the Island.

Above the bed of ferruginous sand, and over the surface of the highest parts of the Isle of Sheppey, rounded pebbles are found, not deposited *en masse*, but detached and scantily scattered over the surface. Hence the boggy nature of the Island in wet weather, the London Clay coming up to the surface almost uncovered. These pebbles, both in their shape and mode of deposition, are precisely similar to those which are found in some localities N. of London, as at Muswell Hill and Mill Hill; and they appear to be quite distinct from the beds of gravel found in various parts of the valley of the Thames.

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3. *On the* Thickness *of the* London Clay; *on the* Relative Position *of the* Fossiliferous Beds *of* Sheppey, Highgate, Harwich, Newnham, Bognor, *&c.*; *and on the* Probable Occurrence *of the* Bagshot Sands *in the* Isle *of* Sheppey. By Joseph Prestwich, Jun., F.R.S., F.G.S. &c.

§ 1. *Thickness of the Clay.*

Having frequently had my attention directed by Mr. Searles Wood to the question of the exact position in the London Clay of the peculiar and remarkable fossiliferous beds of Sheppey, and of the thickness of the London Clay itself at that place, I have, with that special object in view, made a further examination of the Island, and now beg to lay before the Society the result of these observations. I have availed myself of this opportunity to determine also more correctly the importance of the London Clay in other parts of its range, and to settle approximately the position of the strata of some other localities, well known for their fossils—separate lists of which I give at the end of this paper.

This question of the thickness of the London Clay remains nearly in the state in which it was left by Phillips and Conybeare in 1822. The impression likely to be conveyed by the observation on this subject in their valuable work * is one which would suppose its development to be more irregular, and in places considerably greater, than will, I believe, prove to be the case. They state,—"The actual thickness of the London Clay in Sheppey may be estimated, by adding the height of the cliff to the depth of the wells, at 530 feet." They then proceed to say that "it may be supposed to be much thicker in Essex," estimating it at "High Beech to be about 700 feet thick;" and further, they report it to have been pierced at Wimbledon to the depth of 530 feet, without passing through it. They then give a number of lesser measurements, but without stating whether or not the upper beds have been denuded.

In the following estimates I have deemed it necessary to take only such lines of section as afford a definite upper horizon—the one obtained by the superposition of the Bagshot sands. The base of the London Clay I have ascertained in all cases practicable by means of well-sections.

The fine and complete coast sections in the Isle of Wight show that the total thickness of the London Clay at Alum Bay is 193 feet, and at White Cliff Bay 363 feet. The Artesian well at Southampton affords another exact measure of 320 feet. Passing over to the London Tertiary area, there exist no definite measurements in the neighbourhood of Hungerford or Newbury; taking, however, into consideration the dip of the beds and the height of the hills, I do not think that the entire thickness of the London Clay there exceeds 200 to 250 feet, which increases, as it ranges westward towards Basingstoke and Odiham, to 330 feet †. In the neighbourhood of Reading and Wokingham, judging from a well commenced at Bear Park, the London Clay cannot be less than 370 to 400 feet thick; whilst at Chobham, where it is overlaid by 265 feet of Bagshot sands, it was roughly estimated by the well-digger at 400 feet. In the north part of Windsor Forest it has been found about 350 feet thick, and if to this we add the height of the ground to where the Bagshot sands set in, it will also give us a thickness of about 400 feet. At the foot of Hampstead Hill, in the Tottenham Court Road, and Regent's Park, the London Clay is from 70 to 140 feet thick; at the Lower Heath, 285 feet. If to this we add the depth from the top of the hill, and take off 25 feet, as the thickness of the capping of gravel and Bagshot sands, it will give, in round numbers, a total thickness of about 420 to 440 feet to the London Clay at that spot (see fig. 1, p. 404).

With regard to the exceptional thickness of 530 + and of 700 feet, assigned to the London Clay at Wimbledon and High Beech by Phillips and Conybeare, there are, I believe, errors in both instances. In the first case, the Mottled Clays beneath the London Clay are sometimes so largely developed, that in places not far distant (as at Chertsey and Chobham) there frequently is no sufficient mass of

* Geology of England and Wales, p. 33.

† Well-section at Dogmersfield, Journ. Geol. Soc. vol. x. p. 97.

interstratified sands to afford a water supply, so that wells have been carried through the London Clay, and then passed almost at once into the Mottled Clay, in consequence of which works have been given up and abandoned. This may have occurred at Wimbledon; and possibly no line of demarcation having been drawn between the two clays, they were put down together as one mass of London Clay *. We know the thickness of the London Clay to be 230 feet deep at the Asylum at Garrett, and 210 feet at Mortlake; if to these we add the height of the Wimbledon Hill above those places, it will hardly give a thickness of 400 feet to the London Clay at Wimbledon. The line of section (fig. 1, p. 404) between Hampstead and Wimbledon, which takes the evidence afforded by wells at intermediate stations, shows a structural result in conformity with the foregoing observations †.

The other case, at High Beech, arises from an error, originating apparently with the Trigonometrical Survey ‡, in which that spot is stated to be 750 feet high. Phillips and Conybeare, knowing the height of the ground at a well at Epping to be 340 feet above high water mark, and the thickness of the clay to be 392 feet, added to the latter the additional height of the ground at High Beech, or of 300 feet more,—giving an estimate, therefore, of about 700 feet. I find, however, by observations with the aneroid barometer, that the height of High Beech above the sea level can hardly exceed 440 feet; and further, I find that the hill is capped by a thin covering of gravel and Bagshot sands, amounting together probably to about 20 or 30 feet. In the valley of the Lea, to the west of High Beech, the depth to the base of the London Clay is about 50 feet § at Waltham Cross, 40 feet at Waltham Abbey, 122 feet at Sewardstone, and 80 feet at Turkey-street, Enfield, whilst at Northaw the chalk is at the surface in the valley to the east of the village. Again, at Loughton, a few miles east of High Beech, a well has traversed the London Clay, and reached the Chalk at a depth of 320 feet. Now, if we run a line of section (fig. 2, p. 404) from Northaw, across the valley of the Lea, through High Beech, to Loughton, and take a calculated thickness afforded by the several above-mentioned well-sections (though our line does not exactly pass through any of them), we may approximate very closely to the thickness of the London Clay at these places, and conclude that at High Beech it cannot exceed 430 to 440 feet. At Hunter's Hall, near Epping, and at a height, according to Conybeare and Phillips, of 410 feet above the Thames, the Lower Tertiary sands were reached at a depth of 350 feet. If

* Allowing for this, the reported thickness still seems 100 feet too much.

† Mr. Mylne informs me that the Chalk has recently been reached at Mr. Beaumont's, on the east side of Wimbledon Common, at a depth of 465 feet. —J. P., Jun., Sept. 1854.

‡ Vol. iii. p. 306. Langdon Hill, Essex, is given at 620 feet; but this hill surely cannot exceed about 400 feet above the sea level.

§ I am not quite satisfied as to the exact correctness of these measurements, since in some of the wells the Mottled Clay has, I suspect, been included in the thickness of the London Clay. Making, however, these corrections where they seem necessary, these numbers cannot be far from the truth.

we connect this well with others in the valley of the Lea, and add to it the extra height of the hill at High Beech (deducting the gravel and the Bagshot sands, and judging the beds to be almost level), it will still give about 440 feet as the thickness of the London Clay.

Figs. 1, 2.—*Outline Sections of the London Clay.*

[The vertical dotted lines in figs. 1, 2, 3, & 4 mark the position of well-sections.]

Scale.—Horiz. 1 inch to 6 miles. Vert. 1 inch to 2000 ft.

Fig. 1.—*From Cheam to Hampstead.*

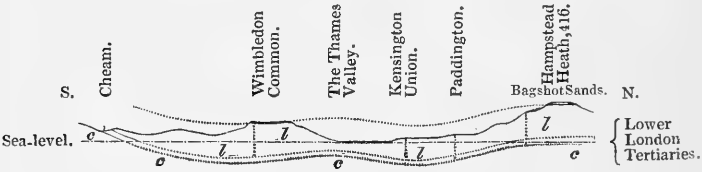
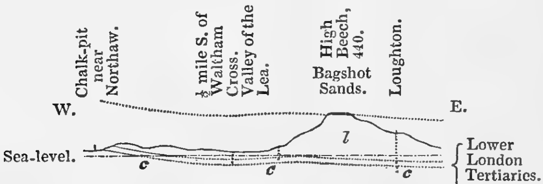


Fig. 2.—*From Northaw to Loughton.*



l. London Clay.
c. Chalk.

A section from Havering-atte-Bower to Brentwood, at both of which places we have traces of the Bagshot sands, passes two points where the lower sands have been reached, and gives an average thickness of 450 feet to the London Clay. Warley Parsonage and Brook-street are both situated about 20 to 40 feet below the level of the Bagshot sands, which cap the summit of the hill at Brentwood, and at the former place the London Clay was found to be 390 feet thick, and at the latter about 400 feet.

Proceeding eastward, we approach the Sheppey and Southend district, and here the London Clay seems to expand. As the strata are apparently not much disturbed, and there are a considerable number of well-sections, we can form a tolerably approximate estimate, although we have no section which traverses this deposit at the points where the series is complete. I will first take an east and west section through Sheppey (fig. 3). At Cowling, near Gravesend, the chalk is at the surface. At Sheerness, $9\frac{1}{2}$ miles eastward from this place, three Artesian wells give respectively a thickness of 347, 356, and 347 feet to the London Clay. At Queensborough (two miles south of Sheerness, and on the same level,—and at the same distance from Cowling), the London Clay is 280 feet deep;

Figs. 3, 4.—*Outline Sections showing the dimensions of the London Clay, and the position of some of its more important Fossiliferous Beds.*

Scale.—Horizontal: 1 inch=6 miles. Vertical: 1 inch=2000 feet.

Fig. 3.—*From Cowling, near Gravesend, to the Chalk Cliffs near Margate.*

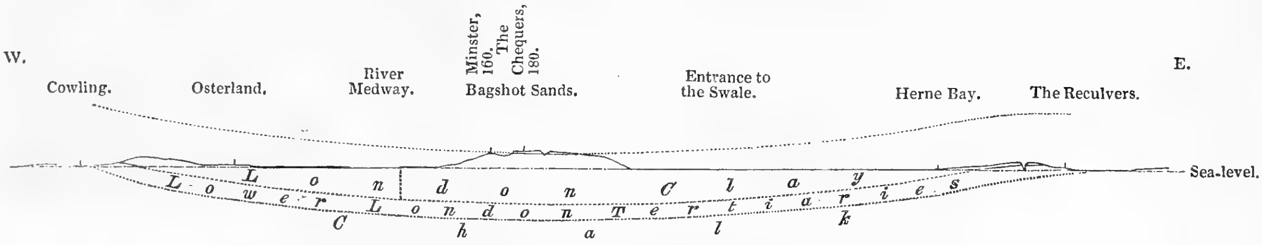
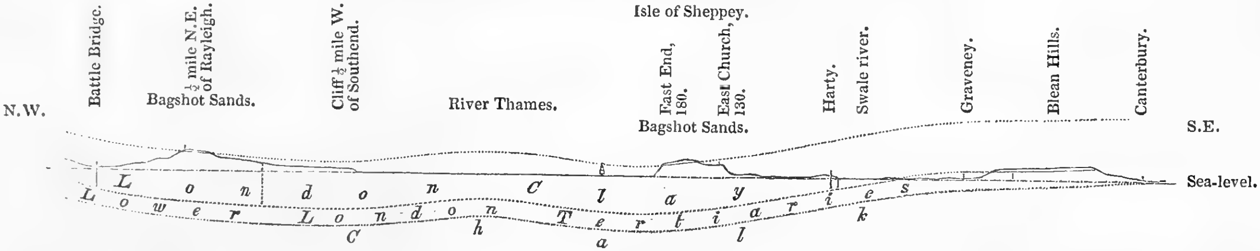


Fig. 4.—*From Battle Bridge, near Rayleigh, to Canterbury.*



our section passes between these two places, and at a point, therefore, where we may estimate the London Clay to be about 320 feet deep *. A rough measurement by the aneroid barometer gave me 160 feet as the height of the ground at Minster Church (where a *Nautilus* was found at a depth of 16 feet, which shows the London Clay to rise to the surface, a bed of gravel excepted), and 180 feet as the height of the hill at "The Chequers," the highest point in the Island. Between these two places a thick bed of light yellow sand sets in, and attains, with the overlying gravel, a thickness of 20 to 30 feet. This bed, which possibly belongs to the lower part of the Lower Bagshot sands, does not extend much further †. As our section now runs parallel with the shore, we may take the dip of the strata along this part of the line from that of the beds in the corresponding portion of the cliffs, or as nearly level along their strike west and east for a distance of about two miles; further on, the strata rise slightly eastward. Passing over the bare London Clay, at the east end of the Island, and crossing the entrance of the Swale, we reach Herne Bay, where the London Clay still continues to rise eastward, at an inclination which, about 1½ mile beyond this town, brings up the Lower Tertiary sands to the sea level. It would appear, therefore, that the centre of the Isle of Sheppey, from Minster to East Church, lies in the deepest part of the curve formed by this line of section; and, after deducting 30 feet for gravel and sand, it would seem that the thickness of the London Clay is here about 470 to 480 feet.

We will now take a line of section (fig. 4, p. 405), intersecting the former one in the centre of Sheppey, and prolonged in one direction south-east to Canterbury, and in the other north-west, crossing the Thames to the cliffs at Southend, and thence to the neighbourhood of Rayleigh. On this line we have a well-section on Blean Hill, where the chalk has been reached at a depth of 160 feet. At Graveney we find the Thanet sands at the surface. The London Clay sets in in the adjoining marshes; and at Harty, on the opposite shore of Sheppey, attains a depth of 133 feet. Thence, crossing the former line of section (fig. 3, p. 405), near East Church, this line reaches the shore at East End, the dip continuing apparently without much diminution as far as this point ‡. The cliff between East End and Ramsley, like the hill to the east of Minster, also exhibits, at its highest points, sections of the sands which I refer

* The curve giving this depth is determined by taking the London Clay at its known outcrop, near Sittingbourne, again at King's Ferry, where it has been ascertained to be 200 feet deep, and continuing this line direct through Queensborough and Sheerness.

† In 1847, I noticed the extension of the Bagshot sands over the top of Langdon-hill to the hills at Rayleigh near Southend, and therefore nearly opposite Sheppey. They are more important at the former than at the latter place, attaining near Rayleigh and above Benfleet a thickness of 30 to 40 feet. I have not been able to find any fossils in these sands. It is therefore possible that they may belong to some drift bed, but the probabilities are, however, in favour of their belonging to the Bagshot series.

‡ In the bed of the Thames I have marked the probable prolongation of the slight anticlinal formed by the chalk at Cliff, Gravesend, and Purfleet.

to the Lower Bagshots; they are from 5 to 20 feet thick, and are overlaid by 5 to 10 feet of gravel. It is difficult to measure the exact height of these clay cliffs, owing to the continual fall of their upper portion, and to the broken and sloping surface which they consequently present. The mean of several observations with an aneroid barometer, and of an approximate measurement with a tape line, gave about 130 feet as the height of the cliff at the Coast-Guard station, East End.

Thence, passing over to Essex, we reach the London Clay cliffs of Southend. A few miles north of this town there are several deep Artesian wells. One at the Union at Rochford traverses the London Clay to a depth of 330 feet, before reaching the Lower Tertiary sands. In another, at Stroud-green, the London Clay is 390 feet deep, whilst at Rayleigh it is 400 feet deep. Allowing for the difference of level, and connecting these several well-sections, the London Clay will be 420 feet deep at the point of intersection with our plan. At a short distance from this spot, and nearer Rayleigh, the hills which there attain a height, by aneroid barometer, of about 180 to 200 feet, are capped by 20 to 30 feet of Bagshot sands. Descending into the valley of the Blackwater, at Battle-bridge, an Artesian well has been sunk through 350 feet of London Clay to the Lower Tertiary sands. Connecting together the different points determined or estimated on this line of section, we come to about the same result as in the previous instance, viz. that the London Clay at Sheppey is probably from 470 to 480 feet thick, and that it is about the same on the opposite coast of Essex.

At Foulness Island, in Essex, there are Artesian wells through the London Clay 400 feet deep. Beyond this place the London Clay gradually rises, its base coming apparently within 20 or 30 feet of the surface at the river level at Colchester, and at the sea level at Walton and Harwich; whilst at Ipswich the Lower Sands come to the surface.

From the foregoing observations it would appear that the London Clay gradually expands as it ranges from west to east, at first rather rapidly until it attains a thickness of from 300 to 400 feet, and then very gradually until, in the neighbourhood of London, it averages from 400 to 440 feet thick *. In the Isle of Sheppey, and on the opposite Essex coast, however, it reaches its greatest development, being there apparently as much as 470 to 480 feet thick. As the regularity of this development does not agree with opinions I have frequently heard expressed on this subject, I may mention in explanation, although probably hardly necessary, that the London Clay was not spread over a denuded land surface, but was a continuation of a series of marine and estuarine deposits, which had previously filled up and smoothed over the irregularity of the old chalk surface. The lenticular shape of this large mass of clay (for it thins off again eastward as it ranges through Belgium) is very striking, and has an interesting theoretical bearing.

* I am now of course speaking of it apart from the local diminution of its thickness produced by denudation, which necessarily gives it at present a very variable thickness.

§ 2. *Position of the Fossils.*

The organic remains of the London Clay are distributed in groups marking particular zones. Of these zones we may take as types—Sheppey, Highgate*, Copenhagen-fields and Primrose-hill, and Bognor. In consequence of the debris masking the surface of the Sheppey cliffs, and from the circumstance of the fossils always being sought for amongst the shingle on the beach, where the sea leaves them after washing away the clay, their exact position in these cliffs has not yet been determined. One fact, however, is apparent; the fossil seeds and fruits, which constitute so peculiar a feature in the organic remains of this locality, are found in the greatest profusion here where the cliffs are capped by the Bagshot sands; the inference, therefore, is, that this singular flora belongs mainly to some of the highest beds of the London Clay, probably chiefly to the upper 50 to 60 feet. At least, I presume that it may be owing to the absence of these highest beds, which alone are wanting at Southend, that the fossil fruits and seeds are so much scarcer there, though well-preserved specimens of shells and crustacea, similar to those found at Sheppey, abound. Otherwise there is a general community of species, which induces me to include them in one zone, whilst the position of the beds, as determined in fig. 4, p. 405, shows them to be nearly in the same horizon. The few fossils found at Brentwood (in the railway cutting) and at Egham Hill belong to this zone.

The Highgate fossils belong to a rather lower portion of the London Clay; they occur chiefly near the level of the road at the Archway in beds of sandy clay, which are about 110 to 130 feet below the outlier of Bagshot sands capping the hill. The faunas of Newnham † and of Clewet's-green ‡ near Basingstoke agree very closely with that of Highgate, whilst the position of the beds is also similar §. There is, however, a greater admixture of some of the forms which prevail in the lower zones.

The Chalk-farm, Primrose-hill, and Copenhagen-fields fossils form another zone, about 100 feet still lower in the London Clay. The fossils of Kew and Brentford belong to this zone, whilst further westward these beds are probably represented by the fossiliferous beds of Cuffell, near Basingstoke ‖; but here again there is a greater community of species in the several zones.

The Harwich and Bognor group of fossils belongs to the lowest part of the London Clay, as do also the fossils of the lower strata at Potter's-bar near Barnet, of Sherfield and Old Basing near Basing-

* That different beds of the London Clay are characterized by peculiar groups of fossils was a fact first noticed in the neighbourhood of London by Mr. Wetherell, in 1836, in an interesting paper published in the Lond. and Edinb. Phil. Mag. vol. ix. He there shows that the Highgate fossils are many of them peculiar to that spot, that the fossils of Primrose-hill and Regent's-park constitute another group on a lower level, and considers that the beds at Islington and west of Herne Bay form a third level.

† Quart. Journ. Geol. Soc. vol. iii. p. 371. ‡ Ibid. p. 370.

§ Some fossils found at the railway station of the Crystal Palace indicate the occurrence of these beds near the summit of the Norwood hills.

‖ Quart. Journ. Geol. Soc. vol. iii. p. 369.

stoke, and part of the sections at Pebble-hill near Hungerford, and of Clarendon-hill near Salisbury *.

At Alum Bay, in the Isle of Wight, where the London Clay is not so thick, its palæontological divisions are less marked, and similar fossils are more generally prevalent throughout its entire mass.

Confining ourselves to the London district, it would appear, that, although a great proportion of the fossils range at intervals vertically throughout the London Clay, yet their development is very different in different zones, being abundant in some and scarce in others, whilst each zone is further marked by a few characteristic species, thus forming distinct, although nearly related groups;—that plant remains occur sparingly throughout the mass of the London Clay, but that their chief development is in the uppermost, or perhaps superadded, beds in the eastern area, in which also are entombed the great bulk of the reptilian and fish remains;—that a profusion of molluscs indicating waters of a more moderate depth characterise its second descending stage;—that deeper-sea forms prevail in the third stage in the eastern area, but are replaced by a shallower water fauna, more nearly allied to the fossils of the second stage, as we proceed westward;—and that the same change takes place also in the fourth and lowest stage, many of the forms of the upper divisions being common to it in the westward area, where the sea was evidently shallow, whilst eastward we have indications of the maximum depth of the London Clay sea, with a very scanty fauna of deep-sea forms.

It must not, however, be supposed that the fossils are dispersed either vertically or horizontally with any uniformity as to numbers: although, as before mentioned, certain zones are characterized by certain groups of organic remains, yet the fossils tend to occur in greater or less abundance in certain beds. This is especially the case in the lower zone, which is frequently almost totally unfossiliferous; the third zone, likewise, is often marked by the absence of fossils, and so again with the upper zone; the fossils appear more permanent in the second zone. These zones are necessarily artificial, as no actual division exists, and the organic remains and mineral characters are continuous; but they serve to mark the distinct conditions of the fauna and flora at particular periods, and show the prevalence generally of like forms on the same levels; they are not, however, to be taken, by any means, as constant, but merely as local centres for convenient reference and grouping.

The following table shows this general order of succession, and the position of the several fossiliferous zones. The divisions are not given as very definite; they may vary 50 feet either one way or the other, according to the thickness of the London Clay itself in different parts of its area; but they will serve to show generally the relative position of the beds at the different places named. Only the principal localities are given.

* Quart. Journ. Geol. Soc. vol. ii. p. 235, 236, and vol. iii. p. 367.

Zones.	General average thickness. Westward area. Feet.	Eastward area. Feet.	Fossiliferous localities.
First (uppermost).	70	150	Cliffs of Sheppey and of Southend; Brentwood-hill; Egham-hill.
Second.	80	100	Margaretting-street, near Chelmsford; Highgate Archway*; Wandsworth Common; Railway station, Crystal Palace; Newnham; Clewet's-green.
Third.	100	140	Cliffs between Herne Bay and Whitstable; Colchester; Chalk-farm; Primrose-hill; Copenhagen-fields; Islington; Whetstone; Hornsey; Colney Hatch; Kew; Brentford; Cuffell.
Fourth.	50	90	Harwich; Walton; Cliff east of Herne Bay (?); Potter's-bar (?); Hedgerly; Old Basing; Sherfield; upper part of Pebble-hill and of Clarendon-hill; Bognor.
	300	480	

A question arises, whether the upper beds of the London Clay in Kent and Essex may not represent some portion of the Lower Bagshot or Bracklesham sands of Berkshire and Hampshire, or whether the 200 to 300 feet of London Clay of the latter district represents, in mass as well as in time, the 460 to 480 feet of the former district. I am inclined to take the latter view, and to consider the eastern district to have derived its superadded features from its proximity to the sources of the river supply of the period, and to the greater depth of the sea in that area (or to a more rapid subsidence of the bed of the sea), so as to allow of a larger accumulation of sediment, and to result in a greater depth of strata.

§ 3. *Lists of Organic Remains.*

As no separate and complete lists of the fossils of Sheppey, Highgate, and other localities mentioned in the text have been published, I have endeavoured to determine with some accuracy these different faunas. There are, fortunately, several special collections of great value to assist an inquiry of this nature; Mr. Wetherell, who has materially assisted me in this inquiry, having for many years zealously collected all the fossils found at Highgate and its vicinity (the road at the Archway on Highgate-hill, the railway cuttings at Primrose-hill, Copenhagen-fields, Hornsey, and Whetstone, &c.); whilst Mr. Bowerbank, on his side, has amassed a like unrivalled series of the Sheppey fishes, reptiles, crustacea, and plants. The collection of Mr. Edwards from both these places, although subordinate to his admirable collection of Bracklesham Bay fossils, is very important. More recently Mr. Lunn has formed a valuable collection of the Southend fossils. My own attention has been chiefly turned to such less important localities and sections, as from their distance or temporary nature have not come within the examination of such assiduous collectors.

Further, the valuable publications of the Palæontographical Society

* The beds at Finchley and at Haverstock-hill would seem to occupy a position intermediate between these second and third zones. The zones may possibly be multiplied.

have, during the last few years, advanced most materially, and given an unusual completeness to most branches of Tertiary palæontology *. The Report also by Professor Agassiz, in 1844, on the fossil fishes of the London Clay is a monograph of the greatest value, and presents us with a research such as few other strata have undergone †. The Crustacea yet offer a rich and almost unexplored field; Professor M'Coy has, however, described a few species ‡. Mr. R. Jones has commenced an examination of the Foraminifera and Entomostraca, which will, it is hoped, be continued.

[Parts of these lists will be found more complete than the rest, in consequence of some groups of fossils and some beds having been the object of more especial research than others. Many species will probably be found to have a greater range. The prevalence, however, of certain fossils at certain levels is the essential and prominent feature. An asterisk marks the common and characteristic *shells*; I cannot at present safely apply it to the other groups.]

First Zone.—*Isle of Sheppey Fossils* (*cliff-section*).

Aves.

Halcyornis Toliapicus, *Owen.*
(*Larus*, Kön.)
Lithornis vulturinus, *Owen.*
—— (?) Emuinus, *Bowerb.*

Reptilia.

Chelone breviceps, *Owen.*
—— convexa, *Owen.*
—— cuneiceps, *Owen.*
—— latiscutata, *Owen.*
—— longiceps, *Owen.*
—— subcarinata, *Owen.*
—— subcristata, *Owen.*
Emys bicarinatus, *Bell.*
—— Comptoni, *Bell.*
Emys Delabechii, *Bell.*
—— lævis, *Bell.*
—— testudiniformis, *Owen.*
Platemys Bowerbankii, *Owen.*
—— Bullockii, *Owen.*
Trionyx pustulatus, *Owen.*
Crocodilus champsoides, *Owen.*
—— Toliapicus, *Owen.*
Palæophis Toliapicus, *Owen.*

Pisces.

Acestrus ornatus, *Ag.*
Acipenser Toliapicus, *Ag.*
Ætobatis irregularis, *Ag.*
—— subarcuatus, *Ag.*
Ampheristus Toliapicus, *Kön.*
Auchenilabrus frontalis, *Ag.*
Bothrosteus minor, *Ag.*
Brachygnathus tenuiceps, *Ag.*
Brychetus Mulleri, *Ag.*
Calopomus porosus, *Ag.*

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* The following very important monographs on the Eocene fossils have already been published:—

Professor Owen and Professor Bell, "On the Chelonia of the London Clay," 1849.
Mr. F. E. Edwards, "On the Cephalopoda of the Eocene Formations," 1849.
Professor Owen, "On the Crocodilia and Ophidia of the London Clay," 1850.
Milne-Edwards and J. Haimes, "On the Corals of the Tertiary Formations," 1850.
Mr. Charles Darwin, "On the Fossil Lepadidæ of Great Britain," 1851.
Mr. Thos. Davidson, "On the British Tertiary Brachiopoda," 1852.
Professor E. Forbes, "On the Echinodermata of the British Tertiaries," 1852.

Where the London Clay is spoken of in these monographs it is generally understood to include the Bracklesham sands and the Barton clays. I restrict the term to the lower deposits of London and of Hampshire.

† Report of the Brit. Assoc. for the Advancement of Science, 1845, p. 279. This has been further revised and added to by Sir Philip Egerton in Mr. Dixon's "Geology of Sussex," and in the edition just published of Morris's Catalogue. I avail myself of the assistance afforded by this latter very valuable work, which has reached me as this paper is going through the press, in the final revision of the lists in the text.—J. P., August 1854.

‡ Ann. and Mag. Nat. Hist. 2nd Ser. 1849, vol. iv. p. 161.

Carcharodon angustidens, *Ag.* *C. Toliapicus* & *C. heterodon*, Ag.
—— subserratus, *Ag.*
Cœlocephalus salmoneus, *Ag.*
Cœloperca latifrons, *Ag.*
Cœlopoma Colei, *Ag.*
—— læve, *Ag.*
Cœlorhynchus rectus, *Ag.*
Cybium macropomum, *Ag.*
Elasmodus Hunteri, *Eger.*
Eurygnathus cavifrons, *Ag.*
Glyphis hastalis, *Ag.*
Goniognathus coryphænoides, *Ag.*
—— maxillaris, *Ag.*
Gyrodus lævior, *Ag.*
Halecopsis lævis, *Ag.*
Hypsodon oblongus, *Ag.*
—— Toliapicus, *Ag.*
Labrophagus esocinus, *Ag.*
Lamna compressa, *Ag.*
—— elegans, *Ag.*
—— Hopei (*Odontaspis*), *Ag.*
—— verticalis (*Odontaspis*), *Ag.*
Laparus alticeps, *Ag.*
Loxostomus mancus, *Ag.*
Megalops priscus, *Ag.*
Merlinus cristatus, *Ag.*
Myliobatis acutus, *Ag.*
—— canaliculatus, *Ag.*
—— Colei, *Ag.*
—— Dixoni, *Ag.*
—— goniopleurus, *Ag.*
—— gyratus, *Ag.*
—— heteropleurus, *Ag.*
—— jugalis, *Ag.*
—— lateralis, *Ag.*
—— nitidus, *Ag.*
Myliobatis Oweni, *Ag.*
—— punctatus, *Ag.*
—— striatus, *Ag.*
—— Toliapicus, *Ag.*
Myripristis Toliapicus, *Ag.*
Notidanus serratissimus, *Ag.*
Otodus macrotus, *Ag.*
—— obliquus, *Ag.*
Pachycephalus cristatus, *Ag.*
Percostoma angustum, *Ag.*
Periodus Kœnigii, *Ag.*
Phalacrus cybioides, *Ag.*
Phasganus declivis, *Ag.*
Phyllodus irregularis, *Ag.*
—— marginalis, *Ag.*
—— medius, *Ag.*
—— planus, *Ag.*
—— polyodus, *Ag.*
—— Toliapicus, *Ag.*
Pisodus politus, *Owen.* *P. Owenii*, Ag.
Podocephalus nitidus, *Ag.*
Pomophractus Egertoni, *Ag.*
Pristis bisulcatus, *Ag.* (?)
Psaliodus compressus, *Eger.*
Ptychocephalus radiatus, *Ag.*
Pycnodus Toliapicus, *Ag.*
Rhinocephalus planiceps, *Ag.*
Rhipidolepis elegans, *Ag.*
Rhoncus carangoides, *Ag.*
Rhynchorhinus branchialis, *Ag.*
Sciænurus Bowerbanki, *Ag.*
—— crassior, *Ag.*
Scombrinus nuchalis, *Ag.*
Sphyrænodus crassidens, *Ag.*
—— priscus, *Ag.* *Dictyodus*, Owen.
Teratichthys antiquitatis, *Kön.*
Tetrapterus priscus, *Ag.*

MOLLUSCA.

Cephalopoda.

Belosepia sepioidea, *Blainv.*
*Nautilus centralis, *Sow.*
*—— imperialis, *Sow.*
—— regalis, *Sow.*
—— urbanus, *Sow.*
*—— (Aturia) zic-zac, *Sow.*

Gasteropoda.

Acteon simulatus, *Sow.*
Ancillaria.
Aporrhais Sowerbii, *Mant.* *Rostellaria*, Sow.
Buccinum junceum, *Sow.* ?
*Bulla attenuata, *Sow.*
Cancellaria quadrata, *Sow.*
Cassidaria nodosa, *Brand.* *Buccinum*, Brand.; *C. carinata*, Desh.
—— striata, *Sow.*
*Cerithium Charlesworthii, n.s.¶
Corbula.
*Conus concinnus, *Sow.*
Cypræa oviformis, *Sow.*
Dentalium nitens, *Sow.*
*Fusus bifasciatus, *Sow.*
—— coniferus, *Sow.*
Murex cristatus, *Sow.*
—— spinulosus, *Desh.*
*Natica labellata, *Lam.*
*Pleurotoma prisca, *Sow.* *Murex*, Br.
—— rostrata, *Sow.* *Murex*, Brand.
*Phorus extensus, *Sow.*
Pyrula tricostata, *Desh.* ?
—— angulata, *Edw.*
*Rostellaria lucida, *Sow.*
Scalaria reticulata, *Sow.*, *non Brand.*
*Solarium patulum, *Sow.*

¶ I give this name to a beautifully sculptured *Cerithium*, figured, but not described, by Mr. Charlesworth in 1849, amongst some illustrated Barton specimens (card fig. *f*). At Barton it is an extremely rare species, but it is very common and characteristic at Sheppey and Southend.

Solarium canaliculatum, *Lam.*
Terebra striata.
Triton.
*Turritella imbricataria, *Lam.*
Voluta nodosa, *Sow.*

Lamellibranchiata.

Arca.
*Astarte rugata, *Sow.*
*Avicula papyracea, *Sow.*
—— media, *Sow.*
Cardita.
*Cardium nitens, *Sow.*
*Cryptodon Goodhallii (*Lucina*), *Sow.*
Cyprina planata, var., *Sow.* (?)
—— nana, *Sow.*
Cytherea obliqua, *Desh.* *Venus tenuistriata*, Sow.?
Isocardia sulcata, *Sow.*
Modiola, n. sp.?
*Neæra inflata (*Nucula*), *Sow.*
Nucula amygdaloides, *Sow.*
—— Bowerbankii, *Sow.* ?
Ostrea.
*Pectunculus decussatus, *Sow.*
Pinna arcuata, *Sow.* ?
Syndosmya splendens (*Tellina*), *Sow.*
*Teredo antenautæ, *Sow.*
Teredina personata, *Lam.*

Brachiopoda.

*Terebratulina striatula, *Sow.*

Articulata.

Crustacea.

Archæocarabus Bowerbanki, *M'Coy.*
Basinotopus Lamarckii (*Inachus*), *Desm.*
Hoploparia Bellii, *M'Coy.*
—— gammaroides, *M'Coy.*
Zanthopsis bispinosa, *M'Coy.*
—— hispidiformis (*Brachyurites*), *Schlot.*
Zanthopsis Leachii (*Cancer*), *Desm.* *B. gibbosus* (?), Schlot.
—— nodosa, *M'Coy.* *Cancer tuberculatus* (?), Kön.
—— unispinosa, *M'Coy.*

Annelida.

Serpula.
Vermicularia Bognoriensis, *Mant.* (*Vermetus*, Sow.)

Echinodermata.

Astropecten armatus, *Forb.*
—— (?) Colei, *Forb.*
—— crispatus, *Forb.*
Cœlopleurus Wetherelli, *Forb.*
Goniaster Stokesii, *Forb.*
Goniaster marginatus, *Forb.*
—— tuberculatus, *Forb.*
Hemiaster Bowerbankii, *Forb.*
—— Prestwichii, *Forb.*
Pentacrinus subbasaltiformis, *Mill.*

Zoophyta.

Graphularia Wetherelli, *M.-Edw.*
Trochocyathus sinuosus (*Turbinolia*), *Brong.*
Paracyathus brevis, *M.-Edw.*
—— caryophyllus (*Turbinolia*), *Lam.*

Plantæ.

Lycopodiaceæ.

Lycopodites squamatus, *Brongn.*

Coniferæ.

Callitrites, *Endl.* (*Cupressinites*, *Bow.*), 4 species.
Frenelites, *Endl.* (*Cup.*, *Bow.*), 4 sp.
Solenostrobus, *Endl.* (*Cup.*, *Bow.*), 5 sp.

Aurantiaceæ ?

Wetherellia variabilis, *Bowerbank.*

Cucurbitaceæ.

Cucumites variabilis, *Bowerb.*

Leguminosæ.

Faboidea, *Bowerb.*, 25 species.
Leguminosites, *Bowerb.*, 18 species.
Xulionosprionites, *Bowerb.*, 2 species.

Malvaceæ.

Hightea, *Bowerb.*, 10 species.

Nipaceæ.

Nipadites, *Bowerb.*, 12 species.

Proteaceæ.

Petrophiloides oviformis, *Bowerb.*

Sapindaceæ.

Cupanoides, *Bowerb.* (*Amomocarpum*, Brongn.), 8 species.
Tricarpellites, *Bowerb.*, 7 species.

Mr. Bowerbank has in his collection 1 or 2 new species of Turtles, 10 or 12 new fishes, about 14 undescribed species of Crustacea (10 *Zanthopsis*, 4 *Hoploparia*, and *Archæocarabus* ?), and probably as many as 300 to 400 undescribed fossil seeds and fruits, including Palmacean fruits, a few cones, fruits of *Potentillas*, and 1 *Cocos*, with seeds of 2 or 3 species of *Anana*.

In consequence of the Sheppey shells occurring so generally in the state of pyritous internal casts, it is often difficult to determine the species. The number I believe to be greater than given above. It is to be observed also that the Sheppey shells have not yet been worked out with the same care as those of Highgate.

SECOND ZONE.—*Highgate Fossils* (*Road-cutting at the Archway*).

REPTILIA.

Vertebra of Palæophis? Small Reptilian teeth?

PISCES.

Carcharodon.
Cœlorhynchus.
Lamna elegans, *Ag.*
Myliobatis Dixoni, *Ag.* ?
Notidanus.
Otodus obliquus, *Ag.*

MOLLUSCA.

Cephalopoda.

Belemnosis plicata, *Edw.*
Beloptera Levesquei, *D'Orb.*
Belosepia sepioidea, *Blainv.*
*Nautilus imperialis, *Sow.*
—— Sowerbyi, *Weth.*
—— zic-zac, *Sow.*

Gasteropoda.

Acteon crenatus, *Sow.*
*—— simulatus, *Sow.* *Bulla*, Brand.
Ancillaria.
Aporrhais Sowerbii, *Mant.* *Rostellaria Margerini*, Kön.
Buccinum junceum, *Sow.*
*Bulla attenuata, *Sow.*
*Cancellaria læviuscula, *Sow.*
*Cassidaria nodosa, *Brand.*
*—— striata, *Sow.*
Cerithium concinnum, *Charlesw.*
Cypræa oviformis, *Sow.* *Ovulum retusum*, Sow.
*Conus concinnus, *Sow.*
*Dentalium nitens, *Sow.*
Eulima subulata, *Sow.*
Fusus bifasciatus, *Sow.*
*—— coniferus, *Sow.*
*—— curtus (*Murex*), *Sow.*
—— complanatus, *Sow.*
—— interruptus (*Murex*), *Sow.*
—— porrectus (*Murex*), *Brand.* (*F. rugosus*, Sow.)
*—— trilineatus (*Murex*), *Sow.*
—— tuberosus (*Murex*), *Sow.*
Hipponyx.
*Melania.
Mitra pumila, *Sow.*
*Murex coronatus, *Sow.*
—— cristatus, *Sow.*
—— frondosus, *Sow.* (non *Lam.*)
—— minax, *Brand.*
—— spinulosus, *Desh.*
*Natica labellata, *Lam.* *N. glaucinoides*, Sow.
—— Hantoniensis, *Sow.*
—— sigaretina, *Sow.*
Odostomia.
*Phorus extensus (*Trochus*), *Sow.*
Pyramidella.
*Pyrula angulata, *Edw. MSS.*
Ringicula turgida, *Sow.*
*Rostellaria lucida, *Sow.*
—— macroptera, *Lam.* (*Strombus amplus*, Brand.)
Pleurotoma acuminata, *Sow.*
*—— colon, *Sow.*
*—— comma, *Sow.*
—— fusiformis, *Sow.*
—— plebeia, *Sow.*
—— rostrata, *Sow.*
—— semicolon, *Sow.*
—— Waterkeynii, *Nyst.*
—— Volgeri, *Phil.*
Scalaria reticulata, *Sow.*
—— undosa, *Sow.*
Skenea?
Solarium canaliculatum, *Lam.*
*—— patulum, *Sow.*
Sigaretus canaliculatus, *Sow.*
Triton fasciatus, *Edw.*
Typhis muticus, *Sow.*
Turritella imbricataria, *Lam.* (*Turbo*, Brand. *T. conoidea, elongata, brevis*, Sow.)
—— scalaroides, *Sow.*
Volvaria?
*Voluta nodosa, *Sow.*

Lamellibranchiata.

Anatina?
Astarte rugata, *Sow.*
Arca impolita, *Sow.*
Anomia lineata, *Sow.* *A. striata*, Sow.; *A. tenuistriata*, Desh.
*Avicula media, *Sow.*
—— papyracea, *Sow.*
*Cardium nitens, *Sow.*
Cardita?
*Corbula globosa, *Sow.*
—— cardiiformis, *Edw. MS.*
*Cytherea obliqua, *Desh.*
Cryptodon Goodhalli, *Sow.*
*Lucina.
Modiola depressa, *Sow.*
*—— elegans, *Sow.*
—— subcarinata, *Sow.*
Neæra inflata, *Sow.*
Nucula minima, *Sow.*
—— trigona, *Sow.* *N. similis*, Sow.
Ostrea.

Panopæa intermedia (*Mya*), *Sow.*?
(*Corbula dubia*, Desh.)
*Pecten corneus, *Sow.*
*Pectunculus decussatus, *Sow.*
Pholadomya?
Pinna affinis, *Sow.*
—— arcuata, *Sow.*
Sanguinolaria compressa, *Sow.*
*Solen affinis (*Cultellus*), *Sow.*
*Syndosmya splendens (*Tellina*), *Sow.*
Teredina personata, *Lam.*
*Teredo antenautæ, *Sow.*

Brachiopoda.

Lingula tenuis, *Sow.*

Bryozoa.

*Flustra.
Eschara, undet. sp.
Cellepora, undet. sp.
Crisia, undet. sp.

Articulata.

Crustacea.

Archæocarabus?
Basinotopus.
Zanthopsis nodosa, *M'Coy.*
—— Leachii, *Desm.*

Cirripedia.

Scalpellum quadratum, *Dix.*

Annelida.

Serpula heptagona, *Sow.*?
—— crassa, *Sow.*
Vermicularia Bognoriensis, *Mant.*
Ditrupa incrassata (*Dentalium*), *Sow.*
(*D. strangulatum*, Desh.)

Echinodermata.

Cœlopleurus Wetherelli, *Forb.*
Ophiura Wetherelli, *Forb.*
Pentacrinus Sowerbii, *Weth.*
Hemiaster?

Zoophyta.

Graphularia Wetherellii, *M.-Edw.* *Pennatula*, Weth.

Foraminifera.

Cristellaria.
Dentalina.
Robulina.
Rosalina.
Rotalina.
Truncatulina.

Plantæ.

A species of Nipadites and a few other rare fruits resembling those of Sheppey.

In Mr. Wetherell's collection there are, besides, a considerable number of new and undescribed shells, especially of the genera *Fusus* and *Pleurotoma*; also a few undetermined species of bony fishes.

Third Zone.—*Fossils from Primrose Hill*, P.; *Copenhagen Fields*, C.; *Whetstone*, W. (*railway cuttings*); *Islington*, I. (*canal tunnel*); *Haverstock Hill*, Hav. (?); *Hornsey*, Ho.; *Holloway*, H. (*general surface sections and wells*); *Hampstead Well*, Ha.§

Aves.

Sternum of a small Wader, *Owen* P.

Reptilia.

Trionyx.................. P.

§ The well on the Lower Heath, Hampstead, traverses the lower 285 feet of the London Clay, but the exact position of the fossils was not noted; only the probable position of a portion of them is therefore given in this list. Some others, not placed, are given at page 419. For particulars of the well and list of fossils, see Mr. Wetherell's paper, Trans. Geol. Soc. 2 ser. vol. v. p. 131.

Pisces.

Lamna elegans, *Ag.* .... P.H.
Otodus obliquus, *Ag.* .... P.W.
Myliobatis...................... W.Ha.
Notidanus............... Kensal Green.
Ætobatis .... " "

Mollusca.

Cephalopoda.

Belosepia .... W.
*Nautilus centralis, *Sow.* P.C.H.W.
*—— regalis, *Sow.* ...... P.H.W.Ho.
—— Sowerbii, *Weth.*... P.
—— urbanus, *Sow.* ... P.W.
—— zic-zac, *Sow.* ...... P.W.

Gasteropoda.

Acteon simulatus, *Sow.* P.Ho.W.
—— crenatus, *Sow.* ... P.H.W.
*Aporrhais Sowerbii, *Ma.* P.C.Ho.W.
Buccinum junceum, *Sow.* P.Ho.W.
Bulimus .... P.
*Bulla attenuata, *Sow.*... P.
*Cassidaria striata, *Brand.* P.C.W.Ho.
—— nodosa, *Sow.*...... P.
Cancellaria læviuscula . P.
Chemnitzia? .... P.
Cerithium Charlesworthii..P.W.Ho.
Cypræa Wetherellii, *Edw.* P.
*—— oviformis, *Sow.* ... P.W.Ho.
Dentalium anceps, *Sow.* P.W.Ho.Ha.
—— acuticosta, *Desh.*? Hav.
Eulima subulata, *Sow.*.. P.
Fusus carinella, *Sow.* ... P.C.H.W.
—— curtus, *Sow.* ...... P.C.Ho.W.
*—— bifasciatus, *Sow.*.. P.
*—— interruptus, *Sow.*. P.
—— coniferus, *Sow.* ... P.
—— trilineatus, *Sow.*... P.C.
—— tuberosus, *Sow.* ... P.W.
*Natica labellata, *Lam.*.. P.H.Ho.W.
Murex cristatus, *Sow.*... P.Ho.W.
Nerita globosa, *Sow.*?... P.
Phasianella? .... P.
Phorus extensus, *Sow.*.. P.Ho.
*Pyrula Smithii, *Sow.* ... P.C.W.Ho.
*—— angulata, *Edw.* ... P.W.
—— tricostata, *Desh.*... P.
*Pleurotoma acuminata.. P.W.H.
—— plebeia, *Sow.* ...... P.C.H.W.
Rissoa? .... P.
*Rostellaria lucida, *Sow.*. P.W.I.C.Ho.
—— macroptera, *Lam.*. P.
*Scalaria reticulata, *Sow.*? P.C.W.
*Solarium patulum, *Sow.* P.Ho.W.
Sigaretus canaliculatus. P.Ho.W.
Triton fasciatus, *Edw.*.. P.W.
Trivia .... P.W.
Turritella? scalaroides.. C.P.Ho.W.
—— imbricataria, *Lam.* P.Ho.
Typhis muticus, *Sow.*... P.W.
Voluta elevata, *Sow.* ... P.
*—— protensa, *Sow.* ... P.W.
—— tricorona, *Sow.* ... P.W.
*—— Wetherellii, *Sow.*.. P.C.H.W.Ho.

Lamellibranchiata.

Anomia lineata, *Sow.*... P.C.W.Ha.
Arca impolita, *Sow.* ... P.C.Ho.W.Ha.
—— nitens, *Sow.* ...... P.Ha.
Astarte rugata (var.) ... P.Ho.W.
Avicula media, *Sow.* ... P.Ho.W.
—— arcuata, *Sow.*...... P.W.Ha.
*Cardium Plumsteadiense P.Ho.C.I.
—— nitens, *Sow.* ...... C.
*Corbula globosa, *Sow.*.. P.Ho.
—— Regulbiensis, *Mor.* W.Ha.
*Cryptodon angulatus.... P.C.W.Ho.I.
(*Axinus*, Sow.)
*—— Goodhalli, *Sow.*...P.C.Ho.W.Ha.
*Cyprina planata, *Sow.*.. P.W.
Isocardia sulcata, *Sow.*.. P.Ho.W.
Lucina .... P.H.
Modiola elegans......... P.
*Nucula amygdaloides... P.C.W.Ho.H.
—— minima, *Sow.*? ... P.
*—— Bowerbankii, *Sow.* P.C.H.W.Ho.
—— Wetherellii, *Sow.*. P.W.Ha.
*Neæra inflata, *Sow.*...... P.C.H.Ho.W.
Ostrea.................... P.W.
Pecten duplicatus, *Sow.* P.H.W.Ha.
*Pinna affinis, *Sow.*...... P.C.Ho.W.
*Pholadomya margaritacea, *Sow.*........... P.W.Ho.
*Syndosmya splendens... P.C.Ho.W.
Teredo antenautæ ...... P.C.W.H.I.

Brachiopoda.

*Terebratulina striatula.. P.W.C.

Bryozoa.

Flustra crassa, *Desm.*... P.

Articulata.

Crustacea.

Cythere, 3 n. sp. .... C.
—— (Bairdia) subdeltoidea, *Mün.* C.
—— (Cythereis) angulatopora (?), *Reuss*.............................. C.
—— —— horrescens, Bosq. ...... C.
—— (Cytherella) Munsteri, *Roem.* C.
—— —— ovata (?), *Roem*......... C.
Hoploparia Bellii, *M'Coy*...... P.W.H.
Zanthopsis Leachii, *M'Coy* ... Ha.C.
Archæocarabus.....................P.

Annelida.

Ditrupa plana (*Dentalium*), *Sow.* P.H.
—— incrassata, *Sow*.............. W.H.
Serpula prismatica, *Sow.* .... P.H.
—— trilineata, *Sow*................ P.
Vermicularia Bognoriensis.......P.Ho.W.

Echinodermata.

BourgueticrinusLondinensis,*Forb.* C.
Cainocrinus tintinnabulum, *Forb.* Ho.C.
Hemiaster Branderianus, *Forb.*... Hav.
Pentacrinus Oakshottianus, *Forb.* P.
—— subbasaltiformis, *Mill.* C.Ho.P.Ha.
—— Sowerbii, *Weth*............ I.Ha.

Zoophyta.

Dasmia Sowerbii, *M.-Edw.* ... P.W.Ha.
Graphularia Wetherellii, *M.-E.* P.H.Ha.
Leptocyathus elegans,*M.-Edw.* Hav.
Mopsea costata, *M.-Edw.* ...... H.
Stephanophyllia discoides, *M.-E.* Hav.
Turbinolia Prestwichii, *M.-Edw.*. Hav.
Websteria crinoides, *M.-Edw.* ... Hav.

Foraminifera.

Cristellaria .... Hav.
Dentalina acuta, *D'Orb.* .... C.
—— Adolphina, *D'Orb*......... C.Hav.
—— consobrina, *D'Orb*......... C.Hav.
—— pauperata, *D'Orb.* .... C.Hav.
Glandulina .... C.
Globulina .... C.
Globigerina .... C.
Marginulina Wetherellii, *Jones*.. C.Hav.
Nodosaria affinis, *D'Orb*......... C.H.
—— bacillum, *Defr.* .... C.Hav.
Nodosaria Badenensis, *D'Orb*... C.
—— longiscata, *D'Orb.* .... C.
—— rustica, *Jones* .... C.Hav.
Quinqueloculina (*Miliolites*, pars) C.Hav.
Robulina .... C.Hav.
Rotalina (*Rotalia*) .... C.
Spirillina .... C.Hav.
Textularia carinata ?, *D'Orb.* ... C.Hav.
—— lævigata ?, *D'Orb.* .... C.
Triloculina (*Miliolites*, pars) ...C.H.Hav.
Truncatulina .... P.

Plantæ.

A very few specimens of Nipadites, and of fruits and seeds similar to those of Sheppey .... C.P.W.Ha.

Mr. Wetherell's collection contains a beautiful series of Crustacea from this zone, most of them new; also several new and undescribed shells.

Some of the clay at the railway cutting at Copenhagen Fields was found by Mr. R. Jones to be rich in Entomostraca and Foraminifera; the other zones have not been submitted to so careful an examination, which may account for the comparative poverty of the other lists. From a recent examination of specimens in Mr. Wetherell's collection, Mr. R. Jones has observed that the clay at Finchley yields a very similar group of Foraminifera to that obtained from the clay at Copenhagen Fields.

As there is no place in the London Tertiary district where the beds of the fourth or lower zone have afforded the opportunity of so thorough an examination of their organic remains as at Bognor, on the Sussex coast, I have added a list of the fossils found there. This list is chiefly taken from the 'Geology of Sussex' of the late Mr.

Dixon, of Worthing, whose valuable collection from this locality was the result of many years' careful and continued research.

Fourth Zone.—*Bognor Fossils (from the rocks and clays exposed on the shore at low tide).*

Reptilia.

Chelone declivis, *Owen.*
Crocodilus Spenceri ?, *Buckl.* (*Dixon*) †.

Pisces.

Lamna subulata, *Ag.*
Otodus obliquus, *Ag.*

Mollusca.

Cephalopoda.

Nautilus imperialis, *Sow.*
*—— regalis, *Sow.*
*—— Sowerbii, *Weth.*
*—— centralis, *Sow.*

Gasteropoda.

Acteon simulatus, *Sow.*
*Aporrhais Sowerbii, *Mant.*
Buccinum ?
*Cassidaria nodosa, *Brand.*
—— striata, *Sow.*
Fusus tuberosus, *Sow.*
—— nodusus, *Sow.*
*Infundibulum trochiforme, *Sow.*
Calyptræa, Lam. *I. tuberculatum*, *I. spinulosum*, *I. echinulatum*, Sow. *Trochus apertus*, *T. opercularis*, Brand.
Littorina sulcata, *Pilk.* ?
Natica Hantoniensis (*N. striata*), *Sow.*
.—— microstoma, *Sow.*
*—— labellata, *Lam.*
*—— patula, *Desh.*
*—— sigaretina (*Ampullaria*), *Sow.*
—— subdepressa, *Mor.*
Pleurotoma prisca.
Pseudoliva semicostata (*Buccinum*), *Desh.*
*Pyrula Smithii (*Murex*), *Sow.*
Solarium bistriatum, *Sow.*
*Turritella imbricataria, *Lam.*
—— scalarioides, *Sow.*
*Voluta denudata, *Sow.*

Lamellibranchiata.

*Anomia lineata, *Sow.*
*Cardita Brongniartii, *Sow.*
*—— quadrata, *Sow.*
Cardium Plumsteadiense, *Sow.*
Corbula globosa, *Sow.*
Cultellus affinis, *Sow.*
Cyprina planata, *Sow.*
—— (?) nana, *Sow.*
Cytherea obliqua, *Desh.*
—— suberycinoides, *Desh.* ?
*Modiola elegans, *Sow.*
—— simplex, *Sow.*
*Ostrea elephantopus, *Sow.*
—— cariosa, *Desh.*
*—— tabulata, *Sow.*
*Panopæa intermedia, *Sow.*
—— puella, *Sow.* ?
*—— corrugata, *Sow.* ?
*Pectunculus terebratularis, *Lam.*
*—— decussatus, *Sow.*
Pinna margaritacea, *Sow.* ?
*—— affinis, *Sow.*
Pholas Pechellii, *Sow.*
Pholadomya Dixoni, *Sow.*
—— Koninckii, *Nyst.*
—— margaritacea, *Sow.*
—— virgulosa, *Sow.*
*Teredo antenautæ, *Sow.*
Teredina personata, *Desh.*
Thracia oblata, *Sow.*

Brachiopoda.

Lingula tenuis, *Sow.*

Articulata.

Crustacea.

Hoploparia Bellii, *M'Coy.*
*Zanthopsis Leachii, *M'Coy.*

Cirripedia.

Scalpellum quadratum, *Dix.*

Annelida.

*Ditrupa plana, *Sow.*
Serpula flagelliformis, *Sow.* ?
*Vermicularia Bognoriensis, *Mant.*

Note.—To complete the enumeration of the described organic remains of the London Clay, I annex a list of those species, not

† This species is now merged in Prof. Owen's *C. champsoides* and *C. Toliapicus*. I have no means of knowing to which of the two this Bognor specimen belongs.

embraced in the above lists, found in other localities of the London Tertiary district (see some local lists in Quart. Journ. Geol. Soc. vol. iii. p. 369–371).

Mammalia.

Coryphodon eocænus, *Owen*. Off the coast between Harwich and St. Osyth.
Hyracotherium leporinum, *Owen*. Cliff W. of Herne Bay.

Reptilia.

Chelone crassicostata, *Owen*. (*Testudo plana* ?, Kön.) ... Harwich.
—— planimentum, *Owen*. (*C. Harvicensis* (?), Woodw.) Harwich.

Mollusca.

Gasteropoda.

Cypræa Prestwichii, *Edw*. Cuffell, near Basingstoke.
Bulimus ellipticus, *Sow*. Ha.
Fusus angusticostatus, *Mell.* ? Cuffell, near Basingstoke.
—— bulbus, *Brand*. (*F. bulbiformis*, Lam.) Newnham, near Basingstoke.
Marginella bifidoplicata, *Charlesw*. London Clay (Stratum No. 4), Alum Bay.
Pleurotoma elegans, *Mell*. Cuffell.
Scalaria semicostata, *Sow*. Ha.
Turritella sulcifera, *Desh*. Cuffell and Newnham.

Lamellibranchiata.

Astarte donacina, *Sow*. Old Basing.
Ostrea Bellovacina, *Desh*. (var. *pulchra*, Sow.) Newnham, and Clewet's Green.
Nucula compressa, *Sow*. Ha.
—— striata, *Lam*. Ha.

Entomostraca and Foraminifera.

Cythere barbata, *Sow*. .... Ha.
Dentalina soluta (?), *Reuss*.......... Ha.
—— elegans (?), *D'Orb*. .... Ha.
Rotalina, 4 sp. .... Ha.
Cristellaria Wetherellii, *Jones*. ... Ha.

Plantæ.

Petrophiloides (Proteaceæ), 5 sp., *Bowerb*. Herne Bay.

Note. (See page 403.)

My friend Mr. R. W. Mylne has just informed me that, from actual survey, he finds the height of High Beech to be 393 feet above the level of Trinity high-water mark at London Bridge.—J. P., Oct. 28, 1854.

June 7, 1854.

Thomas Wynne, Esq., was elected a Fellow.

The following communications were read:—

1. *On some* Fossil Reptilian *and* Mammalian Remains *from the* Purbecks. By Professor Owen, F.R.S., F.G.S.

The fossil remains which form the subject of the following descriptions were kindly transmitted for my examination by W. R. Brodie, Esq., and Charles Willcox, Esq., of Swanage, by whom they were discovered—the mammalian fossils exclusively by Mr. Brodie—in certain members of the Purbeck formation at Durdlestone Bay, near that town.

I propose to commence with the reptilian fossils, and first with those transmitted by Mr. Willcox, to whom I owe opportunities of describing many rare and interesting remains from the rich locality which he has so successfully explored.

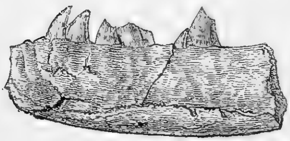
Class REPTILIA.

Nuthetes* destructor, Owen.

The specimen (figs. 1, 2, 3, & 4) on which this genus and species is founded is a portion of the left ramus of the lower jaw, with seven more or less perfect teeth, of a Pleurodont Lizard, allied to the

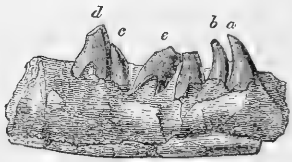
Figs. 1, 2, 3, & 4.—*Part of the left ramus of the lower jaw, with teeth, of* Nuthetes destructor, Owen.

Fig. 1.



Outside, nat. size.

Fig. 2.



Inside, nat. size.

Fig. 3.

End view, nat. size.

Fig. 4.

Magnified view of two of the teeth (*d*, *c*).

Monitors of the modern genus *Varanus*. The length of the fragment is $1\frac{1}{2}$ inch; the depth of the outer wall (fig. 1) is 6 lines, that

* Abbreviated from νουθέτητης, *monitor*, in reference to the affinities of the fossil to the modern lizards so called.

of the inner wall (fig. 2) is from 3 to 4 lines. The exterior surface of the bone is smooth and polished, but impressed by very fine, longitudinal linear markings, and perforated by nervous or vascular foramina along the alveolar wall: it is traversed near the lower margin by a line answering to the suture dividing the dentary from the angular piece in the jaw of the *Varanus*. The ramus is compressed (fig. 3), scarcely 2 lines across at its thickest part, but it has been slightly crushed.

The enamelled crowns of the teeth are moderately long, slender, compressed, pointed, slightly recurved, and with a well-marked serrated margin both before and behind (fig. 4, magnified): they are thickest towards the anterior part, as in the *Megalosaurus*, and closely resemble, in miniature, the teeth of that great carnivorous reptile.

The present fossil differs, however, from the *Megalosaurus* in having the inner alveolar ridge of the jaw not more developed than in the modern *Varani*, and in not exhibiting any rudiments of alveolar divisions; the bases of the teeth, which are anchylosed to the outer wall, being completely exposed on the inner side of the jaw (fig. 2.) In the two largest teeth, *d, e,* which are 2 lines in diameter at their base, that base is excavated on the inner side through absorption caused by pressure of the matrix of a successional tooth. A young tooth, *c,* straighter and more conical than the rest, which has thus displaced its predecessor, is rising up between the two old teeth above described. The first and second teeth, *a* & *b,* in this fragment are fully formed, are entire, and show well the normal characters of the crown. At the opposite end of the series was the crown of a young tooth which had not risen above the outer alveolar wall. The crowns of the teeth are of a dark grey colour, marked with transverse bands of lighter grey.

The entire of this interesting fragment gives evidence of a carnivorous or insectivorous Lizard of the size of the *Varanus crocodilinus,* or great Land Monitor of India*. The specific name relates to the formidable adaptation of its teeth for piercing, cutting, and lacerating its prey.

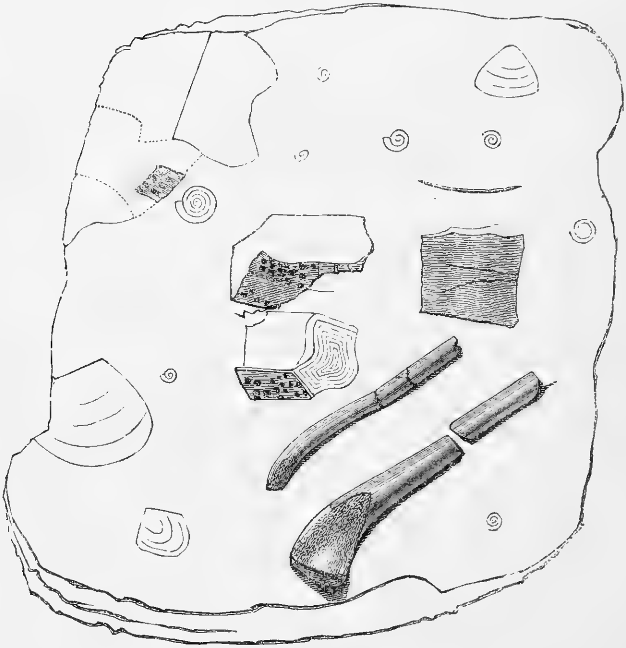
In a block of the laminated marly bed of the Purbecks, containing shells (*Cyclas* and *Planorbis*), transmitted by Mr. Willcox, are imbedded some fragments of bony scutes, and the major part of a tibia and fibula of a small Saurian reptile (fig. 5), agreeing in size with the species indicated by the above-described portion of jaw. The length of the portion of tibia preserved is $1\frac{1}{2}$ inch, and the impression of the shaft extends 3 lines longer: about the same length is indicated of the fibula by the bone and its impression. The diameter of the shaft of the tibia is $1\frac{1}{2}$ line; and the proportion of the length to the breadth of both bones is greater than in any known recent form of Lizard or Crocodile. The species to which the bones

* See my 'Odontography,' p. 265. pl. 68. fig. 3; fig. 3′ gives a magnified view of the crown of a tooth of this species, showing its resemblance to the fossil. The specimen above described was obtained at the Feather Quarry, and from the division of the Chert-beds marked J. 81–84. in the stratigraphical list in the Rev. Mr. Austen's 'Guide to the Geology of the Isle of Purbeck,' 8vo. Blandford, 1852.

of the leg in the present slab belonged must have been characterized by unusually long and slender hind-legs.

The scutes, as shown by their impressions on the matrix (fig. 5),

Fig. 5.—*Slab of stone from the "Feather Quarry," Purbeck, with* Cyclas *and* Planorbis, *and containing fragments and impressions of square reptilian scutes, and the tibia and fibula of a small reptile* (Nuthetes?). *A fish-scale also is seen in the middle of the slab, lying against one of the scutes.* Nat. size.



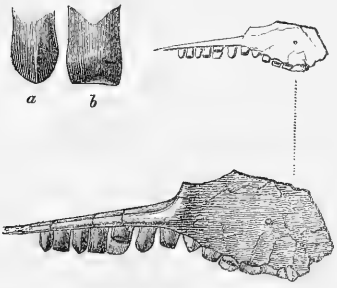
were subquadrate, about 8 lines by 5 or 6 lines; smooth on the inside; impressed by minute circular pits on the outside; and presenting more the character of the bony scutes of *Crocodilia*, than of those of any of the modern Lizards that possess dermal bones.

Macellodus Brodiei, Owen.

Of the specimens discovered by W. R. Brodie, Esq., in the freshwater shelly "dirt-bed" of the Purbecks, at Durdlestone Bay, I propose first to describe those that are referable to the class *Reptilia*.

The characters of the Lacertian order in this class are unequivocally shown in the specimen, marked *f* 7, in Mr. Brodie's collection, and represented in fig. 6, of the natural size in outline and magnified in tint. It consists of a right superior maxillary bone, containing eight nearly entire teeth, and showing the places of attachment of thirteen or fourteen such teeth; which teeth are anchylosed to the bottom of an alveolar groove and to the side of an outer alveolar ridge. The crown of these teeth is broad, laterally compressed, with an almost semicircular contour, and slightly pointed where unworn, as at *a*, fig. 6;

Fig. 6.—*Part of the right side of the upper jaw, with teeth, of the* Macellodus Brodiei, Owen. (Nat. size, and magnified.)



a, *b*. Two of the teeth magnified.

but some of them exhibit the summit either worn away or broken off, as at *b*: the enamel is marked by very fine longitudinal ridges, which give a subcrenate character to the unworn margins of the crown. The third tooth in the present specimen exhibits the minute germ of a successional tooth entering the cavity on the inner side of its base. The eighth tooth is represented by the apical half of the crown, which has not arisen to the level of the outer alveolar groove: the tooth which this germ was in course of succeeding has been shed or broken away. The third and sixth teeth are less advanced than the second, fourth, and fifth teeth.

The inner part of the alveolar groove, from the second to the seventh tooth inclusive, terminates internally in a free smooth convex surface, which has formed the outer boundary of a wide and extended palatal vacuity, as in modern Lizards. Beyond this the upper jaw expands to join the palatine bone. This structure, with the unequal development, and the evidence of the succession, of the teeth, together with their mode of implantation, gives unequivocal proof of the saurian nature of the fossil in question. From the resemblance of the teeth of this small Lizard to the blade of a spade, I propose to call the genus which it represents *Macellodus* (*μάκελλα, a spade, ὀδοὺς, a tooth*), and the species, in honour of its discoverer, *Brodiei*.

The specimen was obtained from a part of the Purbecks, marked K. 93. in Mr. Austen's 'Guide,' and called the "dirt-bed, containing shells*," high up the cliff, at Durdlestone Bay, Isle of Purbeck.

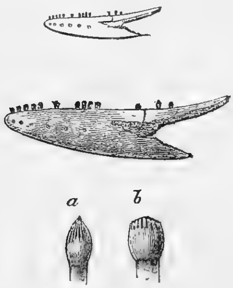
To the same species belong some at least of the organic remains in the specimen marked *K. 7.* in Mr. Brodie's collection.

This is a block from the Purbeck formation of a laminated marly character, from the lower part of the so-called "dirt-bed, containing

* The specimens of this deposit sent with the bones contain *Physa Bristovii*?, *Valvata*, *Limnæus*, *Cypris*, and vegetable remains.

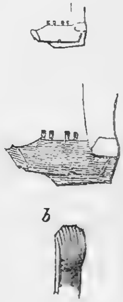
shells." In it are imbedded some dermal bony scutes, portions of ribs, the neural arch of a vertebra, and parts of the dentary elements of the rami of a lower jaw with teeth—one (fig. 7) containing thirteen teeth, the other (fig. 8) four teeth; in both figures the natural size is given in outline. The teeth are anchylosed to an exterior alveolar wall, and have short, broad, subcompressed, rounded, obtuse crowns (*b*, *b*). The hinder teeth show a little increase of size, are more obtuse and compressed, and are slightly expanded. Some of the anterior teeth (fig. 7, *a*) are a little pointed. The enamel is

Fig. 7.—*Part of the left side of the lower jaw, with teeth, of the* MACELLODUS BRODIEI, Owen. (Nat. size, and magnified.)



a, *b*. Two of the teeth magnified.

Fig. 8.—*Part of the lower jaw, with teeth, of the* MACELLODUS BRODIEI, Owen. (Nat. size, and magnified.)



b. One of the teeth magnified.

polished, but is marked by fine longitudinal grooves as it approaches the summit of the crown, like those in the upper jaw of the *Macellodus*; from which character, and from the progressive acquisition of a similar spade-like shape of the crown, as the teeth recede from the apex of the jaw, I conclude that the present is the lower jaw of the same species. The teeth are separated on the average by a space equal to the antero-posterior diameter of the crown; but some are closer together, others wider apart. The dentary bone (fig. 7) containing them exhibits a wide posterior notch for articulation with the angular and surangular elements. The outer surface of the dentary element is smooth and convex. The teeth are much smaller in proportion to the jaw than in the *Nuthetes*, figs. 1 & 2, and evidently belong to a distinct genus of Lizard.

The dermal scutes are subquadrate, smooth, and slightly concave on the inner surface; they are impressed with small round pits on the outer surface, as in the existing loricated reptiles; but the teeth in the portions of jaw in the same block are anchylosed to the jaw, not lodged in distinct sockets as in the *Crocodilia*. In a specimen of two of these scutes in natural juxtaposition, one slightly overlaps the other. The neural arch of the vertebra in the same block exhibits long diapophyses, as in the lumbar and anterior caudal vertebræ of most modern Lizards, a moderately long spine, and a circular neural canal: the exposed surface of the arch is fractured, and the zygapophyses have been removed. There is no trace of the vertebral body, which has most probably been detached from the sutural connection with the arch, before this became imbedded in the present matrix.

In modern *Lacertilia* the neural arch anchyloses with the centrum at an early period, but in the *Crocodilia* it retains its sutural union. On the supposition of the neural arch being separated from a sutural union and not broken away, that arch would accord with the crocodilian characters afforded by the subquadrate scutes; the size of the two parts also supports their reference to the same animal. The presence in the same block of the Lacertian jaws and teeth leads to a suspicion that they belong to the same reptile; but similar crocodilian scutes are associated, in another block of Purbeck clay, with jaws and teeth of an animal to which they could not have belonged.

The length of the portion of the dentary bone containing the thirteen teeth is 17 millimetres, or 9 lines.

The breadth of the neural arch across the diapophyses, and including them, is 20 millimetres, or 10 lines; the long diameter of one of the scutes is 17 millimetres, or 9 lines; its breadth is 6 lines, or 13 millimetres.

Fig. 7 *a* is a magnified view of one of the anterior teeth, and fig. 7 *b* of one of the hinder teeth in the dentary bone, fig. 7.

As the anterior teeth in this specimen present nearly the same degree of resemblance to those figured in my 'Odontography*,' that have been referred to the *Hylæosaurus*, as the teeth of the *Nuthetes* do to those of the *Megalosaurus*, it became equally necessary to consider the question of the relationship of the *Macellodus* to the *Hylæosaurus*, as being possibly the young of the latter Wealden reptile.

The teeth of the *Macellodus* that most resemble those of the *Hylæosaurus* do not present so long and cylindrical a base, so angular an expansion of the crown, or the mode of abrasion of the crown by two sloping facets meeting at an angle of 80°, which is peculiar to the presumed Hylæosaurian teeth: moreover, the correspondingly enlarged representations of the spade-shaped teeth of the *Macellodus* have not yet been met with in the Wealden strata that have yielded the teeth and other remains of the *Hylæosaurus*.

The large Saurian teeth that come nearest in shape to the typical and most numerous teeth of the *Macellodus* are those of the *Cardiodon* of the Forest Marble of Wiltshire (Odontography, pl. 75 A. fig. 7 *a*), and of the *Palæosaurus platyodon* of the Magnesian conglomerate (*op. cit.* pl. 62 A. fig. 7): but the differences which will be seen on comparing the enlarged figures of the teeth of *Macellodus*, figs. 7 & 9, with the above-cited figures, are not reconcileable with the supposition that they might be due only to a difference of age of individuals of the same species.

* Vol. i. pl. 62 A. fig. 8 *a, b*.

GONIOPHOLIS CRASSIDENS, Owen; Brit. Assoc. Report, 1841, p. 69.

In some of the blocks of Purbeck stone transmitted by both Mr. Willcox and Mr. Brodie are imbedded portions of jaws, teeth, and other parts of the Swanage Crocodile (*Goniopholis crassidens*).

I shall not, however, dwell on the remains of this well-known reptile of the Purbecks, but proceed at once to the description of the most novel and interesting fossils of the present collection, which have been obtained exclusively by Mr. Brodie.

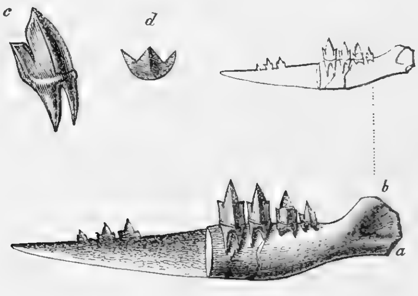
CLASS MAMMALIA.

At first sight the specimens appeared, as their discoverer had supposed, to differ only in species from the similarly-sized jaws of the Lizards with which they were associated; and it was only after a careful removal of the matrix that concealed their most characteristic features, that I became satisfied of their relationship to the Mammalian class.

SPALACOTHERIUM * TRICUSPIDENS, Owen.

The first of the specimens indicative of the little insectivorous mammal, for which the above name is proposed, is a left ramus of the lower jaw, indicated by nearly the whole of the posterior half, and by the impression of nearly the anterior half of the bone: it is represented, of the natural size in outline, and magnified in tint, at fig. 9. The posterior half contains four teeth, which at first sight

Fig. 9.—*Left ramus of the lower jaw, with teeth, of the* SPALACOTHERIUM TRICUSPIDENS, Owen. (Nat. size, and magnified.)



a, b. Proximal extremity of jaw. *c.* Oblique view of a molar tooth. *d.* Crown of the same, seen from above.

appeared to have simple long slender pointed conical crowns, with a basal ridge. The portion of jaw containing them extended backwards beyond the dental series; and, instead of showing the com-

* From σπάλαξ, *a mole*, & θηρίον, *a beast*.

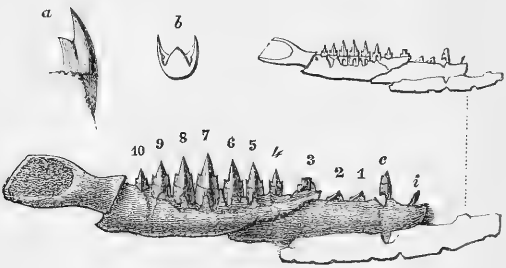
pound structure which that part of the jaw exhibits in the Lizard tribe, continued undivided, with the convex surface as it were bifurcating to include a smooth depression, the lower division or ridge, *a*, answering to that going to the condyle and angle of the jaw, and the upper one, *b*, to that going to the coronoid process, in the ramus of the jaw of the Mole and Shrew. This character first led me to endeavour to ascertain more of the characters of the fossil; but before meddling with this delicate and brittle but most precious evidence of the Purbeck fauna, I committed it to Mr. Dinkel's care, for a drawing of the part of the natural size, and a magnified view of so much as was exposed of the largest of the teeth. Having received these drawings with the specimen, I proceeded to expose more of the crowns of the teeth, when they were found to be tricuspid, the inner part of the crown being produced into a point both before and behind the longer cusp which formed the chief outer division of the crown, and which alone had been exposed on first view. I next proceeded to examine into the mode of implantation of these teeth, and found them fixed by a fang divided externally into two roots, in a distinct forked socket in the substance of the jaw. The multicuspid crown, the divided root of the tooth, its complex implantation, and the undivided or simple structure of the ramus of the jaw, all concurred, therefore, to prove the mammalian nature of this fossil.

Fig. 9 *c* is an oblique view of the anterior side of the crown of the first of the four teeth, showing that the basal ridge bends up and is lost upon the side of the accessory cusp. Both the posterior and anterior cusps project upwards on a plane more internal than the middle or chief cusp; and the crown of the tooth, viewed vertically, gives the contour represented in fig. 9 *d*. The four back teeth represented in fig. 9 progressively decrease in size to the hindmost, which seems to be the last of the series. The sharp multicuspid character of so much of the dental series as is here preserved repeats the general condition of the molar teeth of the small insectivorous Mammalia in a striking degree: one sees in them the same fitness for piercing and crushing the tough chitinous cases and elytra of insects. The particular modification of the pointed cusps, as to number, proportion, and relative position, resembles in some degree that of the Cape Mole (*Chrysochlora aurea*), but accords more closely with that of the extinct *Thylacotherium* of the Oolite (Trans. Geol. Soc. 2nd Ser. vol. vi. pl. 6. fig. 1) than with any of the existing types of insectivorous dentition.

The minor antero-posterior extent of the crown is considerable as compared with the proportion of that diameter with the height of the crown in the true molars of any of the modern Moles and Shrews, except the *Chrysochlora*. The impressions of the inner side of some teeth anterior to those in place show plainly the tricuspid character of the crown, and indicate also a greater number of such molars in the fossil than in any of the recent mammalia, with the exception of the marsupial *Myrmecobius*; of this further and more important affinity of the *Spalacotherium* to the *Thylacotherium*, the following specimens yield more decisive evidence.

d 7. The specimen so marked is a portion of the so-called 'dirt-bed,' from the Purbecks at Durdlestone Bay, having imbedded in it the right ramus of the lower jaw of the *Spalacotherium*, wanting the ascending branch, but containing one incisor, a canine or canine-shaped premolar, and ten succeeding molar teeth. It is represented of the natural size in outline, and magnified in tint, in fig. 10.

Fig. 10.—*Right ramus of the lower jaw, with teeth, of the* SPALACOTHERIUM TRICUSPIDENS, Owen. (Nat. size, and magnified.)



a. Oblique view of the molar tooth No. 8.
b. Crown of the same, seen from above.
c. Laniariform tooth (=first premolar ?).
i. Incisor.

The incisor, *i*, is the smallest of these teeth, and has a subquadrate or very obtusely-conical crown, convex externally. The canine or canine-shaped premolar, *c*, is more than twice as long and broad as the incisor, with a subcompressed, sharp-pointed conical crown, a little inclined backwards; it appears to have been inserted by a divided root, like the similarly-shaped and proportioned first premolar in the Mole. The two succeeding teeth, 1 & 2, are one-third smaller than the canine, with subcompressed, conical crowns, at the fore and back part of which the base is slightly produced: each is implanted by two distinct fangs. The third and fourth teeth have a similar form and complex implantation, but are somewhat larger, and the basal cusps are more developed: in the fourth tooth this development gives a distinctly tricuspid character to the crown, the middle cusp, representing the crown of the preceding teeth, being the largest and highest. The six following teeth, 5 to 10, repeat the same unequal tricuspid form, with increased but varying size; the middle teeth, 6, 7, 8, being the largest, and the last tooth, 10, diminishing in size in a greater ratio than the penultimate one, 9. These last six molar teeth are so close together that it was difficult at first to persuade oneself that they were not so united as to constitute fewer and more complex molars. The lateral cusps incline inwards and project from a plane more internal than the longer middle cusp. The inner side of the crown presents a wide longitudinal groove at the base of the middle cusp, between the inwardly inflected lateral cusps: the base of the crown presents externally a well-defined narrow cingulum or ridge; beneath which the two fangs, or the two external fangs, descend into the substance of the jaw.

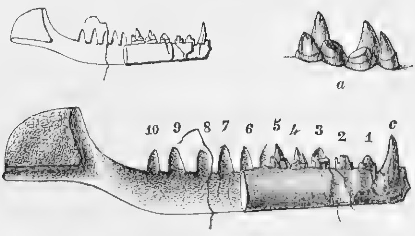
In the state in which this most instructive portion of the Spalacothere was presented to me, the matrix concealed all save the large middle cusp of the molar teeth, which teeth then seemed to be wider apart, and presented a more lacertine aspect. By the careful application of a fine needle and graving tool, I succeeded in displaying the lateral cusps and grinding surface of the crown, and the other teeth, as shown in the enlarged view given in fig. 10.

Fig. 10 *a* gives a magnified view of the antepenultimate molar, 8, viewed obliquely from behind; and fig. 10 *b* is an outline of the crown of the same tooth, viewed vertically: these figures accurately represent the mammalian and insectivorous characters of the teeth.

So much of the jaw-bone as is preserved in this specimen, fig. 10, corresponds in size and shape with the portion and impression of the opposite (left) ramus, fig. 9; and shows the same vertical contraction or decrease of diameter behind the molar series, prior to the expansion of the jaw into the ascending ramus. The horizontal ramus has suffered an oblique fracture since its fossilization across the alveolar series, with a very slight depression of the fore part containing the four anterior teeth: a second fracture crosses the contracted part of the jaw behind the last molar in place. There is not any clear evidence of a smaller molar tooth behind the last in place, marked 10. Between the large laniariform tooth, *c*, and the fore end of the ramus of the jaw, there is space for three incisors like the small one preserved, *i*, and also for a small canine, which tooth is demonstrated in one of the specimens (*a* 7) in Mr. Brodie's collection.

The specimen marked *e* 7 in this series is the anterior half and an impression of most of the remaining part of the left ramus of the lower jaw, with its inner surface exposed, showing the large canine

Fig. 11.—*Inner aspect of a left ramus of the lower jaw, with teeth, of the* Spalacotherium tricuspidens, Owen. (Nat. size, and magnified.)

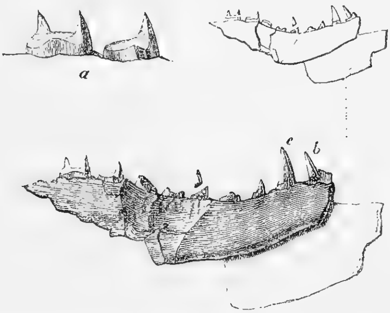


a. Two molars, numbered 4 & 5. *c*. Premolar or canine ? tooth.

or canine-shaped premolar, *c*, and five following teeth in place, a fragment of a sixth molar, and impressions of four succeeding molars. The crown of the canine-shaped tooth is long, subcompressed, slightly recurved, pointed, with a posterior basal tubercle. The adjoining tooth has a compressed, pointed crown, scarcely half the height of the canine and two-thirds as broad at the base, with a ridge along the inner side of the base, and a more developed posterior basal tubercle: it is divided by a small interval from the canine. The second molar, with a slight increase in size and a similar shape, has the fore part of the basal ridge developed into a low point, and the hinder tubercle is relatively larger and more pointed. The third tooth is larger than either of the two preceding, but resembles them in form. The fourth, with the same antero-posterior extent, has a lower crown, the middle cusp being relatively shorter, but both the anterior and posterior ones are larger, and now begin to assume the character of independent cusps; their bases almost meeting upon the inner side of the base of the middle cusp. The fifth molar, with a slight increase of size, shows a still further development of the accessory cusps, which now are inclined backwards, or project from a more internal plane than the middle cusp. The impressions of the succeeding teeth show that their middle cusp was longer in proportion to its basal breadth; and thus agree, like the foregoing teeth, with the teeth similarly marked in fig. 10. The canine-like tooth seems to have a bifid fang; the three succeeding premolars, implanted each by two fangs, in this respect, as in their general form and proportions, resemble the four premolars of the lower jaw of the Mole. The ramus of the jaw very closely resembles in shape that of the Mole, but is larger than that of the *Talpa europæa*, being 1 inch 3 lines, or 32 millimetres in length, that of the Mole being 1 inch, or 25 millimetres. The crown of the laniariform tooth is relatively longer, and the fourth tooth counting therefrom is of a different form, being of much smaller size and of a more simple structure than is the corresponding tooth which forms the first true molar of the Mole. The greater number of molar teeth indicated in the present and displayed in other specimens of the *Spalacotherium* decisively demonstrate not only its specific but generic distinction from the Mole, or any known existing insectivore; the marsupial Myrmecobius being the sole mammal, with incisors and canines, that resembles the Spalacothere in the excessive number of the molar teeth. Fig. 11 *a* is a magnified view of the teeth 4 & 5, showing the meeting of the accessory cusps on the inner side of the crown.

In the specimen marked *a* 7 in Mr. Brodie's series, and represented in fig. 12, the tooth, *b*, that immediately precedes the large canine-shaped tooth, *c*, is preserved; it is also canine-shaped, but about half the size of that tooth. There is a trace of a small incisor in the crushed and broken anterior end of the jaw in front of the above teeth. This specimen the more inclines me to the belief that the larger canine-shaped tooth is the first premolar, as in the Mole; but it appears to be implanted by a simple expanded base in the present specimen: the crowns of the three succeeding teeth, and the fractured bases of the crowns of the four or five following molar teeth are shown in this mutilated portion of the right ramus of the lower jaw of the *Spalacotherium*. Fig. 12 *a* is a magnified view of two of these teeth, from which the middle and hind cusps have been broken away.

Fig. 12.—*Portion of the right ramus of the lower jaw, with teeth, of the* SPALACOTHERIUM TRICUSPIDENS, Owen. (Nat. size, and magnified.)



a. Two molars, without the middle and hind cusps; magnified.
b. Canine tooth?
c. First premolar?

In the same block of Purbeck "dirt-bed" are imbedded part of a vertebra, a fragment of the jaw with a few teeth of the *Macellodus*, and three of the small subquadrate and externally pitted dermal scutes. There is also a beautifully clear impression of the dentary bone, with six or seven of the anterior minute teeth, and a row of fine vascular pits or foramina, of the *Macellodus*.

In regard to the *Spalacotherium*, sufficient evidence, it seems to me, is afforded by Mr. Brodie's fossils, described in the foregoing pages, to satisfy the most scrupulous palæontologist as to the mammalian and insectivorous character of the species. The portions of the jaws and teeth on which the genus and species are founded, show precisely the same dark charred colour as the reptilian fossils with which they are associated; and there can be no doubt of the mammalian and lacertian remains being of the same date, included, as they often are, in the same block of matrix. There is no satisfactory evidence of the marsupial character of the jaws of the *Spalacotherium*: from the great number of the tricuspidate molars, one might be inclined to infer its affinity with the recent Myrmecobius; but, although the molar teeth are not so numerous in any placental Insectivore, they manifest so much variety in number and shape, in the existing species, that a further deviation from the common type in regard to number would not be a very violent departure from the characters of the true Insectivorous order. The straight uninflected angle of the lower jaw of the *Thylacotherium* has led me to view that genus as more nearly allied to the placental than to the marsupial Insectivora; and the *Spalacotherium* has closer affinities with the *Thylacotherium* than with any known existing *Insectivora*. In a comparison with these, the Spalacothere most closely resembles, as to the shape of its teeth, the iridescent Cape Mole (*Chrysochlora aurea*):

the last five molars of this species have tricuspid crowns, with the anterior and posterior smaller cusps on a plane more internal than the middle one, but the smaller cusps are given off nearer the summit of the crown. These teeth also resemble the molars of the Spalacothere in their small antero-posterior extent, but they are fewer in number and are placed farther apart in the Cape Mole, which also is restricted to the number of ten teeth in each ramus of the lower jaw, incisors and canine inclusive.

The Spalacothere has nearer affinities, as has been already intimated, to the Thylacothere of the Stonesfield Oolite than to any known existing species of Insectivore, and from the present evidence I should place it in the same natural family of the Insectivorous order of Mammalia.

Touching the wider question of the successive appearance of the grades of animal life on this planet, the present acquisition from the Purbecks in no way affects the question as it was left by the long-contested but finally settled evidence of mammalian life at the period of the deposition of the oolitic slate at Stonesfield.

Between that period and the oldest of the tertiary deposits, where hitherto mammalian remains have next presented themselves in the order of appearance, the interval is immense; the lapse of time having sufficed to allow of the deposition of the oolitic strata from the Great Oolite upwards, of the Wealden and Neocomian beds, and of the formation, by more or less minute marine animals, of the major part, if not the whole, of the carbonate of lime of which our Chalk downs and cliffs consist. The chief interest in the discovery of the *Spalacotherium* is derived from its demonstration of the existence of Mammalia about midway between the older oolitic and the oldest tertiary periods.

Both the Oxford oolitic slate and the Purbeck marly shell-beds give evidence of insect-life; in the latter formation abundantly, as was shown in Mr. Westwood's paper read at a former meeting of the Society*. The association of these delicate Invertebrates with remains of plants allied to *Zamia* and *Cycas* is indicative of the same close interdependency between the insect-class and the vegetable kingdom, of which our power of surveying the phænomena of life on the present surface of the earth enables us to recognize so many beautiful examples. Amongst the numerous enemies of the insect-class ordained to maintain its due numerical relations, and organized to pursue and secure its countless and diversified members in the air, in the waters, on the earth and beneath its surface, bats, lizards, shrews, and moles now carry on their petty warfare simultaneously, and in warmer latitudes work together, or in the same localities, in their allotted task. No surprise need therefore be felt at the discovery that mammals and lizards co-operated simultaneously and in the same locality at the same task of restraining the undue increase of insect life during the period of the deposition of the Lower Purbeck beds.

The placental Insectivora are far from being the highest of the Mammalian class, but at the same time they are not the lowest: if

* See above, p. 378.

they have small unconvoluted brains, they are unguiculate and claviculate; some are fitted for flight (*Vespertilionidæ)*, some for swiftly burrowing in the earth (*Talpidæ*), some for swimming and diving (*Soricidæ*), others for rapid course over the dry land (*Macroscelidæ*).

All that can be legitimately inferred as to the grade of mammalian structure now brought to light from the oldest of the Wealden epochs is that it displays the mammalian modification which we know to be best adapted to profit by a co-existence with the insect population of the same period.

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2. *On a* Section *lately exposed in some Excavations at the* West India Docks. By W. T. Blanford, Esq.

[Communicated by the President.]

An excavation lately made to join two portions of the West India Docks has exposed a section of the deposits in the valley of the Thames to a depth of above 30 feet, showing beds of peat with stems of trees, and, below these, gravels containing organic remains. The thickness of the different beds varies considerably, but their general succession and their measurement where best exposed are shown by the accompanying diagram, p. 434.

The two beds, *c* & *d*, vary in character and thickness; stems of trees, most of which lie horizontally, though some of the smaller ones are vertical, are scattered throughout the peat; and this deposit is interspersed with specks of blue phosphate of iron. Throughout the clay, *c*, are sparingly scattered the following species of freshwater shells:—

Bithinia tentaculata.
Limnæus palustris.
Limnæus pereger.
Ancylus fluviatilis.

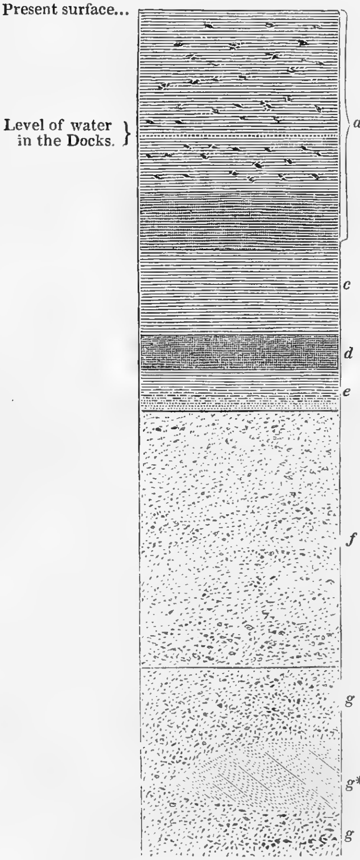
At the bottom of the bed of peat at one place a considerable number of land and freshwater shells of the following species occur (the bivalves having both valves together):—

Helix nemoralis.
H. rotundata.
Clausilia laminata.
Succinea putris.
Valvata piscinalis.
Bithinia tentaculata.
Ancylus fluviatilis.
Pisidium amnicum.
Unio.

This bed, *d*, rests on the very uneven surface of the underlying clays, sands, and gravels (*e*, *f*, *g*), which are much false-bedded, and in some places evidently deposited by currents of considerable strength; beds of sand and small rolled pebbles, dipping at a considerable angle, lie between other beds which are horizontal, though thinning out at short distances. Towards the bottom these are exclusively of pebbles, much larger than those in the upper part, and mainly composed of chalk-flints, some of which are very much rolled, others very little; many broken, and with the edges but little rolled. Pebbles of different kinds of sandstone and of vein-quartz also occur.

Without much change in general character, these gravels become mixed at the bottom with shells in great numbers. These appear to be always broken, and the few fragments of *Ostrea* which occur are equally comminuted with the more fragile *Cyrenæ* (mainly *C. cuneiformis*) which form the main bulk of the shells. I also found two fragments of *Pectunculus*. Rolled pieces of clay of various sizes abound in the bed. This clay is dark and much resembles some of the bands in the Woolwich beds.

Section exhibited by Excavations in the West India Docks.



	ft.	in.
a & b. Clay, gravel, soil, &c. ("made earth")	11	11
c. Brown and blue clays with a few freshwater shells	4	6
d. Peat, with stems of trees and shells in one place	1	8
e. Clay of variable character passing downwards into sand	2	0
f. Sand and gravel; the latter very ferruginous at the top. The sand prevailing in the upper part. The gravel much coarser towards the bottom	13	6
g. Pebbles and rolled clay, with broken shells; also (g^*) patches of green sand with plant and insect remains.		

At the bottom of the excavation occur some patches of greenish sand, g^*, intercalated with the pebbles; these patches are a yard or more in thickness in places, but seem to be in isolated masses, only extending for a few feet and then abruptly cut off. They contain thin bands of twigs, leaves, and seeds of plants, with beetle remains, lying inclined at an angle of about 15° towards the north.

Borings in the vicinity have been made; and at a few feet beneath the bottom of the excavation a hard calcareous rock was reached containing *Cyrenæ*.

A similar deposit of peaty and argillaceous matter, with stems of trees, occurs at the excavations now making for Victoria Docks*, about a mile lower down the river. I have also seen something like it at Woolwich; and it is probably continuous over all this part of the valley of the Thames. At Victoria Docks a similar shelly bed occurs, containing most of the shells above enumerated, with one or two additions, viz.:—

Limnæus auricularis.	Helix rufescens.
Neritina fluviatilis.	Planorbis nitidus.

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3. *On the* Distinctive Physical *and* Palæontological Features *of the* London Clay *and the* Bracklesham Sands; *and on the* Independence *of these two* Groups *of* Strata. By Joseph Prestwich, Jun., F.R.S., F.G.S.

§ 1. *On the difference of the Species, and of the physical structure.*

The fact of the London Clay proper having been considered, until within a comparatively recent period, synchronous with the clays and sands of Bracklesham and Barton, gave rather naturally greater weight and prominence to the resemblances than would attach to the differences, in the character of the fauna of these several beds. Not that the differences were overlooked, but they were, owing to this presumed synchronism, referred to changes dependent upon geographical distribution, depth of water, and variations of sediment; and their true value was in consequence hardly sufficiently allowed. This supposition, which levelled the distinction of age, led to the union of the three distinct faunas of the above-named deposits; and consequently, both here and abroad, the comparison of this associated group with the continental tertiary faunas almost necessarily caused the three, as a whole, to be considered synchronous with that deposit with which it possessed a majority of fossils, *i. e.* the *Calcaire grossier*; whilst by a natural reaction the differences in the faunas thus wrongly parallelled were inevitably referred to such causes as had been used to account for the anomalies arising from associating together

* The following is the section at Victoria Docks:—

	ft.	in.
Brown clay, with some land and freshwater shells	6	0
Peat	4	0
Sandy clay and sand, with roots of trees	5	0
Gravels and sands, false-bedded, unfossiliferous, about	20	0
Blue clay, apparently unfossiliferous.		

the clays of London, the sands and clays of Bracklesham, and the clays of Barton, under one name of *London Clay*.

Although I had endeavoured, in 1847, to prove that these three deposits were not synchronous, but in a definite order of superposition, still, owing to the circumstances named above and to the confusion produced by the difficulty of unravelling organic remains so long mixed up together, the extent of the differences between the strata of London and of Bracklesham were not then fully developed, and the evidence in support of these views has not been considered sufficiently conclusive by some foreign geologists who yet adhere to the former views on this question. One of the objects of this paper is to confirm, by a further inquiry into the organic remains of these two deposits, the distinction before pointed out, and with the lists given in the last paper *, to enable more especially our foreign colleagues to judge of the extent of these distinctions, and to afford them specific fossiliferous zones for comparison with their own rich and attractive tertiary series. So late as 1850, one of the most able of the French naturalists, in comparing the corals of the English marine eocenes with those of the *Calcaire grossier*, is led, by adopting the old meaning of the "London Clay," to a theoretical difficulty in the explanation of the range of species, which, by taking the more restricted meaning, would not exist, and which restriction the work itself, in fact, directly corroborates by the distinctive determination of the London and Bracklesham species. Thus M. Milne-Edwards, after remarking on some points of resemblance between the English fauna and that of the "Calcaire grossier," observes nevertheless, that "most of the corals found in the environs of Paris have not been met with in the Eocene strata of the London Clay, and many of the corals belonging to the last-mentioned deposits have not been discovered elsewhere †;" and then states, that, as "at the present period similar differences to those existing in these French and English Eocene series exist at small distances in the same zoological region, and appear to depend principally on the depth of the sea and the nature of the bottom, by analogy we are therefore led to suppose that in the Eocene marine fauna they are only indicative of some such local peculiarities ‡."

M. Hébert, who has so thoroughly studied the French Tertiaries, still considers that the differences existing between the fauna of the *Calcaire grossier* and that of the London Clay proper, are to be accounted for by such causes as above-named, and is therefore unwilling to admit any difference of age in these deposits §. Whilst the distinguished palæontologist, M. A. d'Orbigny, writing in 1852, and speaking also of our three English groups taken together, observes that "the identity of the London Clay and of our 'Etage Parisien' (*i. e.* the *Glauconie grossière*, *Calcaire grossier*, and

* See above, p. 411–19.

† Monog. Palæon. Soc., vol. for 1850. *Brit. Foss. Corals*, p. 12.

‡ M. Agassiz also seems to refer the differences in the fishes to similar causes. Rep. Br. Assoc. 1846, p. 52.

§ Bull. Soc. Géol. de France, 2nd ser. vol. ix. p. 350, and Comptes Rendus, for 1850, p. 852. M. Hébert considers the Basement-bed of both alike.

Sables moyens) is now too well known, too palpable to all those who will but look at their respective faunas, to require further proofs from us. Of this it is easy to judge by the great number of similar species found in both districts*."

I merely mention these facts to show how very important differences, which if seen alone could not fail to attract attention, can, when associated by long usage with a certain amount of resemblances, be overlooked when correlating the whole with other strata in which the resemblances are the positive and the differences the negative phænomena.

Since the publication of my paper† "On the probable age of the London Clay," &c., in which lists of the fossil shells of this deposit and of the Bracklesham and Barton beds are given, the valuable publications of the Palæontographical Society and Dixon's 'Geology of Sussex' have rendered practicable a comparison of the other portions of the fauna, whilst the continued researches of Mr. Edwards on the Bracklesham Molluscs, and the additions made by Mr. Wetherell and Mr. Bowerbank to those of the neighbourhood of London and of Sheppey, have materially extended the list of these fossils, at the same time that it has rendered necessary a revision of some supposed identical species. The result of these additions to our knowledge has been not only to confirm the distinction of the faunas of these three tertiary deposits, but also to place this distinction in a still stronger light, so much so as to warrant our assigning to the London series a more definite and separate position than before. In the same paper (p. 377) I expressed an opinion that "we had in this country an important and large 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‡." Of this fact I now feel so assured, as I also am of the sufficient difference existing between the London Clay and the Bracklesham beds, that I would suggest that they should be considered as independent groups, and that the London Clay, with its basement bed, the Woolwich and Reading series and the Thanet Sands, form of themselves a distinct and separate stage in the Tertiary series. To this the term of "the London Tertiary group," or merely the *London Tertiaries*, should be applied, as

* Cours élém. de Paléon. et de Géol. vol. ii. p. 753.

† Quart. Journ. Geol. Soc. vol. iii. p. 354.

‡ Quart. Journ. Geol. Soc. vol. iii. p. 377. M. Alcide d'Orbigny has since made a somewhat similar division of the Lower Tertiaries in France; *i. e.* he has separated from the "Calcaire grossier" the beds beneath it, forming of the upper division his "Etage Parisien," and of the lower his "Etage Suessonien." The London Tertiaries, however, include only part of this lower division: the upper and more important part I am inclined to group with the Bracklesham series, which is the true equivalent of the "Calcaire grossier." M. Dumont, in his classification of the Belgian series, also groups together the "Sables et Argiles Ypresiens," these representing, as I shall show in the next paper, the London Clay and Lower Bagshot Sands, which latter I should, however, rather place in the Bracklesham series.

serving to designate the oldest division of the Tertiary series in this part of Europe;—a series as much marked by its Reptiles and Fishes, as the overlying group is by its Mammals and Molluscs; whilst the absence of Nummulites in this lower group constitutes of itself an important distinguishing feature.

In the first place, the physical features and lithological character of the two groups will be observed to be extremely well defined. The London Clay is persistent over a large area, and everywhere maintains throughout its mass a nearly uniform mineral character. Between this deposit and the overlying Bagshot and Bracklesham series there is no decided passage. It is true that there is no marked unconformability—no eroded surface—nothing in fact to indicate that the London Clay had been elevated and existed as dry land before it was submerged and covered by the Bagshot Sands, but merely that, owing to some extensive alteration in the distribution of land and water, the drainage from other lands and from new rivers overspread the former sea-bed: for it is evident, from the completely changed nature of the Bracklesham series, from the prevalence throughout its mass of vast beds of sands with subordinate green sands and shifting clays, and the entire cessation of the repetition in that series of the mineral character of the London Clay, that the debris forming each deposit was derived from two distinct and separate sources. Further, the immediate change was probably not marked by any very violent action within this area, as the overlying group does not show at its base coarser materials, nor exhibit a more trenchant divisional plane, than prevail in the beds throughout their mass generally. Here and there in the Bagshot area, a band of rolled flint-pebbles occurs at the base of the sands, but this is an exceptional case; on the contrary, the admixture of the upper surface of the London Clay with the first 2 or 3 feet of sands—a necessary condition of a muddy clay sea-bottom—gives rise at places to some appearance of a passage between the two deposits. In the last paper* it was shown that the London Clay is thickest in Kent and Essex, and becomes much thinner as we proceed west and south-west; but this I do not believe to arise from the wearing down of the London Clay, or from any unconformability of the strata, so much as from the larger original accumulation of the London Clay in those areas, owing, as I before stated, to the nearer proximity to the river mouth.

With respect to the palæontological evidence, although the London Clay forms but the upper division of the London Tertiary series, and the Bracklesham beds are the lower part only of the overlying series, still, as these two deposits constitute by far the most important members of each series, offer the best known organic remains, and present the nearest like terms both in physical and zoological conditions, I will take their two faunas as the fittest for comparing the life of these lower and middle Eocene periods.

Mammalian remains are very limited in number. Prof. Owen, in

* *Loc. cit.*

his valuable work on British Fossil Mammals, mentions only two mammals from the London Clay, and one from the Bracklesham sands*; they are distinct species.

The remains of four species of Birds are found in the London Clay, but the Bracklesham series offers in this class no terms for comparison.

The Reptiles† constitute an important and well-characterized group of 21 species, of which number two only have been identified among the 7 Bracklesham species; and one of these, the *Chelone longiceps*, must be received with a doubt, owing to the imperfect character of the specimens upon which the determination rests. In the families occurring in the two deposits there is a marked concordance.

The Fishes of the London Clay are equally characteristic and still more abundant, amounting to as many as 83 species; whilst in the Bracklesham sands 28 species have been recognised‡. Of these, although several of the genera, as *Myliobatis*, *Ætobatis*, *Otodus*, *Lamna*, are well represented in both, only 10 species are common to the two deposits. It will be observed, that a great point of resemblance in the two groups is the abundance of cartilaginous fishes of the Shark and Ray tribe, and that the distinctive feature is the presence in the London Clay of a considerable number of *Ganoidei*, an order which is entirely wanting in the Bracklesham series.

Of the Mollusca we find a larger proportion common to the two periods. In 1847 the known species altogether numbered only 283, and of these 43, or about 15 per cent., were considered common to the two deposits. Mr. Edwards has had the kindness to furnish me with a list, which is appended to this paper, of the Bracklesham (see p. 450) and London Clay species in his collection, and has also greatly assisted me with his opinion as to the species common to the two series§. The total number of determined species now amounts to 540, of which 316 are peculiar to the Bracklesham beds, and 168 to the London Clay, while the number common to both does not exceed 56 species, or under 10 per cent., a proportion which may possibly be further reduced when a larger number of species are accurately determined. Of the Cephalopoda there are 10 species in the London Clay, and but 8 in the Bracklesham beds: of these 4 are common to the two series. Of Gasteropoda there are, on the contrary, but 138 species in the former deposit, and 232 in the latter: of these 37 species are common. Nearly the same proportion holds good in the Lamellibranchiata, of which there are 70 species in the one, and 127 in the other; of these 14 are found in both. Of Brachiopoda there are 2 species, of which one is in common. There are 4 species of Bryozoa in the Bracklesham beds, and 4 in the London Clay; they are all distinct, but one

* It is not until we get higher in the Middle Eocenes that mammals become numerous.

† Mon. Palæont. Soc., vol. for 1850–51; Owen and Bell, "Fossil Reptiles of the London Clay."

‡ Agassiz's "Poissons Fossiles," and Trans. Brit. Assoc. for 1844, p. 307.

§ I am also indebted to Prof. Forbes and Mr. Morris for their aid in the critical discussion of this subject.

of the former, the *Lunulites urceolatus*, has been recognised by Mr. Rupert Jones in the Woolwich beds beneath the London Clay.

Of the Crustacea, which form so remarkable a group in the London Clay, comparatively little is at present known. Prof. M'Coy has described 7 species, but the number of determinable species in the collections of Mr. Wetherell and Mr. Bowerbank amounts to at least 20 or 30, all or most of which appear to be peculiar to the London Clay; but it must be observed that very few crustacean remains have been found at Bracklesham, and these have not been satisfactorily determined. It is doubtful whether there are species in common. Mr. R. Jones has determined 9 species of Entomostraca from the London Clay, and 6 from the Bracklesham Sands; 2 species are common.

Mr. Darwin mentions only one species of Cirripedia from these Eocene strata, and that one is peculiar to the London Clay.

The Annelids number 11 species, of which two only are in common.

The Eocene Echinodermata have been thoroughly examined by Prof. E. Forbes, and it seems that although 17 species occur in the London Clay, it is doubtful whether any one species passes upwards. The Bracklesham Sands, however, contain but one species.

The Corals, as now very fully determined by Mr. Lonsdale and M. Milne-Edwards, give an equally definite result: 26 species are described, of which it seems that not one is common to the London Clay and the Bracklesham Sands, there being 10 species found in the former, and 16 in the latter deposit.

The Foraminifera yet require further examination: 23 species are found in the London Clay, and 8 in the Bracklesham beds, and of these it is doubtful whether any one is in common; but the great and marked feature is the total absence of Nummulites in the former, and their presence in such abundance in the overlying deposits of the Bracklesham Sands.

With regard to the Plants, the London Clay is so exceptional in the mineral conditions which have preserved its remarkable and abundant flora, that no part of the Bracklesham series offers a fit term of comparison, and we cannot therefore take into consideration the many hundred species of fruit and seed remains which are peculiar to the London Clay. Mr. Dixon, however, in his list of the Bracklesham fossils, quotes the *Lycopodites squamatus* and *Cucumites variabilis*, both of which are Sheppey species, whilst his *Pinites Dixoni* is peculiar to Bracklesham. These 3 species constitute at present all the known Bracklesham flora.

In these comparisons some allowance must necessarily be made for differences of conditions and habitat, but the equality is sufficiently maintained not to affect the general conclusions.

The lists of the organic remains of the London Clay contained in the last paper, and that of the Bracklesham Sands appended to this paper, give the following results*.

* As many of the new species of Molluscs, although undescribed, have been specifically determined by Mr. Edwards, I have included them in the numbers given in this table, and which are therefore so much in excess of the numbers given in the preceding lists. No additions are made to the other portions of the fauna.

Table showing the distribution and number of species in the London Clay and Bracklesham Sands, and the number of species common to these two deposits.*

Class of the Organic Remains.	Number of species.		
	London Clay.	Bracklesham Sands.	Common to the two series.
MAMMALIA.			
Pachydermata	2	1	0
AVES.			
Vulturidæ and Struthidæ?	2	0	0
Halcyonidæ	1	0	0
Ardeidæ?	1	0	0
	4	1	
REPTILIA.			
Crocodilia	2	1	0
Ophidia	1	2	0
Chelonia	18	4	2
	21	7	2
PISCES.			
Malacopteri apodes	1	0	0
——— abdominales	4	1	0
Pharyngognathi malacopterygii	5	3	1
——— acanthopterygii	1	0	0
Anacanthini thoracici	5	0	0
Acanthopteri	26	2	1
Ganoidei	11	0	0
Holocephali	2	4	1
Plagiostomi	28	18	7
	83	28	10
MOLLUSCA.			
Cephalopoda dibranchiata	3	5	1
——— tetrabranchiata	7	3	3
Gasteropoda opisthobranchiata	5	13	3
——— pulmonifera	1	0	0
——— prosobranchiata	132	219	34
Lamellibranchiata monomyaria	14	19	5
——— dimyaria	56	108	9
Brachiopoda	2	1	1
Bryozoa	4	4	0
	224	372	56
ARTICULATA.			
Crustacea entomostraca	9	6	2
——— malacostraca	9	2?	?
Cirripedia	1	0	0
Annelida	8	5	2
	27	13	4

* I have re-arranged this list in conformity with the classification adopted in the last edition of Mr. Morris's Catalogue, which has appeared since this paper was read.—J. P., Sept. 1854.

TABLE (*continued*).

Class of the Organic Remains.	Number of species.		
	London Clay.	Bracklesham Sands.	Common to the two series.
ECHINODERMATA.			
Crinoidea	5	0	0
Ophiuroidea	1	0	0
Asteroidea	6	0	0
Echinoidea	5	1	0
	17	1	
ZOOPHYTA.			
Zoantharia	7	15	0
Alcyonaria	3	1	0
	10	16	
FORAMINIFERA.			
Stichostegia	13	0	0
Helicostegia	4	6	0
Enallostegia	4	0	0
Agathistegia	2	3	?
	23	9	
PLANTÆ.			
See pp. 413 & 454	106	3	2

Admitting certain differences of condition, it is still evident that there is a well-marked and maintained distinction between the organic remains of the London Clay and of the Bracklesham Sands—a distinction which has become more apparent as the fossils have become better known. This fact being established with regard to the more important marine member of the London Tertiaries, we will now (in order to include the whole series, and at the same time to enable us to embrace a wider range of conditions than that afforded by the London Clay only) take the entire group of the London Tertiaries, which will give us the æstuarine, freshwater, and terrestrial, as well as the marine conditions of that period, and briefly consider its relations, not only to the overlying Tertiary group, but generally also to the underlying Cretaceous series.

Taken in conjunction with the Basement bed of the London Clay, the Woolwich and Reading series, and the Thanet Sands, the organic remains (the plants excepted) of the *London Tertiaries* present the following total number of species* :—

* Among the species ranging upwards are several which miss the Bracklesham Sands, but reappear in the Barton Clays: thus in the Molluscs we have the *Pleurotoma colon*, *P. comma*, *Murex frondosus*, *Cancellaria læviuscula*, *Fusus interruptus*, *Natica sigaretina*, *Cultellus affinis*, and *Scalaria undosa*; in the Annelids, the *Ditrupa incrassata* and *Serpula crassa*; whilst in the Echinodermata, the *Ophiura Wetherellii* and *Hemiaster Branderianus* are both quoted by Prof. Forbes, but with a doubt, from the neighbourhood of London and from Barton: in the Zoophytes, the *Graphularia Wetherellii* is the only one mentioned by M. Milne-Edwards as occurring at Highgate and Barton.

	Number of species.	Species ranging upwards.
Mammalia	6	0
Aves	4	0
Reptilia	23	2
Pisces	84	10
Mollusca	280	68
Articulata	33	5
Echinodermata	17	2 ?
Zoophyta	10	1 ?
Foraminifera	28	?
	485	88

§ 2. *On the Amount of Relation of the London Tertiary Strata to the Cretaceous Series.*

In viewing the London Tertiaries as a group, and comparing them, as usual, directly with the underlying Chalk, it is to be observed that we are not comparing like terms of the two periods. That a great and essential difference existed between these periods must be admitted, but it is a question how far that difference is widened by the comparison being instituted between the deep and open sea deposits of the Chalk, and the littoral, shallow-sea, and fluviatile deposits of the Tertiary period, instead of between strata deposited under like conditions during those two periods. As an indication of how these differences tend in many respects to lessen in force when we have an approach to more equal conditions, may be instanced the Thanet Sands and their equivalent in Belgium—the Lower Landenian system of M. Dumont. In these beds no mammalian remains have been found, and, with the exception of *Calyptræa, Glycimeris,* and *Saxicava,* the other genera, amounting to twenty-one in number, are such as lived in seas of little depth during and before the Cretaceous period; the species it is true are different, but they still—those of the Lower Landenian especially—present a *facies* so closely resembling that of analogous groups of certain lower cretaceous strata, that some eminent palæontologists and geologists are inclined to consider the Belgian beds as more Cretaceous than Tertiary. Where more shallow-water conditions again prevailed during the later Cretaceous periods, as at the time of the deposition of the *Calcaire pisolitique,* the fauna which then flourished presents forms so closely resembling those of the overlying tertiary strata, that the opinions of some of the most able geologists of France have been, and still are, divided, as to which of the two periods this deposit should be referred*. I mention these facts, not as attempting to ignore the value of the distinction drawn between the Cretaceous and Tertiary periods, but for the purpose of suggesting whether that distinction is so extreme as we have con-

* The shells were at first all referred to tertiary species. A closer examination has however detected specific differences, although it is apparent that, with respect to the genera, the analogy must be strong to have given rise at all to such an opinion. The question is still under discussion.

sidered it in this part of Europe. Admitting the infra-position of the London Clay to the Bracklesham Sands and the *Calcaire grossier*, we are thereby carried back to another and equally important Tertiary period, one stage older than the group formerly placed at the base of the Tertiaries; whilst in the Thanet Sands we have a further recession, for only nine species out of the thirty-one found in this deposit range up into the London Clay, and, as before mentioned, the general aspect of the fauna is less distinctly tertiary *. Not only so, but Sir Charles Lyell mentions the occurrence in the Lower Landenian of Orp-le-Grand of a *Cardiaster*, a genus hitherto only met with in cretaceous strata, and further states that in the same beds at Tournay the *Ostrea lateralis* occurs. In supporting the view of these beds being intermediate between the Cretaceous and Tertiary, Sir Charles observes that no *Baculites*, *Belemnites*, and *Ammonites* are found in them, but justly suggests that the same may be said of the true cretaceous strata in many other regions. The *Pholadomya Koninckii* of the Thanet Sands can hardly be distinguished from a cretaceous species, and Mr. Flower has recently shown me a specimen of the *Ostrea lateralis* from those beds at the Reculvers, apparently identical with the *Exogyra conica* of the Gault and Chalk.

At the same time, the physical changes which commenced during the latter part of the Cretaceous period would seem to have been continuous with those which introduced the Tertiary epoch. A rise of a portion of the sea-bed, accompanied by the destruction of a portion of the already-formed chalk, and the wear of its flints into pebbles, preceded the commencement of the Maestricht beds; and a very analogous change, but rather more strongly defined, marks the commencement both of the Thanet Sands and of the Woolwich and Reading series, each successive change being marked, not by a total change in lithological structure, but rather by a somewhat gradual diminution in the chalk-like and calcareous character of the strata, and by a successive increase of arenaceous and argillaceous ingredients. The changes in this respect, taking each stage separately, are on the whole of a like order, and are as steps in the same direction. The divisional planes between these stages are, however, abrupt, and indicate more or less considerable alterations in the sea area of these periods.

The adaptation of this area at the Thanet Sands period to the existence of the numerous shallow-water burrowing Lamellibranchiates, whatever the duration of the intervening time, would necessarily unfit it for the deeper sea Cephalopoda, Brachiopoda, and other families which prevail in our Cretaceous series. But if we compare the *Panopææ*, *Pholadomyæ*, and other associated genera of the former deposit with the similar groups which flourished under like conditions at an early date of the Cretaceous period, then, although the interval is infinitely greater, a close analogy of forms becomes apparent †.

* It may be a question hereafter, when the fossils of the Thanet Sands have been more thoroughly investigated, whether these strata may not form a separate division in the Tertiary series, bearing probably the same relation to the Woolwich beds and London Clay as these latter do to the Bracklesham Sands.

† So marked in some instances is this likeness, that of the two specimens of the

We have therefore, in viewing the tertiary strata in relation to the underlying Chalk, to take into consideration that the existence of certain classes of fossils in the former of necessity implies the non-existence of other classes found in the latter deposit; and this, even should the two have been in consecutive and uninterrupted sequence in time. To estimate exactly the value of the differences existing between these strata, we should consequently look to those portions of them where the terms are nearly alike. To a certain extent this is practicable in the instance of the Maestricht beds and the *Calcaire pisolitique*, but we are not yet sufficiently well acquainted with the molluscs of the latter to reason positively on the subject. We can however analyse the character of the fauna of the London Tertiaries, and see how far any resemblances to forms which flourished during any of the Cretaceous periods can be traced.

The somewhat Cretaceous *facies* which exists, as before observed, in the Lower Landenian and the Thanet Sands fossils is to be recognised in some portion of the fauna of the London Clay itself. Thus amongst the Echinodermata, the *Hemiaster*, a common cretaceous genus, has three species in the London Clay, and but one in the Barton Clay; whilst the prevalence of Crinoids, amongst which is a species of *Bourgueticrinus*, hitherto considered a chalk genus, and three species of *Pentacrinus*, and the new *Cainocrinus* of Forbes, are features more resembling those prevailing in Mesozoic than those usual in tertiary strata. The two genera of *Asteridæ* (*Astropecten* and *Goniaster*) which occur in the London Clay are common in the Cretaceous strata, the Oolites, and Lias.

The four genera of Crustacea described by Prof. M'Coy are all extinct; and one of them, the *Hoploparia*, of which two species are abundant, is a well-known form common in some of the Lower Cretaceous beds.

The Fishes present some very marked characters, one of which is the prevalence of *Pycnodontidæ*. This extinct family, so well developed in the Cretaceous series, has also ten species in the London Clay. The extinct genus *Hypsodon* is represented by two species in the Chalk, and by the same number in the London Clay, above which it does not range. The *Notidanus* is another common chalk genus which is often found in the London Clay. The genus *Otodus*, of which also several species occur in the Chalk, is a very common form in the London Clay. This genus, however, as well as the last, ranges higher, although both become scarcer. Altogether the eighty-three species of fishes belong to twenty-three families, of which eleven existed during the Cretaceous period; several of the genera do not extend upward beyond the London Clay, whilst others appear in much diminished numbers. The cretaceous affinities of some of the families of fishes found at Sheppey were, I find, made the subject of

Venus (*Cytherea*) *ovalis*, figured in the 'Mineral Conchology,' one is from the Greensand of Blackdown, and another (as probable) from the Lower Tertiary sands of the neighbourhood of Faversham. It would seem also that the *Pholadomya Koninckii*, which is now considered a tertiary species, was, I am informed by Mr. Morris, originally figured with the inference of its being a cretaceous specimen.

remark by Agassiz in his 'Poissons Fossiles.' At the same time, notwithstanding the presence of so many old forms, the London Clay shows, in another portion of its fish-remains, a close analogy with the ordinary families and genera existing at the present day—some in warmer climates, but a not inconsiderable number identical with those frequenting the existing coasts*.

The Corals of the London Clay and of the Bracklesham Sands belong chiefly to different families ; the latter are closely related to the forms prevalent in the Paris Basin ; whilst the former, with a certain amount of resemblance to some of these species, exhibit marked differences and divergent relations. Of the *Turbinolidæ* there are four genera in the London Clay, three of which belong to that section, the "*Cyathinæ*," which has several representatives in the Chalk and Gault especially. Of the section *Turbinolinæ* there are, on the contrary, one species in the London Clay and seven in the Bracklesham Sands. The *Eupsammidæ* furnish also four genera ; the species which occurs in the London Clay, the "*Stephanophyllia discoides*," is of the flat lenticular form peculiar to the Cretaceous section of this genus. The other three genera occur in the Bracklesham Sands. The *Pennatulidæ* and *Gorgonidæ*, of which there are three species in the London Clay and one in the Bracklesham Sands, are however distinctly Tertiary families.

The Mollusca present a more decided tertiary *facies*, but still even in this respect the Bracklesham group exhibits features more marked than the London Clay. Amongst the *Lamellibranchiata* of the latter there are but few genera which are not of older date, 26 out of the 31 commencing in the Cretaceous or Oolitic series ; in the Bracklesham Sands there are in addition to these 4 more Tertiary and 15 older genera. Amongst the *Gasteropoda* there is a far larger introduction of new genera ; for of the 44 genera in the London Clay, 16, and of the 59 genera in the Bracklesham Sands, 27 make their first appearance in the Tertiary period. The common occurrence of *Cephalopoda* is a feature to be noticed.

With regard to the distribution of the species in the tertiary strata, if we take the 56 species of the lower London tertiaries, in addition to the 224 species of the London Clay, we have together 280 species, 212 of which do not pass into the overlying strata. Of the 109 genera peculiar to the Bracklesham Sands, there are about 11 which do not descend lower in the English series.

It is doubtful whether there are any extinct genera peculiar to the

* Although the abundance of fishes is a very striking feature in the London Clay, it must not be overlooked that these strata may owe much of their superiority in this respect to their very favourable mineral conditions ; for in the more open, non-concretionary, and coarser arenaceous sediment of the Bracklesham beds and *Calcaire grossier*, the fishes, owing to their perishable character, might have been removed before they could be fixed by fossilification ; whereas in the fine calcareo-argillaceous sediment of the London Clay, the segregating action of the carbonate of lime, setting in as soon as the fish-remains became imbedded in the sediment at the sea-bottom, would quickly and effectually stop the progress of decay, by enclosing them in those concretionary masses of argillaceous limestone in which they are now chiefly found.

London Clay, with the exception possibly of the *Teredina*, which however is probably only a subgenus of *Teredo*.

Unlike the succeeding Tertiary period, the number of Mammalia in the London Tertiaries is very limited. One genus (*Macacus*) is a form now existing, whilst the *Hyracotherium* and *Coryphodon* are extinct and peculiar to the London Clay. The *Lophiodon* is a genus which, scarce in this period, becomes numerous in the overlying group. No mammalian remains have hitherto been found in the lowest division of the London Tertiary group,—the Thanet Sands.

The remains of birds are too few and too fragmentary to have much specific value; nor, as bones of birds are found in the Wealden, are they of importance with respect to their presence as a class.

The large proportion of Reptiles is a peculiar feature; they mostly belong to families and genera which have a prolonged vertical range from the Wealden strata upwards. Although the peculiar and characteristic Cretaceous genera are absent, the prevalence nevertheless of Reptilian forms and the scarcity of Mammals are not without a certain significance.

§ 3. *General Considerations.*

It will be seen from the foregoing examination, that the relationship of the London Tertiaries with the Bracklesham Sands is maintained by several specific identities, and is therefore one comparatively of no distant degree; still the generic differences of the fauna which are so marked in the tertiary strata of the age of the Bracklesham and associated series, as compared with the cretaceous strata, are certainly less prominent in the strata of the London Tertiary group. Although it is true that with one or two exceptions there are no species in common to the two latter series, yet the *facies* of the fauna often presents points of strong resemblance, and a not inconsiderable number of genera are common to the two periods*. It is to be observed also, that in the London Tertiaries not a single recent species is found with the exception of the *Terebratulina striatula*, which species however is common also to the Cretaceous period.

Taking all these facts into consideration, I hold the distinction between the London Clay and the Bracklesham Sands not only to be sufficiently evident upon physical grounds, but to be equally well based on the independent character, in the main, of their organic remains. All the phænomena point to an original difference in the direction of the seas and position of the land. The London Tertiary group seems to have resulted in that order of changes, which, commencing with the elevation of a portion of the Chalk area at the end

* We know how difficult the separation of the cretaceous and tertiary deposits is in some parts of Southern Europe, where the strata of these two periods present similar lithological characters, and exhibit like conditions of life. Might we not therefore expect to find similar or even greater resemblances in these possibly still lower strata of the London Tertiaries, were the mineral character assimilative instead of divergent, and were the terms of comparison alike, instead of being in the strong contrast in which they occur in this more northern part of Europe?

of the Maestricht period, was followed by subsequent depressions which led to the transgressive accumulation of the Lower Tertiaries from north to south. This elevation, I believe, laid dry the Chalk in some direction southward, and would therefore induce one to look to the north for a more uninterrupted succession of the Upper Cretaceous and Lower Tertiary strata. I am now speaking with reference only to that part of the north of Europe over which the Paris, Belgian, and English Tertiaries extend. I have before shown the probability of the existence of dry land to the south and an open sea to the north, during the Thanet Sands period, and of more insular conditions during the Woolwich and Reading series period; and now with respect to the London Clay, the evidence tends in the same direction. With one exception, which proved unimportant, I have never found any transported rock-fragment in the London Clay that would enable me to infer the direction of the land and its main rivers during that period. If, however, we take the evidence afforded by the organic remains, we shall obtain some peculiar results. If, for example, we look to the Molluscs and the Plants, we at once perceive a want of accordance between them; we find in the former an absence of that group of markedly tropical forms which seem to have flourished in the later sea of the Bracklesham period. The prevailing genera are, on the contrary, mostly such as could live in colder regions. Taken altogether, it rather indicates a moderate than a tropical climate, and yet the flora is, as far as we can judge, certainly tropical in its affinities. It is interesting to observe at this early Tertiary period the same evidence of those climatal conditions dependent upon latitude which become more strongly marked as we approach our own period; for these differences in the fauna and flora arise, I believe, from the circumstance that the London Clay was deposited in a sea open to the north, and therefore with an in-set of cold currents determining the existence of a group of molluscs, such as we might expect to find inhabiting waters of moderate temperature; whilst, judging from *the quantity and extent of detritus*, there probably existed to the south an extensive continental area, through which flowed a large river which brought down the sediment forming the London clay, and all the marvellous remains of plants and of land and freshwater remains entombed in it—remains which seem to point to a vegetation of hot or even tropical climates, and to a land fauna in keeping with such a temperature. If this were the case, then we should have during the London-Clay period a continental area stretching southward of England and the north of France, and a sea spreading to the northward of this land; while the subsequent accumulation of the Bracklesham Sands took place after the submergence of that land and the immigration of a marine fauna from more southern seas, into which some few only of the forms of the older sea were continued,—geographical conditions which I hope, in a subsequent paper, to show to be in perfect accordance with the limited range southward of the London Clay and the correlation of the Bracklesham Sands with the wide-spread deposits of the *Calcaire grossier* and other associated beds of the Paris Tertiaries.

We thus see that, while the *London Tertiaries* form a group distinctly separable from the Bracklesham series (which belongs to the Paris group), with which however it possesses a certain community of species and a generally analogous *facies*, although in many of the classes of organic remains there is nothing, or almost nothing in common, yet the former maintain almost unimpaired their Tertiary attributes. Still the one or two cretaceous species which have been found in the London Tertiaries, combined with the more antique cast of some of the fishes, corals, and echinoderms, and a certain cretaceous *facies* in some of the molluscs, may form a link connecting them distantly with the Cretaceous period. But many intermediate links are yet wanting, probably of the Tertiaries, and certainly of the Cretaceous series; for it must not be forgotten that in England the Tertiaries repose upon the *Middle Chalk*, to which belongs the chalk with flints of Gravesend and the neighbourhood, usually termed the Upper Chalk, but which I have elsewhere* shown to be the middle beds of that deposit. To have just terms of comparison, we need a Cretaceous series with a varied marine æstuarine and fluviatile fauna, such as flourished during the successive Tertiary periods†. We have already in the Maestricht beds a change in the fauna—a dying-out of many old forms, and the appearance of many genera common in the Tertiary series, and I look forward with much interest to the important addition likely to be made before long by M. Hébert to our knowledge of the molluscs of the *Calcaire pisolitique*, which beds carry us probably still higher in the series. Still in these we want the mud-banks, the river-courses, and the brackish water estuaries of the Tertiary seas.

In some respects the London Tertiaries, taken as a whole, are however even more tertiary (meaning by that, that they present, in many of the generic forms, a closer approach to those now existing in our climate) than the Bracklesham Sands; for, with a greater per-centage of older forms, they nevertheless contain a large, and probably a larger, proportion of forms such as now flourish on the land and in the sea in these latitudes. The greater number of the common fishes frequenting our seas have their types at this early Tertiary period,—the Reading plants are such as our existing woods might furnish the analogues of,—and the Molluscs, the Lamellibranchiates especially, have many representative forms in our present seas. In considering all these singular vicissitudes, and in contemplating the extent to which certain more northern influences operated in giving to a large portion of the fauna of the London Tertiaries an aspect much more closely resembling that of the present day than is found to exist in many more recent deposits, the question suggests itself—of how far that law, enunciated by Prof. E. Forbes, and according to which the distribution of Molluscs in depths of southern seas is equivalent to their appearance at lesser depths or at the surface in parallels of latitude of more northern seas,

* "The Water-bearing Strata of London," p. 139.

† Can those singular and anomalous beds beneath all the known Tertiaries at Mons, and which contain freshwater shells, belong to any such Upper Cretaceous period?

may by analogy be applied geologically in accounting for any abnormal condition in the vertical succession of organic remains such as here occurs? Can it be that such a group of generic forms, allied to and closely resembling those found in the same zoological province at the present day, had a yet older existence in more northern provinces;—that generic forms of temperate regions have travelled from the north, and have been gradually spread further south, giving, when they encroached upon the more southern forms, a more recent aspect to the faunas of such various geological periods than prevailed in those of the same localities when changes in the distribution of land and water brought back for a time the southern forms which had been temporarily displaced?—a view almost unavoidably suggested by the fauna of the London Tertiaries as compared with that of the Bracklesham and associated beds, and confirmed by the independent physical evidence which we have of seas open to the north during the former, and to the south during the latter period.

Appendix.

List of the Fossil Shells from the Eocene strata of Bracklesham Bay, Sussex. By F. E. Edwards, Esq.

(The species in italics occur also in the London Clay.)

Mollusca.

Cephalopoda.

Aturia ziczac, Sow.
Beloptera belemnitoidea, *Blainv.*
Belosepia Blainvillii, *Desh.*
—— brevispina, *Sow.*
—— Cuvieri, *Desh.*
—— *sepioidea*, Blainv.
Nautilus centralis, Sow.
—— *imperialis*, Sow.

Gasteropoda.

Actæon crenatus, Sow.
—— *simulatus*, Brand.
—— sulcatus, *Lam.*
——, n. sp. 1.
Adeorbis planorbicularis, *Desh.*
Ampullina depressa, *Sow.*
—— pachycheila, *Sow.*
—— *patula*, Lam.
Ancillaria buccinoides, *Lam.*
—— canalifera, *Lam.*
—— fusiformis, *Sow.*
—— obtusa, *Sow.*
Aporrhais Sowerbii, Mant.
Bifrontia bifrons, *Lam.*
—— disjuncta, *Desh.*
—— Laudinensis, *Desh.*
—— marginata, *Desh.*
Borsonia biplicata (*Fasciolaria*), *Sow.*
Buccinum stromboides, *Lam.*
Bulla attenuata, Sow.
—— Defrancii, *Desh.*
—— Edwardsii, *Sow.*
—— elliptica, *Sow.*
—— expansa, *Sow.*
—— extensa, *Sow.*
—— lanceolata, *Sow.*
—— Sowerbyi, *Nyst.*
—— uniplicata, *Sow.*
Cancellaria costulata, *Lam.*
—— evulsa, *Brand.*
—— *quadrata*, Sow.
—— striatulata, *Desh.*
Cassidaria ambigua, *Brand.*
—— coronata, *Desh.*
—— *nodosa*, Brand.
——, n. sp.
Cerithium angulatum, *Brand.*
—— calcitrapoides, *Lam.*
—— cancellatum, *Sow.*
?—— *concinnum*, Charlesw.
—— Cordieri, *Desh.*
—— cornucopiæ, *Sow.*
—— cristatum, *Desh.*
—— echidnoides, *Lam.*
—— elegans, *Desh.*
—— giganteum, *Lam.*
—— incomptum, *Sow.*
—— margaritaceum, *Brongn.*
—— marginatum, *Sow.*
—— muricoides, *Lam.*

Cerithium mutabile, *Lam.*
—— papale, *Desh.*
—— semicoronatum, *Lam.*
—— semigranulosum, *Lam.*
—— turris ?, *Desh.*
—— unisulcatum, *Lam.*
—— variabile, *Desh.*
——, sp. new or not ident. 6.
Conus corculum, *Sow.*
—— deperditus, *Lam.*
—— diversiformis, *Desh.*
—— pyriformis, *Sow.*
—— velatus, *Sow.*
Cypræa Bowerbankii, *Sow.*
—— globularis, *Edw.*
—— inflata, *Lam.*
—— tuberculosa, *Desh.*
Daphnella juncea (*Buccinum*), Sow.
Delphinula Warnii, *Desh.*
?*Dentalium acuticosta*, Desh.
—— costatum, *Sow.*
—— eburneum, *Lam.*
—— *nitens*, Sow.
Emarginula obtusa, *Sow.*
Eulima subulata ?, Mont.
Fasciolaria uniplicata, *Lam.*
Fissurella Edwardsii, *Sow.*
Fusus acuminatus, *Sow.*
—— *bulbus*, Brand.
—— *carinella*, Sow.
—— errans, *Brand.*
—— Gothicus, *Desh.*
—— incultus, *Sow.*
—— læviusculus, *Sow.*
—— longævus, *Lam.*
—— Noæ, *Lam.*
—— parvirostrum, *Sow.*
—— *porrectus*, Brand.
—— pyrus, *Brand.*
—— regularis, *Sow.*
—— rugosus, *Lam.*
—— scalaris, *Lam.*
—— *undosus*, Sow.
—— unicarinatus, *Desh.*
——, sp. new or not ident. 3.
Globulus ambulacrum, *Sow.*
—— conoideus, *Sow.*
—— hybridus, *Lam.*
—— *labellatus*, Lam.
—— ponderosus, *Desh.*
—— scalariformis, *Desh.*
—— Willemettii, *Desh.*
Hipponyx cornucopiæ, *Defr.*
Infundibulum trochiforme, Sow.
Littorina sulcata, Pilk.
Marginella bifidoplicata, Charlesw.
—— eburnea, *Lam.*
—— ovulata, *Lam.*
Melania costellata, *Lam.*
—— marginata, *Lam.*
——, n. sp. 1.
Mitra labratula, *Lam.*
?—— *parva*, Sow.
—— porrecta, *Edw.*
Murex asper, *Brand.*
—— *minax*, Brand.
Natica epiglottina, *Lam.*
—— *Hantoniensis*, Sow.
—— lineolata, *Desh.*
—— obovata, *Sow.*
—— similis, *Sow.*
—— sphærica, *Desh.*
—— turgida, *Sow.*
Nerita tricarinata, *Lam.*
Niso terebellatus, *Desh.*
Odostomia, n. sp. 2.
Oliva, n. sp.
Orbis patellatus, *Lam.*
Parmophorus ? elongatus, *Lam.*
Patella striata, *Sow.*
——, n. sp. 1.
Phorus agglutinans, *Lam.*
—— *extensus*, Sow.
——, n. sp. 1.
Pileopsis squamæformis, *Lam.*
Planaria ?, n. sp. 1.
Pleurotoma acutangulosa, *Desh.*
—— amphiconus, *Sow.*
—— attenuata, *Sow.*
—— curvicosta, *Sow.*
—— dentata, *Lam.*
—— exorta, *Brand.*
—— gentilis, *Sow.*
—— granulata, *Lam.*
—— inarata, *Sow.*
—— inflexa, *Lam.*
—— obscurata, *Sow.*
—— *plebeia*, Sow.
?—— *prisca*, Brand.
—— transversaria, *Lam.*
——, sp. new or not ident. 8.
Pseudoliva obtusa, *Desh.*
—— ovalis, *Sow.*
—— *semicostata*, Desh.
Pyrula lævigata, *Lam.*
—— nexilis, *Lam.*
—— *tricostata*, Desh.
Ringicula ringens, *Lam.*
Rissoa.
Rostellaria ampla, Brand.
—— arcuata, *Sow.*
—— *lucida*, Sow.
Rotella minuta, *Sow.*
Scalaria acuta, *Sow.*
—— interrupta, var., *Sow.*
—— *reticulata*, Brand.
—— *semicostata*, Sow.
—— spirata, *Nyst.*
—— tenuilamella, *Desh.*
——, n. sp. 1.
Sigaretus canaliculatus, Sow.
Skenea.

Solarium canaliculatum, Lam.
—— *patulum*, Lam.
—— plicatum, *Lam.*
—— pulchrum, *Sow.*
—— spectabile, *Sow.*
—— spiratum, *Lam.*
—— trochiforme, *Desh.*
——, n. sp. 2.
Strepsidura armata, *Sow.*
—— turgida, *Brand.*
Terebellum fusiforme, *Lam.*
Triton argutus, *Brand.*
—— expansus, *Sow.*
Trochus, n. sp.
Turbo plicatus, *Desh.*
Turritella abbreviata, *Desh.*
—— bicincta, *Sow.*
—— carinifera, *Desh.*
—— contracta, *Sow.*
—— fasciata, *Lam.*
—— *imbricataria*, Lam.
—— intermedia, *Desh.*
—— marginata, *Sow.*
—— multisulcata, *Lam.*
—— nexilis, *Sow.*
—— sulcata, *Lam.*
—— sulcifera, *Desh.*
—— terebellata, *Lam.*
Voluta angusta, *Desh.*
?—— athleta, *Brand.*
—— Branderi, *Desh.*
—— calva, *Sow.*
—— cithara, *Lam.*
—— crenulata, *Lam.*
—— horrida, *Edw.*
—— humerosa, *Edw.*
—— maga, *Edw.*
—— muricina, *Lam.*
—— *nodosa*, Sow.
—— recticosta, *Sow.*
—— Selseiensis, *Edw.*
—— Solandri, var., *Edw.*
—— spinosa, *Lam.*
—— uniplicata, *Sow.*

Lamellibranchiata.

Anomia lineata, Sow.
Arca Branderi, *Sow.*
—— duplicata, *Sow.*
—— interrupta, *Lam.*
——, n. sp. 1.
Avicula media, Sow.
Cardilia læviuscula, *Sow.*
Cardita acuticosta, *Lam.*
—— elegans, *Lam.*
—— mitis ?, *Lam.*
—— planicosta, *Lam.*
——, n. sp. 2.
Cardium alternatum, *Sow.*
—— hippopæum, *Desh.*
—— ordinatum, *Sow.*
Cardium porulosum, *Lam.*
—— semigranulatum ?, *Sow.*
——, n. sp. 1.
Chama calcarata, *Lam.*
—— gigas, *Desh.*
Clavagella coronata, *Desh.*
Corbula costata, *Sow.*
—— Gallica, *Lam.*
—— *globosa*, Sow.
—— longirostris, *Desh.*
—— pisum, *Sow.*
—— plicata, *Sow.*
—— rugosa, *Lam.*
—— striata, *Lam.*
Crassatella compressa, *Lam.*
—— plicata, *Sow.*
—— rostrata, *Lam.*
——, n. sp. 2.
Cypricardia carinata, *Desh.*
—— oblonga, *Desh.*
—— pectinifera, *Sow.*
Cyrena, n. sp.
Cytheræa elegans, *Lam.*
—— lucida, *Sow.*
—— nitidula, *Lam.*
—— *obliqua*, Desh.
—— striatula, *Desh.*
?—— *suberycinoides*, Desh.
—— sulcataria, *Desh.*
—— trigonula, *Desh.*
——, n. sp. 2.
Diplodonta dilatata, *Sow.*
Gastrochæna corallium, *Sow.*
Goodhallia ? granulosa, *Edw.*
Kellia ? compressa, *Edw.*
Lima expansa, *Sow.*
Limopsis granulatus, *Lam.*
Lithodomus Deshayesii, *Sow.*
Lucina immersa, *Sow.*
—— mitis, *Sow.*
—— serrata, *Sow.*
——, n. sp. 9.
Mactra depressa, *Desh.*
—— filosa, *Edw.*
—— semisulcata, *Lam.*
Modiola elegans, Sow.
Neæra argentea, *Lam.*
——, n. sp. 2.
Nucula bisulcata, *Sow.*
—— *minima*, Sow.
—— ovata ?, *Desh.*
—— serrata, *Sow.*
—— *similis*, Sow.
—— *striata*, Lam.
Ostrea dorsata, *Desh.*
—— elegans, *Desh.*
—— elephantopus, *Sow.*
—— flabellula, *Lam.*
—— inflata, *Sow.*
—— longirostris, *Lam.*
—— picta, *Sow.*

Ostrea radiosa, *Desh.*
—— *tenera*, Sow.
Panopæa corrugata, *Sow.*
Pecten corneus, Sow.
—— plebeius, *Lam.*
—— 40-radiatus, *Sow.*
—— reconditus, *Sow.*
—— squamula, *Lam.*
—— 30-radiatus, *Sow.*
——, n. sp. 1.
Pectunculus globosus, *Sow.*
—— pulvinatus, *Lam.*
Pinna margaritacea, Lam.
Psammobia compressa, *Sow.*
Sanguinolaria Hollowaysii, *Sow.*
Solen Dixoni, *Sow.*
—— obliquus, *Sow.*
—— vagina, ? *Lam.*
Solenocurtus Parisiensis, *Desh.*
Spondylus rarispina, *Desh.*
Syndosmya splendens, Sow.
Tellina canaliculata, *Edw.*
—— concinna, *Edw.*
—— dis-stria, *Edw.*
—— donacialis, *Lam.*
—— filosa, *Edw.*
—— lamellosa, *Edw.*
—— lunulata, *Desh.*
—— obovata, *Edw.*
—— plagia, *Edw.*
—— reflexa, *Edw.*
—— rhomboidalis, *Edw.*
—— scalaroides, *Lam.*
—— speciosa, *Edw.*
—— tenuistriata, *Desh.*
—— textilis, *Edw.*
—— tumescens, *Edw.*
Teredo antenautæ, Sow.
Thracia sulcata, *Sow.*

Brachiopoda.

? *Terebratulina striatula*, Sow.

ANNELIDA.

?*Serpula flagelliformis*, Sow.
—— *heptagona*, Sow.
Serpula ornata, *Sow.*
——, n. sp. 2.

To this list of the shells by Mr. Edwards I now add lists of the other organic remains, which, with the exception of the Fishes, had not been sufficiently studied to admit of special enumeration at the time my former papers on the London Clay and the Bagshot Sands were published*.

MAMMALIA.

Lophiodon minimus, *Cuv.*

REPTILIA.

Chelone convexa, Owen ?
—— *longiceps*, Owen ?
—— trigoniceps, *Owen.*
Gavialis Dixoni, *Owen.*
Palæophis porcatus, *Owen.*
—— typhœus, *Owen.*
Trionyx, sp.

PISCES.

Ætobatis convexus, *Dix.*
—— *irregularis*, Ag.
—— marginalis, *Dix.*
—— rectus, *Dix.*
—— *subarcuatus*, Ag.
—— subconvexus, *Dix.*
Carcharodon angustidens, Ag.
Cœlorhynchus rectus, Ag.
—— sinuatus, *Ag.*
Edaphodon Bucklandi, *Ag.*
Edaphodon eurygnathus, *Ag.*
—— leptognathus, *Ag.*
Elasmodus Hunteri, Owen.
Galeocerdo latidens, *Ag.*
Lamna elegans, Ag.
Myliobatis contractus, *Dix.*
—— *Dixoni*, Ag.
—— Edwardsii, *Dix.*
—— irregularis, *Dix.*
—— *striatus*, Ag.; *sp.* Dix.†

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* These I have taken chiefly from the list given by the late Mr. Dixon in his 'Geology of Sussex,' and from the publications of the Palæontographical Society before referred to. I am indebted to Mr. Rupert Jones for the list of Entomostraca.

† Mr. Dixon figures this specimen as *M. Toliapicus*, but he states that it differs from Agassiz' species in being punctated instead of striated or plicated. I hesitate, therefore, to admit this identification.

Naisia apicalis, *Münst.*
Otodus lanceolatus, *Ag.*
—— *obliquus*, Ag.
Periodus Kœnigii, Ag.
Platylæmus Colei, *Dix.*
Pristis contortus, *Dix.*
Silurus Egertoni, *Dix.*
Sphyrænodus gracilis, *Dix.*

Bryozoa.

Cellepora? petiolus, *Lons.*
Eschara Brongniarti, *M.-Edw.*?
Idmonea coronopus, *Defr.*?
*Lunulites urceolatus, *Lamx.*

Crustacea.

Cythere (Cytherella) Munsteri, *Rœm.*
—— (Cythereis) cornuta, *Rœm.*
—— (——) horrescens, *Bosq.*
—— (——) lichenopora, *Bosq.*
Cythere (Cythereis) striatopunctata, *Rœm.*
*—— (——) plicata, *Münst.*
Macrura, 2 or 3 species undet. (*Dixon*).

Echinodermata.

Echinopsis Edwardsii, *Forb.*

Zoophyta.

Astrocænia pulchella, *M.-Edw.*
Balanophyllia desmophyllum, *M.-Edw.*
Dendrophyllia? sp., *Lons.*
Diphelia papillosa, *M.-Edw.*
Oculina conferta, *M.-Edw.*
——? dendrophylloides, *Lons.*
—— raristella, *Defr.*
Paracyathus crassus, *M.-Edw.*
Porites? panicea, *De Blainv.*
Siderastræa Websteri, *Bowerb.* (*Astræa Ameliana*, Defr.?)
Stereopsammia humilis, *M.-Edw.*
Stylophora emarciata, *Lam.*
—— monticularia, *Schw.*
Turbinolia Dixoni, *M.-Edw.*
—— sulcata, *Lam.*

Foraminifera.

Alveolina elongata, *D'Orb.*? (*Dixon*).
—— fusiformis, *Sow.*
Nummulites lævigatus, *Lam.*
—— scaber, *Lam.*
—— variolarius, *Lam.* (*N. radiatus*, Sow. in Dixon).
Biloculina, sp.
Quinqueloculina Hauerina, *D'Orb.*
Rotalia obscura, *Sow.*
Triloculina cor-anguinum, *Lam.*

Plantæ.

Cucumites variabilis, Bowerb.
Lycopodites squamatus, Brong.
Pinites Dixoni, *Bowerb.*

* These species occur in the Lower Tertiary Sands.

June 21, 1854.

The following communications were read :—

1. *On the* Correlation *of the* Lower Tertiaries *of* England *with those of* France *and* Belgium. By Joseph Prestwich, Esq., Jun., F.R.S., F.G.S.

[Abstract.]

[The publication of this paper is postponed.]

In this paper Mr. Prestwich treated of those Tertiary beds which, commencing immediately above the Chalk, are in England limited superiorly by the Bracklesham Sands; in France, by the *Calcaire* *grossier*; and in Belgium, by the *Système Bruxellien* of M. Dumont; and he endeavoured to show the exact correlation of the several divisions of these lower tertiaries, and claimed for the "London Tertiaries," as a group, a distinct and separate position beneath that of the Paris group, of which latter the *Calcaire grossier* may be taken as the centre and type. The chief points of importance are—that the Lower Bagshots are the equivalents of the *Lits coquilliers*; and that the well-known *Sable de Bracheux*, with its marine fossils, corresponds with the lower part of the Woolwich series.

The author first pointed out that the known equivalents among the Tertiary beds in question are—

1. Calcaire grossier, France = Bracklesham Sands, England = Système Bruxellien, Belgium.

2. Lits coquilliers, France = Syst. Ypresien supérieur, Belgium. (The zone of *Nummulites planulatus*.)

3. Lignites of the Soissonnais = Fluviatile beds of Woolwich and Lewisham.

Mr. Prestwich then described in detail the grouping of the tertiary strata in France, Belgium, and England respectively; and, having pointed out the local differences and peculiarities exhibited by these deposits, he entered upon a detailed comparison of the different divisions of the tertiaries of the several districts.

Beginning with the lowest tertiaries, Mr. Prestwich dwelt upon the correlation of the Thanet Sands of the South-east of England with the Lower Landenian of Belgium, and showed that this series is wanting in the Paris Basin. The Woolwich and Reading series of England is the Upper Landenian of M. Dumont in Belgium; and its lower, middle, and upper divisions are, according to the author, the equivalents, respectively, of the *Glauconie inférieure et Sables inférieurs, lignites et argiles plastiques*, and the *grès et poudingues* of the Soissonnais; whilst at Paris the middle division only, the *argile plastique*, is represented, and lies immediately on the Chalk.

The series next in ascending order is the London Clay, which Mr. Prestwich regards as a clearly defined group, with well-marked testaceous types. This, in Belgium, forms the Lower Ypresian of M. Dumont; and has recently been found by the author near Dieppe, but is wanting in the Paris and Soissonnais districts. In fact, the London Clay dies out southward towards Lille, thus indicating the limits of this old sea on the shore of a southern continent.

This area having been subsequently depressed, the whole region was occupied by the sea in which the Bagshot series was deposited. The lower portion of this group is represented—by the sands below the Bracklesham beds in Hants,—by the Lower Bagshots of the London district,—the Upper Ypresian and the Panisilian combined, in Belgium,—and by the *Lits coquilliers* (which the author here defined), in the Soissonnais district. The middle portion is represented by the Bracklesham beds in Hants,—the middle Bagshots in the London district,—the *Système Bruxellien* of M. Dumont,—and the *Calcaire grossier* of the Soissonnais and Paris. In the last-named locality (Paris), the *calcaire grossier* rests on the *argile plastique*, and this on the Chalk, as the equivalents of the Lower Bagshots and the Thanet Sands are here wanting.

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2. *On the* ORNITHOIDICHNITES *of the* WEALDEN.
By S. H. BECKLES, Esq., F.G.S.

[PLATE XIX.]

IN two former papers communicated to the Geological Society* I observed that certain large trifid bodies, presenting a resemblance to the casts of the impressions of birds' feet, were numerous in the cliffs to the east and west of Hastings; and I suggested, from certain uniform peculiarities which these gigantic tridactyle impressions, or rather casts of impressions exhibited, that they might be really foot-marks of birds.

Up to the date of my first notice, my discoveries of these colossal casts were limited to the east of Hastings and Bulverhithe, but my continued investigations enabled me to announce in my second communication that I had successfully traced them through the entire section of the Wealden rocks exposed on the coast, from Cliff's-end on the east of Hastings to Pevensey Sluice on the west.

Although these tridactyle casts were collectively numerous, they occurred for the most part on detached blocks of sandstone, and never on a surface sufficiently large to admit of three or four consecutive marks; and, although their number and regularity of form afforded good presumptive evidence of their being organic in their origin, yet these circumstances were insufficient to establish a truth where sequence of arrangement, distinct evidence of a phalangeal structure, or some other organic characters were indispensable; hitherto, therefore, these trifid bodies were not supposed to fulfil the necessary conditions of *footmarks*.

The uniformity of character, however, in the casts that I first examined had such an obvious connexion with a definite cause, as to convince me that they were either of organic origin, or the result of a uniform crystalline action; I knew of no mineral law by which to account for them, and I adopted the alternative†.

* Quart. Journ. Geol. Soc. vol. vii. p. 117; and *ibid.* vol. viii. p. 396. The occurrence of similar bodies found by Mr. Saxby, in the Isle of Wight, is alluded to by the late Dr. Mantell in his "Geol. Isle of Wight," &c. p. 247. Mr. Tagart's specimen (see Quart. Journ. Geol. Soc. vol. ii. p. 267) is in the Museum of the Geological Society; and a similar example is in the British Museum. In the Society's Collection there is also a large slab of Purbeck limestone, the surface of which is shaly and covered with coarse fucoidal (?) markings. In this shaly portion are two large, trifid, pachydactylous foot-marks, resembling those from the Wealden, each measuring 12 inches in length.

† With the extensive accumulation of these natural casts in my collection, I felt much surprise that men of real science should still pronounce them mere *accidental concretions.* The cause, whatever it was, so uniformly produced the same effects, whether in clay-rock, sandstone, or shale, as to be inconsistent with our idea of an accident. To reject these trifid bodies as organic phænomena, because

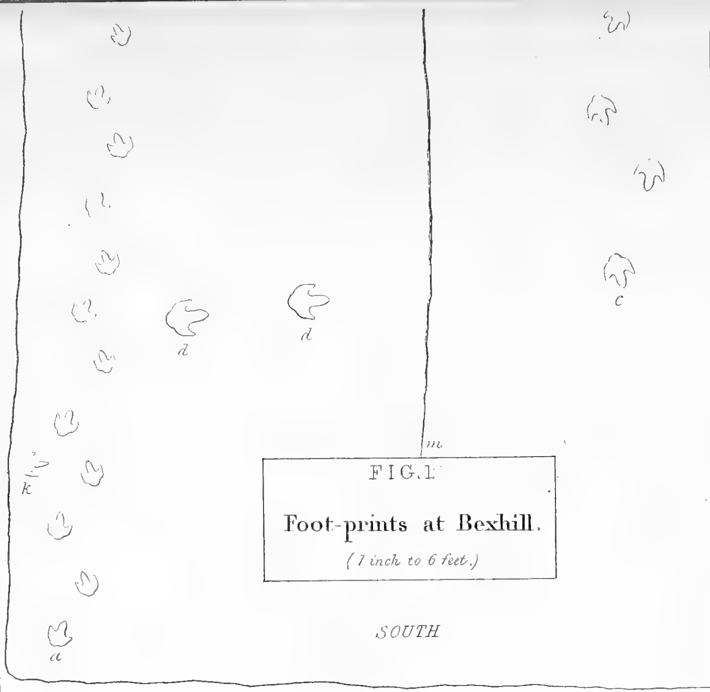
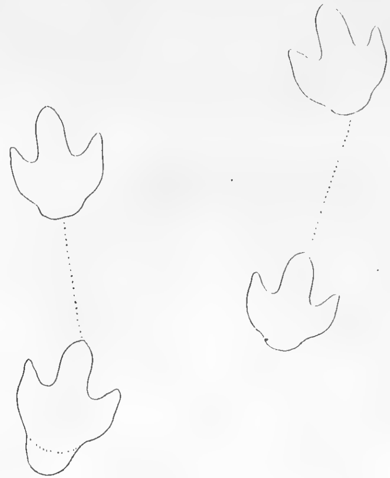


FIG. 1.

Foot-prints at Bexhill.

(1 inch to 6 feet.)

FIG 2.



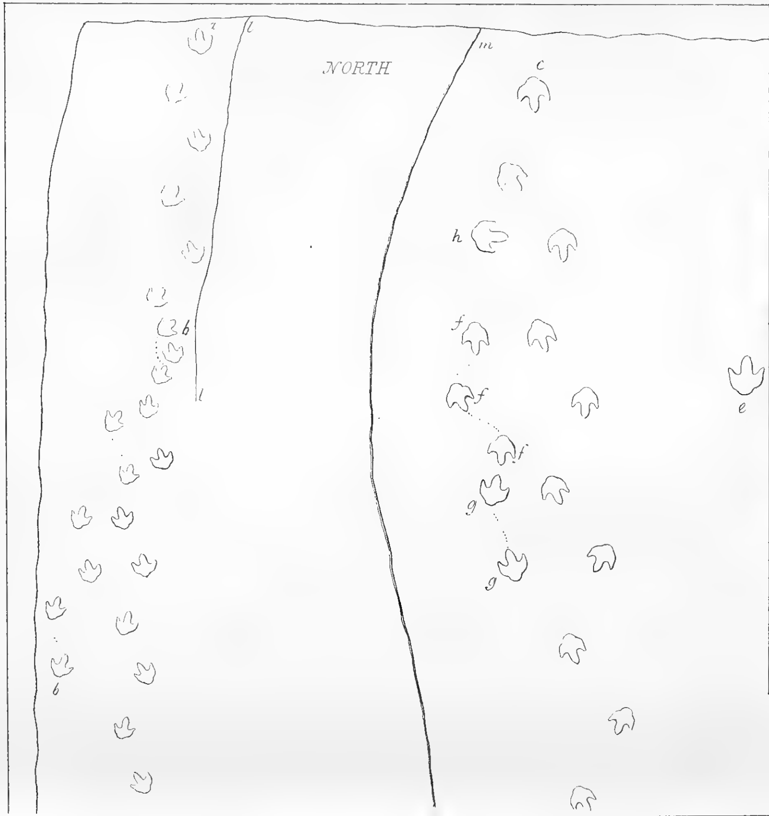
Foot prints. West of Galley Hill.

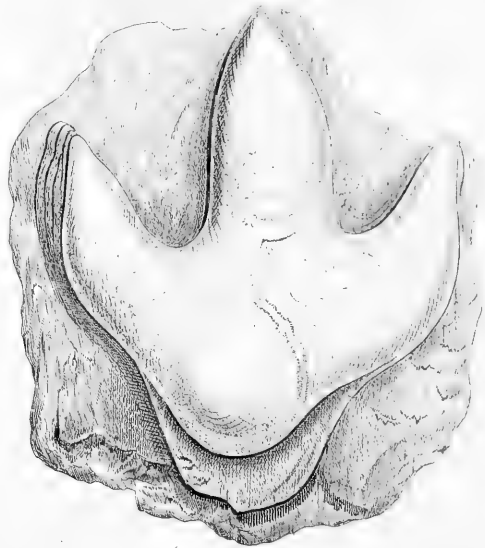
from the same band of Rock as Fig. 1.

(1 inch to 4 feet.)

FOOT-PRINTS IN THE WEALDEN ROCKS ON THE BEACH NEAR HASTINGS.

Achilles, lith. Printed by Malby & Sons.





(⅛ of original Size.)

Natural Cast of Foot-print.

from the Cliff, West of Hastings.

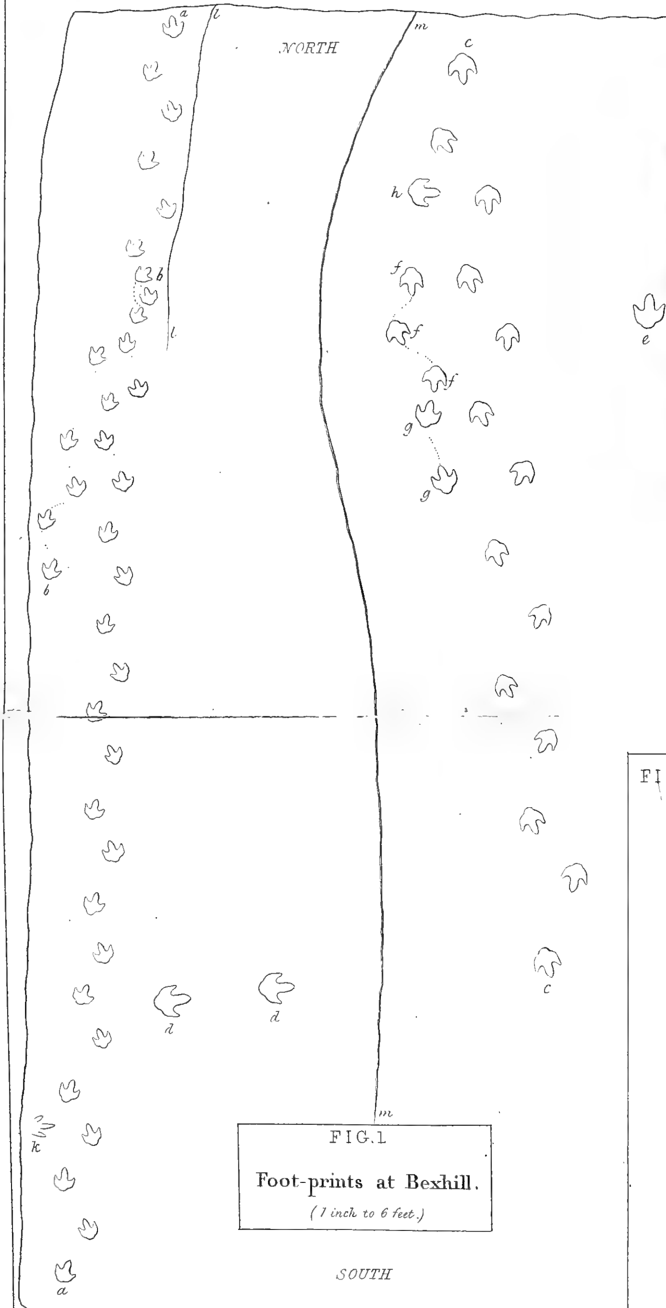
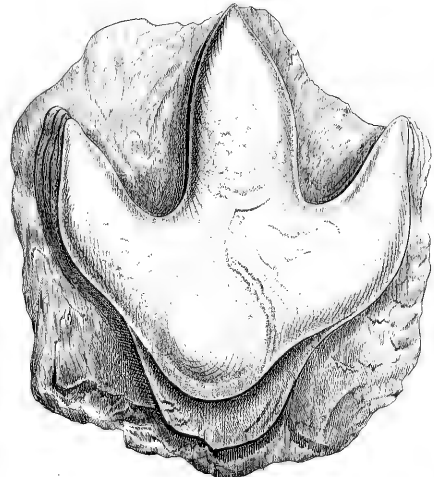


FIG. 1.

Foot-prints at Bexhill.

(1 inch to 6 feet.)



(⅓ of original Size.)

Natural Cast of Foot-print.

from the Cliff West of Hastings.

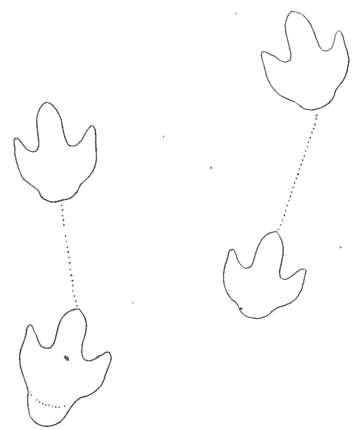


FIG. 2.

Foot prints. West of Galley Hill.

from the same band of Rock as Fig. 1.

(1 inch to 4 feet.)

FOOT-PRINTS IN THE WEALDEN ROCKS ON THE BEACH NEAR HASTINGS.

Achilles lith.

Printed by Malby & Sons.

No subsequent details proved unfavourable to my opinion, and I have watched with intense interest the successive exposure of these wonderful phænomena, until I have at length obtained such evidence of their being organic, as seems to establish the existence of a class of animals of stupendous bulk, and having tridactylous feet, during the Wealden epoch.

Geological position of the Ichnites.—I now have the gratification to announce the occurrence of the Ornithoidichnites of the Wealden in large numbers on the upper planes of strata of arenaceous clay or shale exposed at intervals from Bulverhithe to Cowden*.

This shale or soft sandstone constitutes the lowest member of the "Horsted group" of Dr. Mantell, in this locality. It is to be seen to the east of Bulverhithe, with a dip to the east; and, although it does not, I believe, appear at the top of the cliff, it is superior to it in geological position. It is next observed to the west of Galley Hill, whence it is no doubt prolonged subterraneously to Bexhill, where it again appears and rises abruptly into the low cliff or bank, and occupies a conspicuous and almost vertical position (see fig. p. 458); the strata having been here the scene of violent disturbance. Dipping to the west, it suffers an undulation which brings it to the surface at half a mile, and again at the distance of a mile to the west, or about three-quarters of a mile to the east of Cowden. At each of the above points I have found the characteristic Ichnites, while the intervening spaces, which are occupied by the upper members of the same stratigraphical series, have not as yet furnished these fossil footmarks, but have supplied organic remains which do not seem to extend to the subordinate beds†.

The relative position of the beds is shown in the accompanying section (p. 458) of a portion of the cliff at Bexhill. In this, No. 3 represents the shale in question, and No. 5 the ledge having the three impressions to which I shall hereafter allude‡.

Character of the Ichnites.—The impressions are all tridactylous

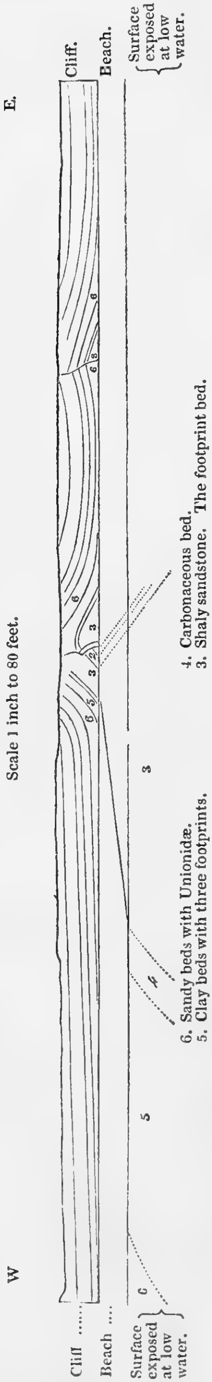
they may not happen to come immediately within the types of existing organization, would be a singular disregard of all those researches which are daily revealing the wonders of former epochs.

* I obtained a separate cast some time since between Cowden and Pevensey Sluice; I anticipate, therefore, that I shall find them *in situ* in this direction; if I do, it will probably be in the Cowden clays. The casts to the east of Hastings (Quart. Geol. Journ. vol. viii. p. 396, &c.) occur on a band of sandstone *subordinate* to, or perhaps constituting a part of Mr. Webster's "M. M." or lowest strata. If Dr. Mantell and Dr. Fitton have given the correct order of superposition, strata several hundred feet thick must be interposed between the footprints to the east of Hastings and those to the west of it. Their present elevation or level, however, is nearly the same.

† In the shale containing the footprints at Bexhill and half a mile to the west of it, I have found the same description of shells, while in the sandstone occupying the intermediate space, I have seen no trace of these, but at least five varieties of *Unionidæ*, both of large and small species.

‡ The occurrence of these impressions in bed No. 5, and of one cast in a course of hard stone in the Cowden clays, which are superior to the "Horsted group," warrant the supposition that the footprints exist more or less in all of these beds.

Section of a part of the Cliff at Bexhill.



and pachydactylous; the inner toe always the shortest; the middle one always the longest, and all of them directed forward; there are no satisfactory distinct phalangeal impressions, but in many examples the distal extremity of the terminal joint is distinctly traceable.

The impressions are disposed in tracks, and the toes of every two successive marks turn alternately right and left.

The impressions differ in size and present a variety in form; the stride also varies in length. The impressions or marks, however, composing a single track or line are uniform in size, and also uniform, or nearly so, in distance from each other; they point also in one general direction.

The marks do not occur in a right line, as in the case of the tracks of gallinaceous birds and in certain fossil footprints from the Connecticut Valley, but the two rows of tracks made by the right and left foot are immediately to the right and left of the line of direction, and the axis of the foot is turned inwards a few degrees towards that line. In this respect, but in this only, these impressions present a striking resemblance to the fossil footprints of the *Herpedactylus rectus,* and coincide with the habit of some recent birds.

The best of the natural casts of these impressions in my collection have a hemispherical or heel-like prominence, which is lateral and always on the side of the outer or longer lateral toe*. In *impressions* this peculiarity is not so obvious, as this part of the surface in usually concealed by adherent portions of the rock; but even in these instances, sufficient evidence exists to prove that the character is uniform.

It is important to add that, while my former evidence was derived from casts standing in relief on the under-plane of the overlying deposit, the present is furnished by marks on the upper and rippled†

* Probably the expansion of the proximal phalanx. See also Quart. Geol. Journ. vol. viii. pp. 396, 397, figs. 1 & 2.

† Where the surface had evidently been only recently excavated, I observed well-defined ripple-marks associated with the footprints.

surface of the substratum, or that deposit on which the animal walked; the majority of the marks, however, are not intaglio, or in the condition of clean impressions, but retain the whole or parts of the natural casts. The overlying sandstone having been worn down by attrition, and not undermined as when casts only are exposed, those portions of it remained which filled the trifidal indentations in the surface of the subjacent layer.

Series of Footprints No. 1. (Pl. XIX. fig. 1.)

The most instructive locality is contiguous to Bexhill, where, on an area of 400 square yards, sixty impressions were found on the surface of the rock at low water; they are disposed in tracks, directed for the most part either to or from the present beach, that is north or south; whilst some have an easterly direction. These impressions vary in size from 8 to 24 inches; but, although they must have been produced by at least six individuals, they might probably be referable to only two species of animals, five series being perhaps varieties in size rather than form, and belonging to the same species of animal at different ages of growth, while a single impression differed from the others both in form and size.

The diagram in the accompanying plate (Pl. XIX. fig. 1), drawn on a scale of $\frac{1}{6}$th of an inch to a foot, illustrates the surface of the rock, and shows the direction and disposition of the footprints.

The longest line, *a a*, has a northerly direction, and is composed of twenty-eight consecutive marks of the smallest size, the footprints being respectively about 8 inches long, and separated by intervals of about 17 inches, sometimes a little less; this track is crossed obliquely by a shorter line of eight marks, *b b* (directed towards the N.N.E.), of the same size, and also having a stride of 17 inches.

A third track of twelve marks, *c c*, each about 15 inches long (or nearly twice the length of the smallest), and about 19 inches apart, runs in a line almost parallel with track *a a*; but it points in an opposite direction (to the south), and is separated from it by an interval of 16 feet and a half at one extremity, and 11 feet 2 inches at the other.

Two consecutive marks, *d d*, the size of the last, but differing in the length of the stride, which is 3 feet 6 inches, form part of a line crossing *a a* at right angles. A single print *e*, also of the size of the last, occurs near the line *c c*, but points in a contrary direction.

Three consecutive prints, *f f f*, each 12 inches long, run parallel to part of the line *c c*; and are met by two others *g g*, also 12 inches in length, and parallel to *c c*, but pointing in an opposite direction.

One print, *h*, 21 inches in length, at right angles to *c c*; and two others, *i j*, each 24 inches long, at a distance from *c c*, and pointing to the north, complete the number that exhibit a more or less general similarity in form.

The solitary print *k*, crossing the line *a a*, has narrow toes, and is an exceptional form.

The slab of soft shaly sandstone exhibited to the meeting displays six of the footmarks from Bexhill; the five consecutive marks are the first five of the line *a a*, and the sixth mark is the single ichnite (*k*) crossing the track *a a*, at right angles between the fourth and fifth marks. In consequence of a fissure which passed longitudinally through the inner toe of the fourth mark and the outer toe of the fifth, the former was divided in two and the surface of the latter destroyed, in their transit from Bexhill to St. Leonard's; fortunately, however, the impressions were deep, and the integrity of both prints was preserved. Such was the incoherence of the stone, from the quantity of absorbed salt water, that a large amount of manual labour proved insufficient to remove it without producing the fractures now observed on its surface, and it was only after a slow process of drying that it acquired sufficient cohesion for its removal to town.

Series of Footprints No. 2.

The next place that contributes to the evidence is half a mile to the west of Bexhill and opposite to the Tower No. 47. Here tracks of impressions were so distributed over a surface of many hundred square yards as to yield neither in numbers nor interest to the preceding series. I have not had an opportunity of seeing this spot entirely free from loose sand, but tracks consisting of 2, 3, 5, 7, and 8 impressions were distinctly traceable, and some of them, continuing into lines of much greater length, no doubt traversed this extensive area in every direction.

One track deviated from a right line; but, with the exception of two extraordinary consecutive impressions, the ichnites here presented no new feature, either in form, size, or stride*. The important exceptions were almost of incredible dimensions; the largest, of which I obtained a specimen, measuring nearly 27 inches in length by nearly 24 in breadth, with a stride of 42 inches. The distal extremity of the ungual joint of the outer toe of each impression was more pointed than that of the inner, and turned inside of its axis,—peculiarities that I have observed in the best casts.

In my collection is a fine natural cast from Galley Hill; a portion of the middle toe is wanting, but the cast measures 23 inches from the tip of the heel to the tip of the outer toe; so that, by analogy, the extreme length of this splendid specimen must have been 27 inches, or of the size of those to the west of Bexhill.

Three disconnected impressions occurred some time since not far from Bexhill, on a ledge too narrow for two consecutive marks; one of these impressions measured 28 inches in length by 25 inches in breadth between the extremities of the lateral toes, proportions that greatly surpass in magnitude those of the most colossal footprints of the Triassic epoch†.

* In some impressions, particularly in a series to the west of Bexhill, the toes appear to be connected by intervening stone which suggests the idea of a web-footed animal; but this peculiarity is susceptible of other explanation.

† The *Brontozoum giganteum*, or colossal biped that produced the largest triassic footprints, is supposed to have been four or five times the size of the large African

Series of Footprints No. 3.

The locality next in importance occurs to the west of Tower No. 49. On an area not so large as either of the former, twenty-five impressions were disposed in three tracks; one track of eight impressions pointed obliquely to the beach; a second of twelve emerged from the beach, and passed in the direction of the sea; and a third of five marks, lying between these two, pointed in the direction of the beach; all of these impressions, and the stride in two of the tracks, show a correspondence to the line of prints *c c* in Pl. XIX. fig. 1; but the third track was characterized by the wide space of 3 feet 6 inches*. All of the impressions were yielding fast to ceaseless tidal attrition, but were sufficiently distinct to be convincing when I last saw them.

Series of Footprints No. 4.

Plate XIX. fig. 2. shows four impressions from the west of Galley Hill, reduced to a scale of $\frac{1}{4}$th of an inch to a foot. The coincidence of a long heel in one of the marks (a character corresponding better to lizards) and the singular approximation of the four impressions suggest that these footprints had been produced either by a four-footed animal, or by a biped having a breadth of body that enabled it to step at a great distance from the line of direction; but the two smaller impressions are on the same side, and the axis of the fore-foot is not parallel to that of the hind-foot. The absence also of certain other essential quadrupedal characters proves that these tracks were bipedal, and that they must have been produced by two individuals.

Had these impressions been the first and only series that I had seen, I must have regarded them with much suspicion. Their enormous proportions, the prolongation backwards of the heel of only one specimen, which has all the appearance of being a distinct character, and a roughness of outline resulting from unequal abrasion, seemed to divest these marks of all true organic pretensions; fortunately, however, two good casts in my collection came from this spot, and the larger specimen corresponds in size and relative proportions to two of these marks.

In the same locality four or five disconnected footprints occur, but too widely separated to be illustrated by a single diagram.

At Bulverhithe, where I have obtained many casts, a few impres-

Ostrich, yet the superficial measure of this gigantic foot could not have been one-third of that of the stupendous Wealden biped.

* The distance between impressions of the intermediate size seems to range from 19 inches to 24 in some tracks, and from 42 inches to 46 in others; while in the case of larger impressions, it appears to be uniformly from 42 inches to 46 inches. The shorter intervals were produced, perhaps, by the ordinary pace of the smaller animal, while the longer show probably the stride of the same individual when it walked fast, and the stride of the larger animal when it walked at a moderate pace. The legs of the adult or larger animal, supposing it to have been a biped, were probably 9 or 10 feet long.

sions may be seen *in situ* on much disturbed surfaces; but they are solitary and do not add to the evidence.

Conclusion.—These are the data by which I have been conducted to the important conclusions which I venture to embody in this communication.

The same strata, however, will no doubt reveal additional evidence when those parts shall be exposed which are now concealed by detritus. But although fresh facts may throw new light on the natural affinities of the creatures that produced these interesting phænomena, and may even multiply their genera and species, little can be wanting to prove that the tridactyle impressions and casts of impressions in the Wealden were produced by the feet of animals, and that those animals were bipeds.

The sum of the preceding facts, and the inferences that seem to result from them, are as follow:—

1st. That, from the number and arrangement of certain large trifidal bodies occurring in the Wealden formation, and from their general uniformity of character, position, and direction, *bipedal* animals having tridactyle feet of enormous proportions lived during the Wealden epoch*.

2ndly. That the alternation of right and left footsteps proves the animals to have been *biped*.

3rdly. The numbers and position of the toes seem to ally these animals to birds;—while, however, it may be regarded as undetermined whether these gigantic creatures were birds, or reptiles with ornithic characters.

It is necessary to remark that the striking evidence afforded by the continuous lines of tracks is not impaired by the want of continuity in the single tracks; which is partly occasioned by the laminations of the rocks, and the distribution of the tracks over the different layers. The tracks *b b* and *d d*, in Plate XIX. fig. 1, for example, are suddenly terminated by the lines *l l* and *m m*, which represent

* That a uniserial or quasi-bipedal track may be produced by a quadrupedal animal, we have strong evidence afforded by the recent uniserial tridactylous footprints found by Mr. E. Hopkins on the sand and mud-banks of the Magdalena River in South America, briefly noticed in Report Brit. Assoc. 1845, Trans. Sect. p. 52. These prints Mr. Hopkins, after careful investigation, discovered to have been made by a pachydermatous quadruped, the "Dante" or Tapir. The impressions are all trifid and pachydactylous; some of them 14 inches long, and 4 feet asunder; others 6 inches long, and 22 inches apart; and they occur in single rows, with the toes of the footsteps pointed outwardly and alternately to right and left. Interspersed amongst these peculiar footprints were the ordinary tracks of birds and tortoises.

In a note with which Mr. Hopkins has favoured me, he observes, "It was difficult at first to conceive how a *quadruped* could produce such angular steps; but, on minutely examining the impressions on the mud-banks, we detected a double marking in each print. Some of these animals are as large as mules; and I saw many of them afterwards, and watched the variable impression they made when walking on sand-banks, mud-banks, up-hill, and down-hill. The double impression could not be detected on the sand-banks; it was only on the mud that we could detect that the Dante in walking places the hind-foot in the exact place occupied alternately by the fore-foot."—[August 24, 1854.]

the edges of the layers, while the track *a a*, which runs in the direction of these lines, and remains on the same layer, is continued over the whole of the exposed surface.

Some impressions, moreover, even on the same laminæ, are such obscure memorials of the originals, that it is easy to infer that tidal erosion may have obliterated others, by which these were probably prolonged into tracks; a deduction warranted also by the condition of some entire lines, which, although well defined, contain some marks less vividly expressed than others, but which will probably disappear, and leave those that are more forcibly developed as the solitary representatives of a former track.

Impressions of the phalanges and integuments might have proved incontestably that these trifids were organic, or have led to the determination of the class of animals that produced them; but how far the *absence* of these anatomical details affects the evidence before us, may be inferred from the fact that all the resources of argument were exhausted before the persevering investigators of the footprints of the New red sandstone of Connecticut obtained that structural proof which the scepticism of many men of science rendered necessary.

The occurrence of the footprints along what was no doubt the muddy shores of the estuary in which the Wealden was deposited, points out a habit that rendered a great expanse of foot indispensable to an animal of such implied massiveness of structure.

The natural casts in my collection present at least six varieties in size, and I have had the gratification to see *in situ* tracks of impressions corresponding to each of these casts except one.

I have not observed an indication of a hind-toe to any of the footprints that occur to the west of Hastings*.

The magnitude of the footprints harmonizes well with the osteology of the Wealden. Our experience of the colossal Ornithoidichnites of the Connecticut Valley prepared us for what might prove almost incredible developments of organic life; and, if there was a period in geological history, antecedent to the appearance of mammalia, when we might have expected such phænomena, it was the æra that ushered in those stupendous saurians which were probably contemporaneous with the gigantic authors of these interesting relics.

Lastly, I would remark, that in using the word *Ornithoidichnites*, I intend rather to convey an intimation that the trifidal bodies are of organic origin, than to determine the affinities of the animals that produced them: I adopt the term, therefore, provisionally and most cautiously. Although the evidence seems to connect the footprints with the class *Aves*, yet I am not aware that it is such as positively to exclude animals of a different organization. Descriptions having for their object the establishment of the *class* of the animals might be premature and fruitless in the present state of the evidence, and only hamper an attempt which is simply intended to prove their existence.

* See Quart. Journ. Geol. Soc. vol. viii. p. 396. figs. 1 & 2.

I shall leave, therefore, to future inquiry the solution of the interesting problem of the natural affinities of these wonderful bipedal forms, contented if I have fortunately been instrumental in placing their significant memorials in the catalogue of Palæontology.

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3. *On the* Geology *of portions of the* Turko-Persian Frontier, *and of the Districts adjoining.* By William Kennett Loftus, Esq., F.G.S.

[Communicated by the Foreign Office, by order of the Earl of Clarendon.]

[Abstract.]

The geological researches detailed in this memoir were made in the years 1849–52, during the progress of a joint commission appointed by the English, Russian, Turkish, and Persian governments for the demarcation of the Turko-Persian frontier.

The line of country investigated during the Survey bears in a N.N.W. direction from Mohammerah, at the head of the Persian Gulf (Lat. 30° 26′ N.), to Mount Ararat (Lat. 39° 42′ N.); a direct distance of rather more than 600 geographical miles.

The first 250 miles, from Mohammerah to near Mendali, is an arid and deserted waste, infested by plundering parties of Arabs and Kurds, but capable for the most part of extensive cultivation.

From Mendali to Zohab (50 miles) the exterior tertiary chain of low gypsiferous ridges, which everywhere skirt the west flank of the Zagros, is crossed; and at the latter place the nummulitic limestone and cretaceous rocks are first reached.

From this point to near the Lake Zerribar (60 miles) is a succession of regular, saddle-formed, limestone anticlinals, with alternate synclinals, containing disconnected portions of the gypsum series, and underlaid by older blue schists.

The remainder of the frontier exhibits a lofty range composed of igneous rocks, which, bursting through the stratified deposits, constitutes the axis of the vast barrier ridge nearly as far as Bayazid, at the south foot of Mount Ararat, a distance of 270 miles.

Other traverses were made as far south as Shiraz (Lat. 29° 36′ N.), and many valuable sections obtained, which are referred to in the memoir.

In the first place the author gives a general section across the great Zagros range, as illustrative of the general arrangement of the rocks in the southern district. Thus the plain of the Tigris and Euphrates consists of red sandstone and variegated marls, bordered by hills of conglomerate, which are succeeded by higher hills of the same, capped by gypsum and underlaid by nummulitic rock. The latter forms still higher escarpments to the eastward, which are also surmounted by disturbed gypsum beds, and are based on cretaceous rocks. These in their turn crop out beyond the nummulitic rocks on the high lands eastward, and are succeeded by a crystalline limestone, obscure in its relations; and this by clay slates and mica schists, which are perforated by the granitic axis of the chain.

Further northwards similar rocks occur, but the igneous eruptions have greatly altered and contorted the sedimentary deposits. Some of the sections in this more northerly region are pointed out by the author as throwing much light on the age of the disturbing forces.

The several geological formations described by Mr. Loftus are as follows:—

I. *Recent Deposits.*

1. The alluvial deposits consist, 1st, of narrow tracks of fluviatile clay, sand, and gravel, now forming along the rivers and canals, and containing recent land and freshwater shells; 2ndly, of marine sands and marls, of greater extent, reaching into the desert at some distance from the rivers, and containing marine shells and corals of recent forms. This marine alluvium is represented by Colonel Rawlinson and Mr. Ainsworth as increasing at the rate of a mile in thirty years, at the head of the Persian Gulf.

2. Lacustrine deposits are very rare in the southern portion of the tract referred to in this paper, one patch only of soft limestone with *Planorbis* and *Limnæus* occurring in the mountains of Lauristan. Calcareous tufa forms an important feature, however, in the northern district, near Lake Van and elsewhere.

3. Limestone gravel, with a few sandstone and quartz pebbles. Enormous accumulations of this gravel, sometimes passing into a conglomerate, abut against the hills skirting the plain, particularly at Dizful, &c., where they are deeply ravined by the streams from the hills. The pebbles are derived from the adjacent mountains.

II. *Tertiary Deposits.*

A. The gypsum series. This presents in descending order,—

1. Fine gravel, passing into
2. Friable, red, calcareous sandstone.
3. Variegated marls, frequently saliferous; with vast deposits of gypsum, and thin beds of impure limestone.

The approximate thickness of the whole is not less than 2000 feet. The gravel and sandstone are unfossiliferous; the marls locally contain fossils, viz. masses of crushed shells resembling *Cyrenæ*. But at Kirrind, where some of the lower portion of the series is exposed, the marls and sandstone have no gypsum, and are fossiliferous, containing,—

Jaw and teeth of a small Reptile.	Natica.	Cardium.
Remains of Crustacea.	Mytilus?	Cardita.
Balanus.	Astarte, 2 sp.	Pinna.
Cerithium.	Modiola.	Arca, 2 sp.
Murex.	Pholas?	Anomia.
Oliva.	Lucina.	Flustra.
Calyptræa.	Nucula?	Serpula.
	Chama.	Astræa.

Bitumen and naphtha springs occur in the gypsiferous series, but are very rare in the next succeeding series—the nummulitic rocks.

The gypsiferous series was traced by Mr. Loftus for nearly 700 geographical miles, along the range separating Persia and Turkey, and probably it extends from the Caucasus to Beloochistan, continuous with similar rocks found by Captain Vicary, in Scinde*. [Gypsiferous rocks abound also in the Punjaub†, and Northern Persia‡.] Mr. Loftus points out that in Persia and Scinde the gypsiferous marls lie beneath and conformable to the associated sandstones, but that in Asia Minor§ Mr. Hamilton describes the gypsum marls as lying unconformably upon the sandstone‖; and he adds that, as a distance of 750 geographical miles intervenes between Persia and Asia Minor, perhaps such a difference in the course of deposition may be due to physical differences in the land and water condition of the several localities at the period in question. The gypsum deposits underlie the valley of the Tigris and Euphrates, occasionally protruding in bosses and ridges between the rivers, and rising up on either side of the adjoining plains.

B. The second tertiary group—the nummulitic series—forms an important feature in the Zagros Range, and has been traced for 800 geographical miles—from Shiraz to Mount Ararat. The nummulitic deposits are conformable with the gypsiferous series; but these groups are lithologically distinct, and have no fossils in common.

The nummulitic rocks are not less than 3000 feet thick, and at Mangerrah they consist of (in descending order)—

1. Compact grey and yellowish limestones, with *Cerithium, Ostrea, Pecten,* and *Echinodermata.* Flint in the upper layers.
2. Red chert conglomerate.
3. Yellow and red sandstones, with thin bands of pebbles.
4. Compact, greyish, fossiliferous limestone, passing into
5. Grey nummulitic rock, with layers of grey marl.

Nos. 4 and 5 contain

Nummulites perforata (small variety).	Alveolina subpyrenaica.
Assilina exponens.	Fragments of Echinoderms.
Orbitoides dispansus.	

These deposits are also well seen in a magnificent section near Kirrind, where the following series (in descending order) is exhibited:—

1. White marble.
2. White marls and limestone.
3. Limestone and red sandstone breccia.
4. Red chert gravel.
5. Yellow sandstone, with slight traces of vegetable remains.
6. Yellowish calcareous marl, abounding with fossils, the lower part with *Alveolina subpyrenaica* in particular.
7. Compact grey limestone.

This is succeeded by unfossiliferous red marls with chert pebbles.

* Quart. Journ. Geol. Soc. vol. ii. p. 261.
† Ibid. vol. ix. p. 194.
‡ Grewingk's Geog. Orog. Verh. N. Persiens, 1853.
§ Q. J. G. S. vol. v. p. 373.
‖ [In another district of Asia Minor Mr. Hamilton has described gypsiferous beds conformable with the red and yellow marl and sandstone. Trans. Geol. Soc. 2 ser. vol. v. pp. 590 & 592.—Ed.]

Amongst the fossils from the bed No. 6 are:—

Nummulites Biaritzensis.	Pecten.
Orbitoides dispansus.	Ostrea, 4 smooth species.
Operculina granulosa?	———, 1 plicated.
Alveolina subpyrenaica.	———, 1 vulselliform.
Several undetermined Zoophytes.	Anomia.
Clionites, 2 sp.	Nerita, 2 sp.
Spines of Cidaris.	Natica, 2 sp.
Echinus.	Turbo?
Temnopleurus.	Trochus?
Teredo, in wood? 2 sp.	Cerithium?
Corbula.	Purpura.
Tellina.	Pleurotoma, 3 sp.
Corbis?	Fusus.
Lucina.	Pyrula.
Venus.	Rostellaria.
Cardium, 2 sp.	Strombus, 3 sp.
Cardita.	Voluta, 2 sp.
Isocardia?	Seraphs.
Arca.	Cypræa, 3 sp.
Pectunculus.	Oliva.
Nucula.	Pileopsis.
Chama.	Nautilus.
Modiola.	Crustacean remains.
Mytilus, 2 sp.	Teeth of Shark.
Perna.	——— Gyrodus.
Spondylus.	

The nummulitic rocks, like all the rest of the rocks of the range, are greatly disturbed. They rise from beneath the beds of the gypsum formation in elongated saddles of compact crystalline limestone, running parallel to each other, and having a quâ-quâversal dip. Frequently, when much elevating force has been exerted, huge masses of the limestone stand isolated, with lofty precipices on all sides, bearing on their summits acres of pasturage and springs of delicious water, to which the native chiefs and their adherents can retire in safety, and, with a handful of men, defy the whole power of the Persian Government.

Mr. Loftus describes in detail the altered conditions of much of this series, and explains the great clefts or "Tangs" (as they are termed in Persian) which pass through the elongated limestone saddles. These tangs are very numerous, and are the most peculiar feature of the nummulitic rocks. All the great rivers which fall into the Tigris from the east rise in the interior of the Zagros; and, as their course is generally from north to south, they cross the ridges of the great chain diagonally. The manner in which this effected is very remarkable. Instead of flowing in a S.E. direction along the trough which separates two parallel limestone saddles, and by this means working out their channel in the soft rocks of the gypsiferous series, or of the alluvium, and afterwards rounding the end of the saddle, at the point where the extremity of its visible axis dips under the overlying deposits, each of these rivers takes a direction at right angles to its former course, and passes directly through the limestone range by means of a "Tang." On reaching the next parallel gypsum trough, it follows for a space its original S.E. course, and again passes through the next chain in the same manner, until it reaches the plains of Assyria and Susiana. The Tangs are not situated at the lowest or narrowest portion of the range, but most frequently divide it at its highest point, and expose perpendicular sections of 1000 feet and upwards. The width of the Tangs varies considerably; sometimes they are exceedingly narrow, and at other times, a mile or more across. One of these Tangs, which forms the pass between the plain of Denever and that of Chambatan, is 10 miles in length and 1½ in breadth; it has three salient and two re-entering angles on the N.W. side, with corresponding bays and projections on the other.

"It is quite out of the question," observes the author, "to suppose that the rivers themselves have been in the least degree instrumental in cutting these cross clefts; for if so, we should expect to find a lacustrine deposit in each trough, between the limestone saddles. But there are no such deposits. Moreover, if the rivers had been pent up in troughs, they would certainly have forced their passage through the soft gypsum rock, rather than through the massive crystalline barriers."

The "Tangs" are, in the author's opinion, due to tension at right angles to the axis of the chains in which they occur, and were probably produced instantaneously by the cooling of the once heated mass; whilst longitudinal fractures of the limestone, which also occur, following the axial lines, were probably caused by the resistance offered by the overlapping of the numerous beds, during their elevation from an horizontal position.

As there are no fossils common to the nummulitic and the gypsiferous series, so there are none common to the nummulitic and the cretaceous rocks next succeeding, although in this case there is sometimes a gradual transition in lithological characters.

III. *Secondary Rocks.*

1. Mr. Loftus refers to the Upper Secondary series a group of limestone and marls, with cretaceous fossils, chiefly exhibited by sections in the Bakhtiyari Mountains. In descending order, these appear as—

1. Bituminous marls (sometimes wanting.)
2. Cream-coloured, fissile, fossiliferous limestone, with flints.
3. Blue shaly marls.
4. Limestone with *Hippurites.*

The bituminous marls afforded at one place a group of *Terebratulæ,* closely resembling *Terebratula carnea* of the Chalk, together with some Plant-remains, and a small bivalve like a *Nucula.* The cream-coloured limestone, in the plain of Bishiwah, abounds with crushed specimens of—

Turrilites: resembling *T. tuberculatus.*	Pecten.
Ammonites; one was 2½ ft. in diameter.	Turrited univalve.
A. planulatus.	Fuci.
Belemnites.	

At other places the limestones were found to contain—

Kilgird Range.	*Dehbid ?*	*Imam Meer Achmet.*
Ammonites.	Rhynchonella.	Ammonites.
Small plicate Ostrea.	Exogyra.	Voluta.
Venus.	Corals.	Tellina.
Turbinate and turrited Univalves.		Gryphæa.
		Serpula.

2. To the Lower Secondary series Mr. Loftus refers the masses of highly crystalline, fetid, blue limestone, much contorted, which is seen in some of the mountain passes to be overlaid by the cretaceous rocks.

IV. *Palæozoic.*—In the Bakhtiyari Mountains Mr. Loftus found some limestone blocks, not *in situ*, which contained specimens of *Orthis*, probably of Devonian or Upper Silurian age, together with a small *Nucula*, and a few other indistinct fossils.

V. *Metamorphic Schists.*—Associated with the altered blue limestone just mentioned, and in juxtaposition with the igneous rocks along the axis of the Zagros Range, from Senna nearly to Mount Ararat, are metamorphic schists, clay-slates, &c., which, like the altered blue limestone, afford no data as to their exact age.

VI. *Granite.*—The central axis of the chain is formed of granite rocks, rising to the height of 13,780 feet at the summit of Kuh Elwend (the ancient Orontes).

As to the date of the eruption of the granitic chain, Mr. Loftus observes that there is every reason to regard it as posterior to the formation of the nummulitic and gypsum series, and subsequent to the accumulation of the comparatively modern gravel conglomerate on the western skirts of the whole chain.

VII. *Trap-rocks.*—Porphyry, trap-porphyry, and serpentine occur on the skirts of the granitic chain.

Part II. of the Memoir comprises the notes made by Mr. Loftus during his travels in the northern part of the frontier. Owing to a severe illness in the mountains, and other causes, these notes are not so systematically arranged as those made in the former part of the journey. The rocks met with along the northern frontier are similar to those previously described, except that there is a great abundance of the products of recent volcanic outbursts, with much tuff or travertine. Mr. Loftus points out some interesting phænomena connected with the deposition of the latter. The volcanic rocks are in force especially at Selmas, Lake Van, Abagha, and Mount Ararat; and the travertine of Derik, and near Khoi and Lake Van is described in detail. In this second part there are full descriptions of the Lakes Urumia and Van, which, like many others of the localities referred to, are illustrated by water-colour sketches, taken by Mr. H. A. Churchill, who accompanied the Commission.

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4. *On the* Geology *of the* Neighbourhood *of* Nágpur, Central India. By the Rev. Messrs. Stephen Hislop and Robert Hunter.

[Communicated by J. C. Moore, Esq., F.G.S.]

[Abstract.]

In the first place the authors describe the physical features of that portion of the Nágpur district to which this Memoir particularly refers, and give a full account of the geological observations already made in that and the neighbouring territories.

In pointing out the general geology of the district, they show that the basis of the country is gneiss, quartz-rock, mica-schist, and granite, on which reposes a sandstone very much interrupted, but stretching far and wide. It is without fossils at Nágpur, but fossiliferous elsewhere; and, according to the authors, of the Jurassic age.

Near Nágpur this sandstone is overlaid by a thick mass of trap rock, an isolated patch of which forms the mass of the Sitábaldi Hill. This trap is compact below and vesicular towards the top, and is surmounted by thin patches of a nodular trap. Between these two trap-rocks is found a thin clay or cherty bed full of the remains of freshwater shells and other fossils. In some places (as in the Tákli plains) the freshwater bed rests immediately on the sandstone, in which case the vesicular trap is wanting, and the overlying trap is sometimes present and sometimes absent. Sometimes a single thin sheet of trap is present without any sedimentary deposit.

The extent and relations of these several formations and of the superficial deposits having been pointed out, the authors proceed to describe their characters and contents, and to offer some observations on their respective ages.

The superficial formations are the black soil (Regur), sometimes 20 feet deep; and the red soil, which is occasionally 50 feet thick, and sometimes contains bones and freshwater shells. Each of these rests on a brown clay, which has an underlying conglomerate, with occasional mammalian remains.

The next oldest formation appears to be the laterite or lateritic grit, which seldom exceeds in thickness 10 feet in this district, and, as usual, is unfossiliferous. Diamond mines have been opened in it to the east of Nágpur. And in connexion with this subject, Mr. Hislop remarks that the diamond matrix probably throughout India is not sandstone in the several localities where the diamonds are found, but an overlying breccia or conglomerate, frequently resting on sandstone, but also occasionally on limestone or gneiss.

The next series of rocks is the trappean—with the enclosed sedimentary deposit.

The upper trap is from 15 to 20 feet thick, and of very great extent.

The freshwater deposit ranges from 1 inch to 6 feet in thickness, and varies in colour and composition; sometimes cherty, sometimes argillaceous. Its fossils also are as variable in their distribution.

Occasionally it appears to be repeated more than once in the escarpments of the trap hills.

This thin deposit has an enormous range; it has been traced more or less interruptedly to a distance of 1050 miles in a direct line, from Rajmahal (on the Ganges) to Bombay, and of 660 miles from the N. to the neighbourhood of Padpangali, near the mouth of the Godaveri.

From the collections made by Messrs. Hislop and Hunter and their friends from this deposit*, the authors mention the following fossils:—

Small bones, probably Reptilian.

Remains of a freshwater Tortoise.

Fish-scales, both Cycloid and Ganoid, in great numbers.

Insects, found at Tákli: Mr. Hunter enumerates about ten species of Coleoptera.

Entomostracans; five or six species of Cypris.

Mollusca, land and freshwater, in great numbers. The following genera are enumerated:—

Bulimus.	Paludina.
Succinea.	Valvata.
Physa.	Limnæus (Camptoceras).
Melania.	Unio.

Plant remains: Mr. Hunter enumerates

Fruits and Seeds, about fifty species.
Leaves, exogenous, six forms.
——, endogenous, three or four.
Stems, exogenous, few species; some specimens six feet in girth.
——, endogenous.
Roots, six or seven kinds.
Chara, seed-vessels.

Of the age of this deposit it is difficult to speak. The flora appears to have some resemblance to that of the London Clay. With two exceptions, all the species of the Molluscs are extinct; and two of the genera (*Valvata* and *Physa*) have disappeared from the plains of Central and Southern India; whilst the *Planorbis* and *Ampullaria*, now so common in India, are altogether absent from this deposit. As an isolated and probably lacustrine formation, though evidently possessing a high antiquity as compared with the superficial deposits of the district, its age cannot at present be predicated with any certainty.

The underlying or vesicular trap is 100 feet thick in the Sitábaldi hill; but it dies out towards Tákli, where the freshwater bed rests on the sandstone. Near Nágpur, Mr. Hislop observes, this lower trap appears to have been forced up beneath the overlying mass of freshwater deposit and upper trap, and to have either filled up and

* An extensive series of organic remains and of rock-specimens, from this deposit, the fossiliferous sandstone, and other formations, has been presented to the Society by Messrs. Hislop and Hunter. The fossils, however, have not yet been worked out.

scattered the superincumbent rocks, or to have raised them horizontally above the level of the plain, forcing itself between the sandstone and the freshwater deposit. This thin fossiliferous band, when not tilted up altogether, is often entangled in this lower trap and much altered in lithological character.

The authors notice the apparent absence of craters throughout the great trap district of Central India. Nor is any spot known where either of the two trap-rocks could be said to have come up from below.

The upper trap appears to have flowed along for immense distances, filling the great ancient lake or lakes, and forming flat and arid plains; and the lower trap, as above stated, appears to have been perhaps nearly as co-extensive in its subterranean intrusions and superficial outbursts. Thus both traps are regarded by the authors as of more recent date than the freshwater formation.

Sandstones and shales of variable character, but possibly referable to one and the same formation, occur in four districts, viz.:

1st. In the vicinity of Nágpur the sandstone occupies a comparatively narrow and irregular stripe along the eastern border of the great trap region, under which it is seen to pass.

2nd. Isolated patches on the south appear to connect the Nágpur sandstone with the extensive sandstone district of Chándá, above and below the junction of the Wardhá and Pranhitá Rivers, extending to Kotá, near the junction of the latter river with the Godaveri.

3rd. To the east of Nágpur there are some outlying patches eastward of the Wein Gangá River.

4th. To the north-west, at the distance of thir yor forty miles from the Nágpur sandstone, there is a broad tract of sandstone around the Mahádewa hills.

The exact relations of these several areas of sandstone and shale are not yet quite settled; but the following is the descending order of the series according to the observations of the authors.

1. Soft ferruginous sandstone; sometimes hard, with iron bands, and affording millstone. This contains fragments of the underlying sandstone, large plant-remains and numerous leaves.

2. Fine and coarse argillaceous sandstones, rich with plant remains. These have afforded

Labyrinthodont reptile* (from Mangali).
Fishes; Lepidoid scales.
Crustaceans; *Estheria*.
Plant-remains.
Fruits and seeds; numerous and undescribed.
Leaves; Conifer, Zamites, Poacites, and Ferns (*Pecopteris, Glossopteris, Tæniopteris, Cyclopteris, Sphenopteris*).
Roots, exogenous and endogenous.
Acrogens: *Aphyllum*?, *Equisetites*?, *Phyllotheca*, *Vertebraria*?.

The thickness of Nos. 1 and 2 together, near Nágpur, is about 300 feet; and in the Mahádewa Hills it is estimated by Lieut. Sankey at 2700 feet.

* See the next following paper.

3. Red shales, 50 feet thick, and green shales, 30 feet. In the former of these there were observed at Korhádi

Reptilian foot-tracks.
Worm-tracks.
Phyllotheca ?

4. White and coloured limestones and marbles (dolomitic), with chert. Not less than 100 feet thick.

In Southern India these limestones (No. 4) are 300 feet thick, and are succeeded by another series of sandstone, termed by Dr. Carter the "Tara sandstone."

All these sandstones, shales and marbles are much disturbed and often changed by the plutonic rocks in the district treated of in this memoir. Beyond the Nágpur district to the N.W. at Chotá Barkoi, according to Lieut. Sankey *, the sandstone proper is succeeded downwards by

Bituminous shales, with fossils; and
Sandstone;

and at another locality, near the foot of the Pachmahari Hills, by

Indurated clay-stone.
Green shale.
Bituminous shale, with fossils.

Mr. Hislop compares this sandstone formation with the sections of the neighbouring regions published by Newbold † and Malcolmson ‡ and supplied to him by Dr. Bell, and he finds that often the position of the shale with reference to the limestone seems to vary; and that these shales, sandstones, and limestones appear (from Dr. Bell's Sections) to be interstratified at Kotá to the S.E., where the shale and limestone have yielded fossil fish of the genera *Lepidotus* and *Æchmodus*, associated with plants and Teleosaurian remains §.

From a general consideration of the character and fossils of the sandstone formation, the authors regard it as lacustrine in origin, like the Bengal coal-field, and of the Lower Jurassic age.

The metamorphic and plutonic rocks are also noticed in detail. The latter probably belong to several epochs; and the authors consider it probable, that, whilst one granitic outburst raised and broke up the old sandstones previously to the formation of the tertiary freshwater deposits, the pegmatite of Nágpur was protruded at a date even subsequent to that of the traps which had covered and again disturbed these lacustrine beds.

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5. Description *of the* Cranium *of a* Labyrinthodont Reptile (Brachyops laticeps) *from* Mangali, Central India. By Prof. Owen, F.R.S., F.G.S.

[Abstract.]

This fossil was obtained by the Rev. Messrs. Hislop and Hunter in the sandstone at Mangali, about sixty miles south of Nagpur,

* Quart. Journ. Geol. Soc. vol. x. p. 55. † Journ. As. Soc. vol. viii. p. 167.
‡ Trans. Geol. Soc. 2 ser. vol. v. p. 541 *et seq.*
§ Quart. Journ. Geol. Soc. vol. viii. p. 233.

as mentioned in the foregoing paper. It consists of a considerable portion of a skull, wanting chiefly the tympanic pedicles and the lower jaw. It is embedded in a block of bright brick-red compact stone, with its upper surface exposed. The skull is broad, depressed, and of an almost equilateral triangular form.

The breadth of the occiput is 4 inches 9 lines; and the lateral border of the skull measures, in a right line, 4 inches 6 lines. The muzzle is rounded and obtuse. Most of the cranial bones are impressed with radiating grooves, the intervening ridges being in some parts broken up by communicating grooves into tubercles. The orbits are entire and situated in the anterior half of the skull. Portions of small, conical, pointed teeth form a single series along the alveolar border of the upper jaw.

In investigating the structure of the occiput, the Professor succeeded in developing two well-defined occipital condyles, not so close together as in the great *Labyrinthodon salamandroides*, but separated as in *Trematosaurus* and *Archegosaurus*.

After a detailed description of the several parts, as far as the abraded and otherwise mutilated condition of the fossil would allow, Professor Owen states that it allows so many characters of the skull of the labyrinthodont batrachians to be determined as can leave no reasonable doubt of its true nature and affinities; and he gives it the appellation of *Brachyops** *breviceps*, in reference to the shortness of the facial part of the skull anterior to the orbits.

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6 *Additional Observations on the occurrence of* PIPES *and* FURROWS *in* CALCAREOUS *and* NON-CALCAREOUS STRATA. By JOSHUA TRIMMER, Esq., F.G.S.

[Abstract.]

THE author considered that, for the full understanding of the views he has taken on the origin of sand-pipes and furrows in and on the surface of strata, some further remarks were required; and offered these additional observations in support of some positions he has taken in former papers on the subject, and which, from their not having been fully elucidated, appeared to require some explanatory remarks in their defence.

* From βραχὺς, short; ὢψ, face.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPER.

On the Insect Beds *of the* Purbeck Formation *in* Wiltshire *and* Dorsetshire. By the Rev. P. B. Brodie, M.A., F.G.S.

[Read June 15, 1853*.]

Prof. E. Forbes, in a valuable paper† in Jameson's Edinburgh Journal, was the first to divide the Purbeck Series in Dorsetshire into upper, middle, and lower, and to define the varied conditions under which the whole was accumulated. In this memoir he pointed out that this Series consisted of alternations of freshwater, marine, and brackish water deposits, differing as much in their lithological as in their zoological characters, giving us also a new and more enlarged view of the distribution of freshwater and marine life during this portion of the Oolitic period.

At the time when I first (now nearly thirteen years ago) laid before this Society an account of the occurrence of Insects and other new fossils in the Purbecks in the Vale of Wardour, I was induced to consider the Insect and Isopod limestones as belonging to the *lower* part of the *lower* Purbecks. Since then, however, the subdivisions of Professor Forbes, and the joint investigations of my friends the Rev. Messrs. Austen and Fisher, have led me to examine the few available sections in the Vale of Wardour again, and to pay a visit to Durlstone Bay, in order to institute a more careful comparison between these two distant portions of the formation,—the result of which I now proceed briefly to describe.

Vale of Wardour.

The upper Purbecks are entirely wanting in the Vale of Wardour‡, but the middle and lower are tolerably well developed; although these

* For the other Communications read at this Evening Meeting, see Quart. Journ. Geol. Soc. vol. ix. p. 317 *et seq.*

† Read at the Meeting of the British Association at Edinburgh, 1850.

‡ For a general Section of the Vale of Wardour, see 'History of the Fossil Insects in the Secondary Rocks of England,' pl. 11, and page 1 *et seq.* See also Trans. Geol. Soc. 2 ser. vol. iv. pt. 2. pl. 7 & pl. 10 *a*.

form a very reduced equivalent of the more enlarged and perfect system in Dorsetshire. It is extremely difficult to get good consecutive sections in Wiltshire, and allowance must be made for faults and denudation; but the following section, in descending order, taken at different points, makes the order of succession clear and definite. It was drawn up by my friend the Rev. O. Fisher, and with his permission I subjoin it here, as it tallies in most respects with a section which I had made in the same direction, and gives one or two beds which I did not detect.

Adjoining Quarries on the south side of the River Nadder, near Teffont Mill.

MIDDLE PURBECKS.	ft.	in.
1. Brownish-yellow clay		
2. Indurated sand, in layers	2	0
3. Whitish sandstone	0	6
4. Brown earth, with comminuted shells	1	0
5. "Beef" (fibrous carbonate of lime)	0	2
6. Layer of oysters	0	6
7. White earthy limestone, with many *Archæonisci* (*A. Brodiei*) and *Corbulæ*	0	6
8. Hard blue limestone*, splitting into laminæ	0	2
9. Thinly laminated white marly limestone and clay ("biscuit"), containing *Archæoniscus* and Fucoids	0	6
10. White sandstone	0	0½
11. Reddish-brown coarse laminated sandstone, with *Ostrea* and *Cyrena* (The contrast of colour here is remarkable.)	0	5
12. Thin-bedded, white, soft limestone	1	8
13. Shale, with *Cypris fasciculata*, and Fish scales. This forms the bottom of the old quarry.		

Proceeding to a newer quarry on the east, the above section is repeated as far as No. 13; and is presumed to continue as follows:—

	ft.	in.
14. Shale, with scales of Fish and *Cyclas major*? on the under side.		
15. Clay, with *Ostrea* and lenticular bands of chert, containing *Cyrena* or *Cyclas*	0	4
16. *Cinder*, with large *Ostrea*; marly at the top, sandy at the bottom, with *Cardium* and *Trigoniæ*	1	10
17. Laminated sand and clay	0	7
18. Very hard fine-grained sandy rock	1	0
19. Ditto, not so fine	0	8
20. Sandy rock, with casts of *Cyrena* or *Cyclas*	0	6
21. Fine white limestone, like the Swanage "freestone"	1	0
22. Ribbon clays and sands, with compressed shells	1	0
23. Hard crystalline limestone, with comminuted shells, *Cypris* and *Cyclas*	1	6

Nos. 21 and 23 may be observed in two small quarries where there is a lime-kiln, towards Teffont; and then follow—

	ft.	in.
24. Brown sand, full of crushed Bivalves and *Serpulæ*	0	9
25. Blue and grey laminated clay with limestone nodules, and thin "beef" and crushed Bivalves	1	0

* On the rising ground opposite this quarry, and about parallel with Nos. 8 and 9, in a partial excavation, many years ago I observed thin slaty limestone, containing traces of Insects, *Archæoniscus*, and *Leptolepis Brodiei*.

This is the lowest of the *Middle* Purbecks; and the *Lower* are—

LOWER PURBECKS.

		ft.	in.
26.	Hard gray marly limestone, having a conchoidal fracture; identical in appearance with the upper Insect beds of Ridgway. *Cypris Purbeckensis*? common	3	6
27.	Dirt-bed	0	3
28.	Laminated clay and soft and hard marls	1	6
29.	Hard marl with conchoidal fracture	0	8
	Bottom of quarry.		

In my earlier examination of the Vale of Wardour, some of the quarries where the above appear were not worked, being only partial excavations for stone; and several others then open are now entirely closed. I had then never observed the "*Cinder*" anywhere *in situ*, which forms so good a line of demarcation in Dorsetshire, occurring towards the lower part of the Middle Purbecks. A violent storm had fortunately exposed it at the time of Mr. Fisher's visit, in a lane leading from Chicks-grove to Teffont, and hence the connexion of the Purbecks in Wiltshire was determined with greater accuracy. It therefore appears evident that the Isopod and Insect limestones (properly so called) overlie the "Cinder." At the eastern end of the Vale, where they first emerge from beneath the Green-sand, they seem to be much less expanded than they are towards Teffont, a little further to the west, and although *Archæoniscus* is tolerably abundant throughout, the Insects are scarcer, and not so well preserved. There is no doubt a certain general agreement in mineralogical character between the Purbecks in Wilts and Dorset; but in the former case, where the whole series is so much reduced in bulk, it is extremely difficult to make a very correct or close comparison. The forthcoming Memoirs of the Geological Survey will no doubt give an accurate account of them, while a closer investigation of the Mollusks and Cyprides and other fossils by Professor E. Forbes will form a complete and valuable history of the Purbeck formation in Great Britain.

Dorsetshire.

The Section at Durdlestone Bay, near Swanage, is now so well known that it is unnecessary to repeat it here. I shall, therefore, merely refer for details to Professor Forbes's paper above-mentioned, and to the Rev. J. H. Austen's 'Guide to the Geology of the Isle of Purbeck*,' in which a full account is given of the strata and their fossil contents†. The richest depositary of Insect remains at Durdlestone Bay, on the coast, is in the lower Purbecks, while in Wiltshire (with one exception) they are confined to the middle division. During a late visit to Swanage, I discovered a small wing in a band

* Published as a small pamphlet, 8vo, by Shipp, Printer and Publisher, Blandford, and Penney, Swanage.

† Of course the important and earlier papers by Dr. Buckland, Mr. Webster, and Dr. Fitton, on the Dorsetshire Purbecks, published in the Geological Transactions, must not be forgotten, for nothing was previously known of the complicated coast sections in Durdlestone Bay and other places, nor of the interesting organic remains which their investigations brought to light.

of hard blue limestone, somewhere about No. 31 in Mr. Austen's list of strata*, towards the upper part of the middle series; and it is worthy of remark, that this layer, and the superior and inferior beds connected with it, especially those designated "Pecten Beds," bear a close lithological and zoological resemblance to the Isopod and Insect limestones and associated strata at Dallards in the Vale of Wardour, and their position accords pretty nearly with that of the latter. Mr. Fisher has favoured me with the following Section of the above in descending order, about 200 yards south of a small stream, not far from the Preventive Station:—

	ft.	in.
Two or three bands consisting of pinkish shelly limestone, with *Corbula*, *Ostrea*, and *Cyrena*	1	6
Clay	0	8
Hard shelly limestone, yellow on the outside, with *Ostrea* and *Bulla*	0	8
Clay, passing from dark blue at the top to yellow, with a little "beef" (fibrous carbonate of lime)	2	4
Thin band of hard shelly stone, *Cypris*, *Cardium*, &c.	0	2
Hard marly limestone, breaking into rhomboidal fragments, with Insect remains	0	3
Ditto, with lenticular masses of *Corbula*, and Insects	0	6
Brown and blue clay, with shells and shelly rubble	2	0
Marly shale	0	5
Hard calcareous cream-coloured and blue marl, splitting into rhomboidal fragments; lower part shaly, contains Insects	0	10
Coarser and shelly stone, with *Cypris*	0	4
Blue shaly clay	0	8
Coarse shelly stone	0	5
Coarse shelly stone and blue clay.		
Total	10	9

The strata containing Insects in these "Pecten beds" are somewhat slaty in their texture, varying in colour and hardness; the blue slaty limestone, which so closely resembles one of the Insect bands in Wiltshire, passes into a yellowish-white fine-grained stone, the prevailing colours being blue, white, and yellow; it has a very uneven fracture. Traces of minute plants occur throughout, consisting of broken carbonized stems and rounded bodies which look like seed-vessels. I requested my cousin Mr. W. R. Brodie, who resides at Swanage, and is a most zealous and indefatigable collector, to examine the above more closely, and he informs me that he has since found a number of wings and elytra; and he has been kind enough to give me a small but interesting collection, from which Mr. Westwood has made a selection for description and figuring.

The inferior Insect-beds†, which consist of two or three distinct

* Mr. Austen describes these as "blue and cream-coloured indurated marls;" they were probably deposited in brackish water.

† In order that the Section may be quite clear to the general reader, I subjoin, from Mr. Austen's 'Guide,' a copy of that portion of the Section which includes the richest Insect beds, beginning with the highest of the *lower* Purbecks:—

	ft.	in.
94. Marly limestone, with thin band of shells	1	0
95. Rubbly marlstone	2	0
96. Cream-coloured marly limestone	2	0

strata, occupy a rather central position in the lower Purbecks in Durdlestone Bay, and are well described in the Section in Austen's 'Guide' above referred to. There are two or three white earthy limestones, like chalk more or less indurated, in which relics of Insects are most abundant. The middle one of these is the richest, especially for groups of elytra and wings, but they are by no means confined to this portion of the formation, having been noticed (as before observed) in the "Pecten beds" above, and again lower down at No. 128 in Mr. Austen's List, near the second chert beds, where they are associated with *Archæoniscus*. Few or no other fossils, except small fragments of carbonized plants, occur in the white Insect-beds at the top of the lower Purbecks. In these I have only seen one small Fish, which was discovered by Mr. W. R. Brodie,

---

		ft.	in.
97.	Soft shaly band	0	4
98.	Cherty band	0	4
99.	Marly limestone	1	3
100.	Rubbly limestone	1	0
101.	Marly limestone	0	8
102.	Rubbly blue marly limestone	3	0
103.	Rubbly white marly limestone	4	0
104.	Marly limestone, with vegetable remains, wings, elytra, and bodies of *Insects*, abundant in patches	3	0
105.	Slaty marl	1	6
106.	White marly limestone, with a harder band in the centre, containing *Insect* and vegetable remains	4	0
107.	Blue slaty marl	1	6
108.	Hard marly limestone	1	6
109.	Blue slaty marl	1	6
110.	Laminated sandy marl, with traces of Vegetables, Fish-scales, *Serpulæ*, small *Cardium*, and a cherty band with *Melania*.		
111.	Marl, with *Cyprides* and shells (*Leda*)	1	6
112.	Slaty marls	4	0
113.	Marly limestone, containing *Insects* and a branching Plant	2	0
114.	Blue laminated shales and marl and gypsum	3	0
	[The beds here are hidden by the fallen cliff.]		
115.	Slaty marl.		
116.	Cream-coloured marl, full of shells (*Cardium*), with vegetable and *Insect remains*	2	6
117.	Cherty band, full of shells, chiefly univalves, and *Cyprides*. A small *Cardium* abundant	0	4
118.	Slaty coloured marls	1	6
119.	Indurated marls, *elytra of Insects*, *Cyprides*, and Univalves	3	0
120.	Bluish marl.		
121.	Indurated marl, with many Bivalves.		
122.	(Cliff disturbed.)		
123.	(Ditto, and contains blocks from several beds.)		
124.	Cypris shales	3	0
125.	Indurated marl and shales alternated; with vegetable remains and *Archæoniscus* }	4	6
126.	Band of white marl, vertically cracked }		
127.	Hard band, containing *Archæoniscus*	0	5
128.	Blue and brown indurated marl, with a large species of *Archæoniscus*, *Cyprides*, *Estheria*, and shells.		

The whole of the above were deposited in brackish water; and it is worthy of remark, that here we have the greatest number and variety of Insect remains.

and he liberally presented it to me. I forwarded this specimen to Sir Philip Egerton, who states, that it most nearly resembles the curious genus *Nothosomus*, but it is too imperfect to warrant any decided opinion upon the subject, as the tail and dorsal fin are deficient. He is inclined to think that it will ultimately prove to be a new genus.

The position of the strata containing Insects at Ridgway near Weymouth is not exactly the same as at Durdlestone Bay (Nos. 103 to 119, Mr. Austen's List), though it agrees pretty nearly with the latter. In the neighbourhood of Dorchester they are somewhat harder, but the prevailing colour is much the same, and no insect remains have as yet been observed there higher than the lower Purbecks.

Observations on the Organic Remains.

No *Archæoniscus* has yet been met with at Durdlestone Bay higher (I believe) than No. 58 in Mr. Austen's list of the strata, not far above the "Cinder" in the middle Purbecks, where the brackish-water series commences in a bed of shaly blue and brown marl, in which I found the claw of an *Astacus*. In all probability, that portion of the series from Nos. 55 to 70 (middle Purbecks), which immediately reposes on the "Cinder," most nearly corresponds with the Section at Teffont from Nos. 10 to 15. At Dallards there are grits and shaly stone associated with the Insect limestone, containing *Ostrea*, *Cyclas*, *Cypris*, and numerous scales, teeth, and coprolites of Fish and Saurians. The first appearance of *Archæoniscus* is in the basement-beds of the lower Purbecks; occurring in the *Cap* at Chicks-grove, in the Vale of Wardour, where I procured some of very large size, associated with *Ophiopsis breviceps*, Egerton (Survey Mem. Decade 6. pl. 6), and a few elytra. At Ridgway, near Weymouth, the same stratum, undistinguishable from the Cap in Wilts, contains numerous fragments of *Archæoniscus* and Fish; but the former has never yet been detected there entire. This crustacean appears to be limited to the "Cap;" here at least it has not been observed higher up in the Section. It occurs again, abundantly and in clusters, towards the lower division of the middle Purbecks, accompanied by a few elytra, in Durdlestone Bay (Nos. 125 & 127, Mr. Austen's List), and again in No. 58 higher up; in both cases, in bands of blue shale and marl, more or less indurated, both of which were deposited in brackish water. The *Archæonisci* vary in size, but the prevailing species appears to be the *A. Brodiei* (M. Edwards), though it is probable that another species will ultimately be determined.

With respect to the general character of the Insect remains in the *lower* Purbecks in Dorsetshire, it appears, from Mr. Westwood's investigations*, that they agree closely with those which mark the

* Those who are aware of the imperfect and fragmentary state in which most of the Insect remains occur in various formations in this country will understand the difficulty of the task which Mr. Westwood has undertaken in elucidating their true characters, and will duly appreciate the result of his labours. The beauty and accuracy of the plates require no comment.—[Aug. 14, 1854.—P. B. B.]

middle Purbecks in Wiltshire, although the *Cyprides* and shells in the former are quite distinct from those in the latter. The Insects in the middle division especially bear a near resemblance to those in the Vale of Wardour, and consist chiefly of wings and elytra. These are from the "Pecten beds," Nos. 31 *et seq*. Many of them indeed are identical, some few agreeing with species in the lower beds, and some (apparently) with those of the Lias, and a few may be new. The elytra and wings are generally detached, rarely collected together in masses, lying in different portions of the stone, and not in particular layers. They are, however, remarkable for their beautiful state of preservation, the elytra usually retaining their elytrine or chitine, and the wings their most delicate nervures and colouring. In this they present a contrast to the insect relics in the inferior strata. They are occasionally mingled with *Corbula, Cyclas*, and *Cypris*. The wing-covers of beetles are tolerably abundant, but of small size. I have observed only one perfect Beetle, a few minute but peculiar larvæ, abdomens, and only one entire dipterous (probably) insect. The detached wings consist chiefly of *Gryllus, Acheta, Blatta*, and *Libellula*, most of which seem to be identical with specimens figured from the Vale of Wardour (see "Fossil Insects," plates 2, 3, 4, 5, 6). One very beautiful wing resembles the *Ephemera* of the Lias (*ibid*. pl. 10. fig. 14). In the lower beds (from Nos. 94 to 128 in Mr. Austen's Section, some of which he denominates "Insect beds," and which form the top of the lower Purbecks, see note, p. 478), elytra are very abundant, grouped together in clusters, especially in one particular stratum at Durdlestone Bay and at Ridgway near Dorchester. As many as sixty or seventy elytra and several wings and bodies have been counted on one small slab. The elytra generally retain their delicate sculptured markings, and sometimes the colour. They are mostly small, though a few larger specimens have been met with; some are of great size, much larger than any I ever procured in the Vale of Wardour, and rather more so than the largest elytra from the Stonesfield slate. A few attached elytra occur, but perfect beetles are extremely rare, only three or four having been noticed. At Ridgway a very peculiar pupa is rather characteristic, and a small beetle, allied to *Notonectis*, which is an aquatic species; and this possibly may account for its being found entire, while all the terrestrial ones are disjointed and imperfect. The grouping together in masses is one distinctive feature in the insect remains from the lower Purbecks in Dorsetshire; the wings too are usually broken, and portions of Insects are scattered about in all directions, and the whole appear to have been carried down a stream of some violence, and deposited at a considerable distance from their original habitats. At any rate they must have been exposed to some very destructive agency before they were imbedded in the mud of the waters in which they floated. In this respect they differ from those in the Vale of Wardour, and in the Lias generally. The smaller number of entire insects (scarcely any in fact) is to be noted.

At Ridgway the masses of elytra have one uniform direction; as if indicating the course of the current. This is not so much the case at Durdlestone Bay. Some gigantic wings of *Neuroptera*, rarely perfect, are rather prevalent; there are also wings of *Gryllus* and other *Orthoptera*, associated with some *Blattæ*, *Homoptera*, and other families. A very large collection of Insects has been made from the Dorsetshire Purbecks* by the officers of the Geological Survey, and by Messrs. W. R. Brodie, Austen, Fisher, and Willcox. I am indebted to the kindness and generosity of Mr. Brodie for the greater part of the specimens in my cabinet, and I have to thank the last-named gentleman for the loan of his valuable collection of insect exuviæ, which also were sent to Mr. Westwood for examination.

P.S.—I cannot conclude without referring to the interesting and important discovery of Mammalian and Reptilian remains near Swanage, by Mr. W. R. Brodie and Mr. Wilcox, which have been lately described by Professor Owen. These consist of two small lizards (*Nuthetes*, from No. 84 of Mr. Austen's Section, and *Macellodus*, from No. 93) and a small Mammal (*Spalacotherium*, also from No. 93†), most closely resembling the *Thylacotherium* of the Stonesfield slate. Professor Owen considers both the Mammal and the Reptiles to have been insectivorous; and although the presence of insects would have led to the inference, as I have elsewhere observed‡, that some insectivorous animals must have existed contemporaneously, it is extremely interesting to be able to prove the fact; and we are greatly indebted to the zeal and energy of the discoverers for bringing these remains to light.—[August 14, 1854.]

* Not long after Prof. Forbes's discovery of a few insect wings in the Hastings Sand in the Isle of Wight, Mr. W. R. Brodie sent me a fragment of a wing from the Hastings sand at Swanage Bay, north of the town. Since then, Messrs. W. and H. Binfield have detected numerous insect remains throughout the Wealden Series near Hastings. See Quart. Journ. Geol. Soc. for May 1854.—[Aug. 14, 1854. —P. B. B.]

† This bed occurs in the "Marly middle freshwater series" of Prof. E. Forbes, and is the basement-bed of the Middle Purbecks.

‡ Fossil Insects, p. 112.

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PART II. MISCELLANEOUS.

CONTENTS OF PART II.

Alphabetically arranged—the names of the Authors in capital letters.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Fossil Plants *found in* Amber.
By Professor Goeppert.

[Berlin Academy, Bulletin, 1853, pp. 450–476; and Leonhard u. Bronn's N. Jahrb. f. Min. u.s.w. 1853, pp. 745–749.]

Since Prof. Goeppert recognized the *Taxodites dubius*, of Sternberg, which occurs abundantly in the plant-bed at Schosnitz, Silesia, as the *Taxodium distichum*, Rich., now living in the southern parts of the United States and in Mexico, and found also some fossil Planes from Schosnitz to be identical with living species, thus pointing out the identity of some tertiary plants with the living, he has had the opportunity of examining a collection of 570 specimens of Amber, containing plant-remains, belonging to M. Menge, of Dantzic, and 30 specimens bequeathed by M. Berendt. With these the author has been enabled to raise the number of the species of plants in the Amber Flora from 44 to 163; of which only *Libocedrites salicornioides* and *Taxodites Europæus* occur fossil out of the Amber; and 30 are identical with existing species. The constitution of the Amber Flora, as at present known, is shown in the following table*.

	Number of Species.	Number identical with existing Species.
Plantæ cellulares.		
I. Fungi	16	4, certainly; perhaps, all.
II. Algæ	1	1
III. Lichenes	12	6 or 7 (with species on the E. and W. coasts of Arctic America).
IV. Musci hepatici: Jungermannieæ } 39 specimens.	11	11
V. Musci frondosi	19	2 or 3, certainly; perhaps, all.
Plantæ vasculares.		
III. Cryptogamæ (Acotyledones).		
Filices.		
Pecopteris Humboldtana, *Göpp. & Behr.*		

* For the lists of genera and species, see the works above referred to.

	Number of Species.	Number identical with existing Species.
IV. Monocotyledones.		
Cyperaceæ.		
Carex eximia, *Göpp. & Menge.*		
Gramineæ.		
Fragments.		
Alismaceæ.		
Alisma plantaginoides, *Göpp. & Menge.*		
V. Gymnospermæ.		
Cupressineæ	20	2
Abietineæ	31*	1
Gnetaceæ	1	
VI. Monochlamydeæ.		
Betulaceæ	2	
Cupuliferæ	10	
Salicineæ	3	
VII. Corollifloræ.		
Ericineæ	22	3
Vaccineæ	1	
Primulaceæ	2	
Verbasceæ	2	1
Solaneæ	1	
Scrophularineæ	1	
Lonicereæ	1	
VIII. Choristopetalæ.		
Lorantheæ		
Crassulaceæ	1	1

The whole Flora as yet known consists of 24 Families, 64 Genera; comprising 163 species†.

The following are the general results of Prof. Goeppert's researches.

A considerable number of tertiary species of plants (especially *Plantæ cellulares*) are still living.

The flora of the Amber being destitute of tropical and sub-tropical forms, it is to be referred to the Pliocene period.

The remains only of forest-plants have been preserved in the Amber.

This flora much resembles the present, especially in the Cellular plants; the *Cupressineæ*, however, are now almost wholly wanting in our latitudes, and the *Abietineæ* and the *Ericineæ* are not abundant. The four species, of *Thuia*, *Andromeda*, and *Sedum*, which are identical with the living, are indeed northern forms; on the other hand, the *Libocedrus Chilensis* is found on the Andes of Southern Chili.

The flora of the northern parts of Europe, Asia, and America is at present less rich in species of *Cupressineæ* and *Abietineæ*, than that of the Amber; although it possesses some of the species found in the latter: nor are the existing northern species of *Coniferæ* so rich

* Of these, eight (the species determined from the fossil wood) afford Amber.

† The number of species may probably be raised to about 180, by additions from about 50 specimens of which the relations are barely determinable.

in resinous products, as were the trees of the Amber-flora, with which the *Damara Australis*, of New Zealand, can alone in this respect be compared; the branches and twigs of this tree being stiff with white resin-drops.

If we take into consideration the enormous extent which the forests of

Abies alba,	Abies ovata,
—— nigra,	Larix Dahurica,
—— balsamea,	—— Sibirica, and
—— Sibirica,	Pinus Cembra,

at present attain in North America and Northern Asia, we are led to infer a similar extension in former times of the Amber-forests throughout the northern regions; to which, indeed, the wide distribution of amber in the late tertiary deposits of North America, Holland, North Germany, Russia, and Siberia to Kamtschatka bears evidence.

If we judge from the proportion which the fir-forests bear to the rest of our northern flora generally, we shall infer, from the prevalence of the *Coniferæ* in the Amber, the existence of a very rich flora contemporaneous with the latter, and of which but a small part has as yet been presented to our notice. Germany contains 6800 species of *Cryptogamæ*, according to Rabenhorst, and 3454 species of *Phanerogamæ*, according to Koch. The proportions are—

	The German Flora.			The Amber Flora.	
	Classes.	Species.		Classes.	Species.
Cryptogamæ	8	6800	......	6	60
	Families.	Species.		Families.	Species.
Phanerogamæ	135	3454	......	20	102
Cupuliferæ	...	12	......	...	10
Ericineæ	...	23	......	...	24

Proportion of trees and plants ... $\left\{\begin{matrix}333\\3121\end{matrix}\right\}=1:10$ ...... $\left\{\begin{matrix}94\\9\end{matrix}\right\}=10:1$

Amber is never found isolated in large or small masses in the bituminous wood of the Brown-coal with resin-ducts of a single row of cells, which never contain yellow masses of resin, but only dark-brown transparent resin-drops, as in the *Cupressineæ*, or the *Cupressinoxylon* of Goeppert. The compound resin-ducts of the *Abietineæ* alone are filled with amber.

It is probable that the amber and its plant-remains have been drifted to the places in which they are now found. The author knows of no well-authenticated instance of the occurrence of amber in the Brown-coal formation itself; it occurs in the drift-beds above it, where, however, it does not appear to have originally belonged. Scheerer has found it in Norway; von Brevern, at Gischiginsk in Kamtschatka; Rink, in Haven Island, near Disco Island, Greenland; and in these instances it is generally in drift-beds. The supposition, however, that it belongs to the Drift-period, is difficult to substantiate, the flora of that period being as yet but little known. The stomach of the fossil Mastodon found in New Jersey contained twigs of *Thuia occidentalis* (found in the Amber-flora); and in the Erie Canal, in New York State, at a depth of 118 feet there have been found freshwater shells, together with portions of *Abies Canadensis*, which still grows in the neighbourhood, and leaves of which are recognized (though with some doubt) in the amber. The fossil wood of the Drift-beds of Siberia, also, is nearly related to that of the present day*.

The height at which amber is found at the Castle on the Riesengebirge near Helmsdorf is nearly 1250 feet [German] above the sea level, and at Grossman's Factory near Tannhausen at 1350 feet.

The amber is not derived from one species of wood only (*Pinites succinifer*), as Prof. Goeppert formerly thought, but also from eight other species, including the *Pinus Rinkianus*, in which Vaupelt observed the amber of Disco Island.

It is probable that all the *Abietineæ* and perhaps the *Cupressineæ* have furnished their share of the resinous matter (at first consisting of various specifically different resins) that afterwards by fossilization became amber; and this is supported by the author's experiments in the formation of amber from resin by the wet process, as in his experiments on the formation of coal from recent plants†.

In form the amber is either like drops, indicative of a former semi-fluid condition, or as the casts of resin-ducts and cavities. Large nodular masses occur, which must have been accumulated in the lower part of the stem or the root, as in the Copal trees.

[T. R. J.]

On the Gosau Flora, *near* Salzburg. By Dr. Constantine von Ettingshausen.

[Jabrb. K. K. Geol. Reichsanstalt, 1853, No. 1. p. 168.]

The fossil flora of the Gosau marls of Aigen, near Salzburg, presents several analogies with that of the Gosau-formation of the Wand, near Wiener-Neustadt. Remains of *Geinitzia cretacea*, Endl., and of *Flabellaria longirhachis*, Ung., are plentiful at both localities. There are also found at Aigen some species, as *Pterophyllum cretosum*, Reich., and *Cunninghamites oxycedrus*, Sternb., which hitherto have been met with only in the chalk-beds of Niederschona near Freiberg. The Dicotyledons, which make their first appearance in the chalk-period, are here represented by some new and particularly interesting forms. Our knowledge of the Cretaceous flora, as yet so little examined, is therefore much increased by means of this locality, the discovery of which we owe to M. Lipold.

[T. R. J.]

[* See Quart. Journ. Geol. Soc. vol. vi. Part 2. Miscell. p. 66.—Transl.]
[† See Quart. Journ. Geol. Soc. vol. vi. Part 2. Miscell. p. 33.—Transl.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Silurian Crustacea, Pteropoda, *and* Cephalopoda *of* Bohemia. By M. J. Barrande.

[Leonhard u. Bronn's N. Jahrb. für Min. u. s. w. 1854, pp. 1–14.]

In a letter to Professor Bronn, M. Barrande gives the following interesting account of the subject-matter of the Second Part of his great work on the Silurian Formation of Bohemia, on which he is at present actively engaged. This forthcoming volume will treat of the remainder of the Crustaceans, and the Molluscs belonging to the Pteropod and Cephalopod Classes.

Crustacea.—Already, as a supplement to the First Volume, says M. Barrande, I have some new Trilobites, two species of which are quite distinct from any yet described,—*Ampyx gratus* and *Bronteus Clementinus*. The latter is distinguished by having as many long spines as there are ribs on the pygidium. I have also materials for completing the description of some of the as yet imperfectly known species, as *Trilobites mutilus, Homalonotus Bohemicus,* and others.

The other crustacean fossils belong to families very different from those of our existing seas. Firstly, some very imperfect remains, which I refer to the genus *Eurypterus*; and, secondly, fragments of different species of *Pterygotus,* which have much resemblance to those portions figured and described by Mr. Salter in the Quart. Journ. Geol. Soc. vol. viii. p. 386. pl. xxi. Thirdly, of the forms which in a former letter I referred to as *Ceratiocaris=Leptocheles**, M'Coy, I distinguish three species, and am acquainted with the whole animal,—its two flaps and the tripartite caudal extremity (Jahrb. 1853, p. 342). This animal, which I have noticed as occurring in France, the United States, and in England, appears likely to be a characteristic fossil of the Third Silurian Fauna.

Fourthly, the family of *Cytherinidæ* has already supplied me with upwards of 30 species, with individuals from 2 to 60 and 80

[* Thus given in the original. The genera *Ceratiocaris* and *Leptocheles* are very distinct, according to Prof. M'Coy's descriptions and figures. *Dithyrocaris* may probably include the forms alluded to. See also Prof. J. Hall's Palæont. New York, vol. ii. pl. 71.—Transl.]

millem. in length. This family thus presents its greatest development as to size at this the earliest period of its existence. Fifthly, there also occur various fragments of large Crustaceans, which I cannot as yet refer to any known genus or even family.

Pteropoda.—The Class of Pteropods in the Silurians of Bohemia affords a somewhat large number of forms, belonging to two genera, *Conularia* and *Theca* (*Pugiunculus*); of the former I enumerate about 17 species, and of the latter 20 species. It is very difficult to obtain perfect specimens of *Conularia*, particularly of the larger species occurring in the schists. I have, however, succeeded in getting sufficient to show the specific characters. The figure of a fragment of *C. grandis* occupies the whole of one of my plates. I have found, moreover, that the surface-ornament of the shell is subject to considerable variations in passing from the young to the adult state. In the case of *C. proteica*, portions of which are very well preserved in the limestones of my Upper Division, very many species might easily be made out by any one studying singly the several individuals found even in one locality, much more specimens from different localities. Appearances resulting from the difference of the inner and outer layers of the shells may also easily mislead. The genus *Pugiunculus* was so named by me in 1847 (Jahrb. p. 554), not being then acquainted with the name *Theca*, established for it by Sowerby and Morris a short time previously*, and which therefore has the priority. Since then this form has been recognized as an apparently characteristic fossil in most of the Silurian regions. I have recognized it in the Primordial Fauna of Bohemia, as well as in that of the United States. It occurs also in the Second Silurian Fauna of Bohemia, England, Portugal, France, the United States, New Zealand, &c. It is continued also into the Third Fauna; and MM. Sandberger have described two species of this genus in the Devonian Fauna of the Rhenish district.

I may here remark that I have discovered an operculum [Deckel] with this shell, in the first instance with *T. striatula*; and I have hereby been enabled to recognise the true nature of certain similar but disconnected bodies which I had met with. These covers of the *Theca* are easily known by their triangular outline†, corresponding to the transverse section of the *Theca* itself, the form of which is that of a more or less elongated [three-sided] pyramid.

Cephalopoda.—The Cephalopods, as a Class, are, as I have elsewhere said, the richest in species of all the Classes of animals that have formerly existed in the Silurian basin of Bohemia. Although I am not quite prepared with the descriptions of all the species, I believe their number may be estimated at from 280 to 290; whilst of Trilobites I have described only 253 species. The large number of the species of these Cephalopods is in strong contrast with the small number of their genera. I know of but ten genera in the Bohemian basin.

[* Strelecki's New South Wales, 1845, p. 289.—Transl.]

[† Figures of the *Theca* and its operculum (together with illustrations of various Cephalopodous shells, are given in a plate in the Jahrbuch, accompanying the original.—Transl.]

NAUTILIDÆ.			
Nautilus	5	Gomphoceras	16
Lituites	4	Phragmoceras	12
Gyroceras	4	Ascoceras	6
Trochoceras	22	AMMONITIDÆ.	
Orthoceras	130	Goniatites	6
Cyrtoceras	80		
		Total...	285 species.

Were I, however, to proceed according to the method of some palæontologists, I could easily double the number of genera. Thus, in *Cyrtoceras* there are species with a dorsal siphuncle, others with a ventral, and others again with a central siphuncle; which would be sufficient with some authors for the establishment of three genera. But I believe that science would gain nothing from such minute subdivision; and since no better generic characters present themselves, I keep these forms together. The same holds good of the genera *Gomphoceras* and *Phragmoceras*, in which the position of the siphuncle is subject to considerable variation. For similar reasons to the above, I keep together, under *Orthoceras*, all the straight forms, whatever position the siphuncle may take, and no matter whether it be cylindrical or swollen between the septa. Indeed I should much rather be disposed to lessen the number of the genera of these Cephalopods; since most of the above-mentioned ten types afford transitions one into another; that is, there are species combining characters that have been hitherto ascribed to different genera. Thus, among my *Orthocerata*, there are several species, all the specimens of which are slightly curved towards the point, the rest of the shell being quite straight. Other species present when in fragments the aspect of *Orthoceras*, but in a perfect condition they have the form of a flattened arch. Lastly, there are others which are always very short and conical, like the phragmocone of a Belemnite, and are straight on one side and arched on the other. Should these forms be arranged with *Cyrtoceras*, on account of their curvature; or, regardless of this, should we leave them with *Orthoceras*, with which they agree in other respects—in general aspect, the circular section, the central siphuncle, round aperture, &c.? This is a question which I cannot answer, and which I leave to better judges. At all events, these species form a transitional group between the genera *Orthoceras* and *Cyrtoceras*. Another instance:—among my species of *Trochoceras* there are some with a high and turreted spire, and there are others having similar general characters, but with so flattened a spire that we should be inclined to connect them with *Lituites* or *Gyroceras*, if their habit were not clearly that of the turreted forms.

I could enumerate many such examples, where one genus presents a transition into another; but reserving these for my Second Volume, I will confine myself here to the extraordinary resemblance of the forms among, and, so to speak, the perfect similarity between, the *Nautilus* and *Goniatites* of my Silurian rocks. In the Nautilus, the siphuncle is subcentral; in the Goniatite it is dorsal; but, if we except this character, there are species of both types presenting a similar aspect in the general form, as well as in the ornamentation of the shell, the curvature of the edge of the septa, &c. Both genera have species with individuals measuring more than 25 centim. in diameter, —a size that could be scarcely expected for the period of their first appearance on the earth's surface. This agreement between *Nautilus* and *Goniatites* is of double importance, since it proves the transition not only between these two genera, but also between the two families of *Nautilidæ* and *Ammonitidæ*; and it is worthy of notice that this transition existed at a time when the latter family was represented only by a single genus, and whilst the former presented its greatest development both in genera and species.

M. Barrande proceeds (p. 5–12) to review the several genera of the Cephalopods of the Bohemian Silurian rocks, succinctly describing the characteristics of each type, with notices of some of the species, and outlines (in an accompanying lithograph plate) of some of the most interesting forms. The geological distribution of these Cephalopods is exhibited in the accompanying Table.

Table of the Distribution of Cephalopoda in the Silurian Rocks of Bohemia.

		Lower Division.			Upper Division.			
		Stages A. B.	Stage C.	Stage D.	Stage E.	Stage F.	Stage G.	Stage H.
	Genera.	Azoic.	1st Fauna.	2nd Fauna.	3rd Fauna.			
1	Nautilus	....	....	....	=			
2	Lituites	....	....	....	≡	—	......	—
3	Gyroceras ...	....	....	....	......	≡	—	
4	Trochoceras...	....	....	....	≡	=		
5	Orthoceras ...	....	....	≡ [Colonies ≡]	≡	≡	=	—
6	Cyrtoceras ...	....	....	[Colonies ≡]	≡	=	—	
7	Gomphoceras	....	....	....	≡			
8	Phragmoceras	....	....	....	≡	=		
9	Ascoceras......	....	....	....	≡			
10	Goniatites ...	....	....	....	......	≡		

This tabular view, says M. Barrande, shows, what I have elsewhere pointed out, that the Class of Cephalopods is not represented in the First Fauna of Bohemia; and this is the case wherever this fauna occurs,—in Sweden, Norway, England, and the United States. It is in the Second Fauna that the Cephalopods first appear; and even in this we have, however, as yet discovered only badly-preserved fragments of a rare species of *Orthoceras* (without referring to those species of *Orthoceras* and *Cyrtoceras* occurring in the "colonies*" of the Stage D, and belonging to the Third Fauna, in which they again appear). In Russia, Scandinavia, and North America the Second Fauna is more richly stocked with Cephalopods than in Bohemia; and there exists a rather large number of *Orthocerata* with wide excentric siphuncles,—a group which is wanting in the Silurians of Bohemia, England, France, Spain, and Portugal. The entire absence of limestones in my Stage D may well explain the nearly total absence of Cephalopods in my Second Fauna. For as soon as calcareous deposits come in at the base of my Upper Division, the Molluscs also appear, and are soon developed in such a richness of form, that in this respect no other country can be compared with Bohemia. In my Stage E, eight genera appear together, all respectively in their greatest development. Three of these, *Nautilus, Gomphoceras,* and *Ascoceras,* are limited to this Stage; five, *Lituites, Trochoceras, Orthoceras, Cyrtoceras,* and *Phragmoceras,* pass upwards into Stage F, where the two latest genera, *Gyroceras* and *Goniatites,* then come in; all the older types, as shown by the diminution of the number of their species, having already lost their vital force. In fact the seven genera of Stage F, taken altogether, scarcely afford $\frac{1}{5}$th so many species as the eight genera in Stage E. This decrement goes on in Stage G, where there are only three genera, *Gyroceras, Orthoceras,* and *Cyrtoceras,* with but few species. Lastly, in Stage H, only the depauperated remains of *Orthoceras* and *Lituites* present themselves.

The transition between my calcareous Stages takes place in a nearly imperceptible manner, and without the traces of any revolution, so that it is difficult to comprehend the sudden disappearance of so many forms of Cephalopods from this ancient sea of Bohemia; and we are thus led to accept the existence of a natural law determining the duration of the different animal forms, independent of the physical disturbances which continually at one place or another convulse the whole surface of the earth.

The succession of specific forms of Cephalopods is very evidently seen in Bohemia, whether we regard them as a whole, or look at the several genera. The Cephalopods, therefore, could be employed, equally as well as the Trilobites†, for distinguishing the different Stages, each of which has its own particular characteristic species; there being only very few species that are continued through several Stages. As my researches in this Class are not yet finished, I cannot accurately lay down the number of species in the several Stages; but at another time I will return to this subject.

[* See Quart. Journ Geol. Soc. vol. viii. Part ii. Miscell. p. 37.—Transl.]
[† See Quart. Journ. Geol. Soc. vol. viii. Part ii. Miscell. p. 31.—Transl.]

Finally, the Silurian Formation of Bohemia has supplied 42 additional species of *Crustacea*, 37 *Pteropoda*, 285 *Cephalopoda*, altogether 364 species, the description of which will be given in my Second Volume. [T. R. J.]

Pseudomorphs. By A. Breithaupt.

[Hartmann's Berg- u. Hüttenmänn. Zeit. 1853, pp. 401, 402, 404. Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1853, pp. 837 & 843; and 1854, p. 76.]

Native Silver and Silver-glance for Red-Silver-Ore.—The combination $\frac{1}{2}$R with R ∞, in which the prism is much lengthened, very frequently observed in red-silver-ore, has been pretty certainly found in the purest native silver, in the Sauschwart mine, at Schneeberg. The crystals are hollow, with the prismatic walls sometimes broken through. Diminution of the space occupied is here very observable. The author has also seen the peculiar form of red-silver-ore in the silver-glance of Schneeberg: the mine is unknown.

Copper-pyrites for Nadel-erz.—At Lohna, near Schleiz, in the Principality of Reuss-Schleiz, copper and silver mines have been worked to a considerable extent at some early period, but all records are lost. In the grey hornstone and hard grauwacke there occur nadelerz [plumbo-cupriferous sulphuret of bismuth, = patrinite], fahlerz [grey copper], and copper-pyrites; and in the clefts, kupfer-lasur [blue carbonate of copper, = chessylite] and malachite; and there are also solid masses of anthracite. The nadelerz has altogether the appearance of that from Beresoffsk, Siberia, and, according to Plattner's blow-pipe researches in its composition, it yields a very little iron and 2 to $2\frac{1}{2}$ ounces of silver in a hundredweight [English]. The acicular crystals consist partly of nadelerz, and partly of this and copper-pyrites,—most, of copper-pyrites, with a distinct and very considerable diminution of the space occupied: in this respect, similar to what we see in the tourmaline and the mica that takes place in the granite of Kursdorf, near Penig, in Saxony.

Iron-pyrites, Red ochre, and Acicular Iron-ore for Barytes.—At Przibram in Bohemia some very interesting pseudomorphs have lately been found, occupying the place of barytes and indeed of its combination oP; P $\breve{\infty}$ $\frac{1}{2}$ P $\bar{\infty}$ with and without ∞ P, the impressions of which in the cavities are quite sharp. First of all there is a thick coating of iron-pyrites; on that, a very thin one of red ochre [Rotheisenerz]; and lastly, a thin coating of velvetty acicular iron-ore [Nadel-eisenerz]. On the last there is a calc-spar in rhombohedrons $-\frac{1}{2}$R, but only in very small isolated crystals.

Picrophyllite and Green-earth for Augite.—Breithaupt saw Picrophyllite in the form of augite; it is nothing more than decomposed augite. Green-earth for augite occurs in the melaphyre of the Fassa Thal, Tyrol, and at Tekörö in the Siebenbürge, in the same rock [T. R. J.]

On the Humite *of* Monte Somma. By M. A. Scacchi.

[Poggend. Annal. supplem. vol. iii. p. 161 *et seq.* Leonhard u. Bronn's N. Jahrb. für Min. u. s. w. 1853, p. 76.]

Humite belongs to the rectangular prismatic system*. The crystals are remarkable for exhibiting three typical forms; each of these being distinguished by definite faces, almost all of which are different from those of the other types. This fact is of the more importance, inasmuch as the sometimes very numerous faces of the crystals belonging to one and the same typical form can be derived by very simple laws from the proportional length of the axes of the primary form. This is not, however, the case with the faces of the crystals of different types, which can only be derived from the same primary form by more or less complicated laws. (The author's interesting crystallographic details illustrative of this subject, could not be understood without the aid of very many figures.)

The Humite crystals are only found among the loose blocks of Monte Somma, in granular limestone, and in a peculiar rock, of granitic structure, consisting of whitish olivine, mica, and magnetic iron. In the limestone the crystals of humite occur on the surface of geodes, or slightly covered by the limestone, and nearly always accompanied by zeilanite and crystals of green mica. In the latter rock, it is mostly associated with zeilanite, idocrase, garnet, and small yellow crystals of augite. More rarely humite is met with in many other rocks, in company with the above-named substances. Its colour is very variable, mostly brown, reddish-brown, yellow or white. Specific gravity, 3·2; hardness, that of felspar. Before the blow-pipe it is unchanged. The pulverized mineral is easily decomposed by heated hydrochloric acid.

The author also remarks, in comparing the crystals of humite with those of olivine, to which they have much similarity in their geometrical properties, that an agreement in the chemical composition of the two minerals may readily be conjectured. [T. R. J.]

Description Géologique et Minéralogique du Département du Bas-Rhin. Par M. A. Daubrée, Ing. des Mines, &c. pp. 500. 8°, Strasbourg, 1852. With five coloured Lithograph Plates of Sections, &c., and a large coloured Lith. Map.

The Geological Map issued with this work is on a scale of $\frac{1}{200,000}$, and is a reduction from the larger map† on a scale of $\frac{1}{80,000}$, which was prepared by M. Daubrée, in 1840–48, by direction of the Council General of the Department, and at the instance of the Director-General of Bridges, Roads, and Mines, who in 1835 recommended

[* In Brooke and Miller's Mineralogy, 1852, Humite is described as "oblique," and reasons are offered for this view of the crystallographic nature of the mineral in question.—Transl.]

† This is published in six sheets, printed in colours. The smaller map may be also had separate.

local geological surveys, and the execution of topographico-geological maps of Departments, as necessary adjuncts to the large geological map of France made in 1823–40.

M. Daubrée has here published the reduced geological map of the Department, and numerous diagrams, plans, and sections, with a comprehensive explanatory text. This is preceded by a short Introduction, comprising a general notice of geological phænomena and their relations. The work itself is divided into four parts. The first treats of the physical constitution of the Department; the second, which is much more extensive, is devoted to the geological constitution of the district,—the relative disposition of the several geological groups of rocks, and the organic remains and the substances useful to man that they contain. The third part comprises a classified account of the minerals found in the Department. And in the fourth part the author gives historical, statistical, and technical notices of the products of the mines, bogs, and quarries of the districts.

[T. R. J.]

On the Specific Gravity *of* Fluor-Spar. By M. Kenngott.

[Miner. Notitzen, Vienna, 1853, vol. ii. p. 10 *et seq.* Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1854, p. 72.]

From sixty experiments on fluor-spar, made without regard to the colour of the specimens, the form of crystal, locality, &c., the result arrived at by the author was that the mean specific gravity of fluor-spar is 3·183. [T. R. J.]

On Crystals *of* Strontian. By A. Müller.

[Verhandl. Nat. Gesell. Basel, 1852, vol. x. p. 103 *et seq.* Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1854, p. 75.]

The author notices some crystals of sulphate of strontian, remarkable for their size and beauty, which were found in the chamber of an *Ammonites Bucklandi*, from the Lias of the Schön-thal on the bank of the Ergolz. The interior of the chamber was coated with druses of calc-spar. The forms of the strontian crystals were like what very commonly occur in barytes. [T. R. J.]

Pyromeline. By Von Kobell.

[Erdmann's Journ. vol. lvii. p. 44. Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1853, p. 836.]

This is a product of decomposition; probably of nickel-arsenic-glance. It occurs as an earthy, mountain-green substance, incrusting or filling small fissures in a quartzose rock, obtained in 1825 from the Frieden's mine, near Lichtenberg, in Bayreuth. Pyromeline is a hydrated sulphate of oxide of nickel, with some arsenious acid. The author furnishes no quantitative analysis. [T. R. J.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Discovery *of* Jurassic Plants *in the* Venetian Alps. By Cav. Achille de Zigno.

[Leonhard u. Bronn's Jahrb. f. Min. u. s. w. 1854, pp. 31–35; with a lithographic plate of sections.]

In the Venetian Alps, above the series of dark grey limestone and reddish sandstone, which are referred to the Trias, and under the white limestone with Neocomian fossils, reposes a thick series of calcareous strata, sometimes crystalline, sometimes compact, and frequently oolitic in structure, and occupying precisely the place of the jurassic rocks of the other countries of Europe.

Order of the Strata in the Val d'Assa (Rotzo), in the Vicentin, and in the Val Tanara (Pernigotti), in the Veronese.

Neocomian.
Callovian and Oxfordian.
Bathonian. (with the plant-bed).
Bajocian.
Dolomite (Lias).
Trias (not seen).

At some places the lower part of this series is composed of slaty clay, brown or greenish in colour, of sandstone-conglomerates with pyroxenic elements, and of greyish violet limestones with crystalline veins. In the Cadore district, along the valley of the Boite, and in the Agordo district, we easily find the rocks which occupy the place of the Lias, although the absence of fossils prevents us at present from referring them with certainty to a determinate position.

In the great valleys of the Piave, Brenta, Astico, Agno, and the Adige, we do not observe the above conditions; but, on the contrary, crystalline limestones in considerable force here form the base of the Jura and Lias.

In the rocks in question fossils are very rare, and the few traces which I met with consisted of some casts, referable perhaps to *Trochus* and *Chemnitzia*, and having indeed much resemblance to the liassic species of other countries. The crystalline limestone in the upper part contains some subordinate beds of compact limestone; and this group, which as a whole I regard as nearly representing the Lias, corresponds with the Dolomite of Signor Pasini.

Above this formation in our Alps we have oolitic beds, alternating to a considerable extent with grey compact limestone; the latter affords numerous fossils, the characters of which, however, it is difficult to determine, as they are not easily separated from the matrix. These mostly belong to the genera *Pholadomya, Gervillia, Isocardia,* and *Nucula.* Pasini has found casts of *Nerinæa*; and I have observed the *Terebratula sphæroidalis,* which is characteristic of the Lower Oolite, to which formation we must refer this group from its position and its fossils. In my opinion, Pasini's series of *upper* and *lower oolitic* beds are comprehended in this one group, which represents the *étage Bajocien* of D'Orbigny.

Following the series upwards, we perceive that this formation is covered by another compact argillaceous limestone, of a grey colour, and often containing shells. Upon this rests a dark grey marly bed, in which, at Monte Spitz, near Rotzo, fine impressions of plants have long since been found. The Abbé Dal Pozzo* mentions the discovery of these fossil plants in the year 1764, when slabs were quarried from the grey limestone to cover the walls of the churchyard. It is singular that these remains have never been critically examined, although the Abbé Fortis† mentioned them. They escaped the notice of Marzari and Maraschini; and Catullo and Pasini, when writing on the subject, dismiss them with a few words. Having made several visits to this locality, I have been enabled to collect a considerable number of specimens, to study their position, and to observe how this plant-bed passes under Monte Spitz, is continued above Mezzaselva and Roana, and comes out in a long zone in the lower neighbouring valley of the Assa.

Having recognized by means of some fossils that the lower group of the oolitic system occurs at some points in the valleys of the Veronese, and that there also (Vajo del Paradiso) a bed with vegetable remains rests upon it, I requested Dr. Massalongo to institute a search, and he soon favoured me with some specimens of fossil plants from the beds of the Pernigotti hill, near S. Bartolamio.

Although the plant-bearing rock of this place differs mineralogically from that at Rotzo, yet it evidently occupies the same geological horizon, and contains some species identical with those of Spitz.

By working at both places, I collected altogether about 700 specimens, representing a flora with the following genera:—

Equisetites.	Cycadites.
Calamites.	Zamites.
Pecopteris.	Otozamites.
Tæniopteris.	Brachyphyllum.
Sagenopteris.	Araucarites.

I shall soon publish my work on these fossils, with illustrations of all the species, in forty 4to plates. I have noticed the discovery itself

* Memorie storiche dei Sette-Communi Vicentini.

† Mémoires pour servir à l'histoire naturelle de l'Italie.

in several journals last year. In the meantime, with the view of establishing my priority in their discovery, and lest any unforeseen delay occur in the publication, I will here offer a general notice of the species (the figures of which are for the most part already executed).

Calamites, sp. Val d'Assa, Vicentin, 1853.
——, sp. Pernigotti, Veronese, 1853.
Equisetites Veronensis, *de Z.* 1852. Val d'Aosta; Pernigotti.
—— crassinodis, *de Z.* 1852. Pernigotti.
—— elongatus, *de Z.* 1852. Pernigotti.
Pecopteris, 2 new species. Rotzo and Val d'Assa, 1853.
Tæniopteris, n. sp.; 2 feet (Ital.) long. Rotzo, 1853.
Sagenopteris Phillipsii, *Sternb.* Pernigotti, 1852.
——, 2 new species. Pernigotti, 1852.
Cyclopteris, n. sp. Val d'Assa, 1853.
Cycadites platyrhachis, *de Z.* Val d'Assa; Pernigotti, 1852.
Zamites, 2 new species. Pernigotti, 1852.
Pterophyllum, n. sp. M. Durlo, 1853.
Nilssonia, a very fine new species. Val d'Assa, 1853.
Otozamites Beani, *de Z.* Rotzo and Val d'Assa, 1852.
—— nov. spp. Rotzo and Val d'Assa, 1852; and Pernigotti, 1852.

CYCADOPTERIS, nov. gen., *de Z.**

Char.—Frons pinnata vel bipinnata, pinnis vel pinnulis integris coriaceis, margine induplicatis, uninerviis, in rachide decurrentibus.

Of this genus there are five species, three of which I have described and figured, but not yet published:—

C. Ungeri, *de Z.*
C. gracilis, *de Z.* } Pernigotti and Rotzo.
C. ornata, *de Z.*

In these above-mentioned localities also occur

Rhabdocarpus, 1 species.
Araucarites, 2 species; one specimen more than 2 feet long.
Brachyphyllum, 2 species.

and many other plants of which the genus, and even the family, is doubtful, as

Tympanophora, Pinnularia, &c.

The study of this fossil flora has shown my classification of this group of rocks to be correct, as made in 1845 on stratigraphical evidence, when I recognized as Neocomian the strata lying above these plant-beds, and assigned all the rocks between the Tagliamento and the Adige to their geological place. Very slight traces of coal and a yellowish bed of marl cover the leaf-beds, and terminate this series of deposits, which in my opinion occupies with us the place of the Great Oolite.

This view is confirmed by the occurrence of a yellowish rock with *Terebratula insignis*, and a white, red, and yellow variegated marble, which is the commencement of the superincumbent red ammonite-limestone. The latter I assigned in 1846 to the Oxfordian series: it is characterized with us by

* Atti dell' I. R. Accademia di Padova, 1853.

Terebratula diphya, *V. Buch.*
—— triquetra, *Park.*
—— bicanaliculata, *Schlot.*
—— resupinata, *Pusch.*
Aptychus latus, *Münst.*
—— lamellosus, *Voltz.*
Ammonites viator, *D'Orb.*
—— Zignoanus, *D'Orb.*
—— anceps, *Rein.*
—— athleta, *Phil.*
—— Hommairei, *D'Orb.*
Spatangus carinatus, *Goldf.*

With this group (which, together with the yellow bed with *Ter. insignis*, appears to me to represent collectively D'Orbigny's *Callovien* and *Oxfordien*) terminates the series of the jurassic rocks of the whole of the Venetian, Lombard, and South Tyrol Alps.

From this short notice it is easily seen, that the jurassic plant-beds of Rotzo in the Vicentin and of Pernigotti in the Veronese are above the Lower Oolite and just at the place which corresponds to that of the Great Oolite, or the *Etage Bathonien* of D'Omalius and D'Orbigny, and therefore contemporaneous with those of Mamers and Scarborough. In each locality* we find a predominance of land-plants, and among these *Cycadeæ* and *Coniferæ* especially abound. The peculiar character, however, is marked by the *Equisetaceæ*.

This discovery enriches the fossil flora of the Oolite with an important number of species, and adds to our knowledge of the geology of the South of Europe. [T. R. J.]

Fossils *of the* Vienna Basin. By Dr. Hörnes.

[From Catalogue of Duplicates published by the Vienna Imper. Geolog. Institute, 1854.]

The following list of tertiary fossils from the Vienna basin has been prepared from the duplicates of the Imperial Geological Institute of Vienna, by Dr. M. Hörnes.

Numerous duplicates having been obtained in collecting these fossils from various localities in the Vienna basin, it was considered desirable to arrange several collections for distribution or exchange; this list represents the contents of these collections. It is true it does not contain all the species of the region, but only such as were sufficiently abundant to supply materials for the collections. At the same time, this will be sufficient to show the chief typical forms.

The collections were chiefly intended for distribution amongst the national provincial museums and educational institutions; others for being forwarded to foreign countries. Some are for sale, and for this purpose the sum of £2 10*s*. has been fixed on as the price of the whole collection of 120 species.

1. Conus fusco-cingulatus, *Bronn.*
2. —— Mercati, *Brocchi.*
3. —— ventricosus, *Bronn.*
4. —— Dujardinii, *Desh.*
5. Oliva flammulata, *Lamk.*
6. Ancillaria glandiformis, *Lam.*
7. ——.
8. Cypræa pyrum, *Gmelin.*
9. Ringicula buccinea, *Desh.*
10. Voluta rarispina, *Lam.*

* Teeth of a small species of *Pycnodus* have been found at Rotzo and at Pernigotti.

11. Mitra fusiformis, *Brocchi.*
12. —— recticosta, *Bellardi.*
13. Columbella curta, *Bellardi.*
14. —— subulata, *Bellardi.*
15. —— nassoides, *Bellardi.*
16. Terebra fuscata, *Brocchi.*
17. Buccinum ventricosum, *Grateloup.*
18. —— reticulatum, *Linné.*
19. —— costulatum, *Brocchi.*
20. —— semistriatum, *Brocchi.*
21. —— mutabile, *Linné.*
22. —— baccatum, *Basterot.*
23. Purpura exilis, *Partsch.*
24. Cassis texta, *Bronn.*
25. Rostellaria pes pelecani, *Lamk.*
26. Murex trunculus, *Linné.*
27. —— polymorphus, *Brocchi.*
28. —— subclavatus, *Basterot.*
29. Ranella marginata, *Lamk.*
30. Pyrula rusticula, *Basterot.*
31. Fusus Stützii, *Partsch.*
32. —— clavatus, *Brocchi.*
33. —— bilineatus, *Partsch.*
34. —— burdigalensis, *Grateloup.*
35. Fasciolaria polonica, *Pusch.*
36. Cancellaria inermis, *Pusch.*
37. —— cancellata, *Lam.*
38. Pleurotoma asperulata, *Lam.*
39. —— granulato-cincta, *Münster.*
40. —— cataphracta, *Brocchi.*
41. —— rotata, *Brocchi.*
42. —— Coquandi, *Bellardi.*
43. —— ramosa, *Basterot.*
44. —— pustulata, *Brocchi.*
45. —— brevirostrum, *Sow.*
46. —— turricula, *Brocchi.*
47. Cerithium bidentatum, *Defrance.*
48. —— papaveraceum, *Basterot.*
49. —— margaritaceum, *Lamk.*
50. —— minutum, *Serres.*
51. —— Bronnii, *Partsch.*
52. —— plicatum, *Lamk.*
53. —— pictum, *Basterot.*
54. —— rubiginosum, *Eichwald.*
55. —— scabrum, *Desh.*
56. Turritella terebralis, *Lam.*
57. —— Riepellii, *Partsch.*
58. —— vermicularis, *Brocchi.*
59. —— Archimedis, *Brocchi.*
60. —— Vindobonensis, *Partsch.*
61. Turbo rugosus, *Linn.*
62. Trochus patulus, *Brocchi.*
63. —— coniformis, *Eichwald.*
64. —— Basterotii, *Partsch.*
65. Vermetus gigas, *Bivonna.*
66. Sigaretus haliotoideus, *Lam.*
67. Natica compressa, *Basterot.*
68. —— multipunctata, *Lam.*
69. —— glaucinoides, *Sow.*
70. —— Josephinia, *Bronn.*
71. Melanopsis Martiniana, *Fér.*
72. —— Dufourei, *Fér.*
73. —— Bouei, *Fér.*
74. Helix vermiculata, *Fér.*
75. Crepidula unguiformis, *Lamk.*
76. Calyptræa muricata, *Brocchi.*
77. Dentalium elephantinum, *Brocchi.*
78. —— Bouei, *Fér.*
79. Mactra podolica, *Eichwald.*
80. Crassatella dissita, *Eichwald.*
81. Corbula nucleus, *Lamk.*
82. —— revoluta, *Brocchi.*
83. Tellina complanata, *Linné.*
84. Lucina scopulorum, *Brong.*
85. —— divaricata, *Lamk.*
86. —— columbella, *Lamk.*
87. Donax Brocchii, *Defrance.*
88. Cytherea pedemontana, *Agassiz.*
89. —— erycinoides, *Lam.*
90. —— multilamella, *Lam.*
91. —— Deshayesiana, *Basterot.*
92. Venus Brocchii, *Desh.*
93. —— ——.
94. —— ——.
95. —— glabrata, *Dujard.*
96. —— plicata, *Gmelin.*
97. —— gregaria, *Partsch.*
98. —— marginata, *Hörnes.*
99. Venericardia Jouannetti, *Basterot.*
100. —— rhomboidea, *Bronn.*
101. —— intermedia, *Brocchi.*
102. —— Partschii, *Goldf.*
103. —— scalaris, *Sow.*
104. Cardium Vindobonense, *Partsch.*
105. —— Deshayesii, *Payraudeau.*
106. Arca Noæ, *Brocchi.*
107. —— barbata, *Linné.*
108. —— pectinata, *Brocchi.*
109. —— diluvii, *Lam.*
110. Pectunculus polyodonta, *Bronn.*
111. —— pulvinatus, *Brongn.*
112. —— cor, *Lamk.*
113. Chama gryphina, *Lamk.*
114. Congeira subglobosa, *Partsch.*
115. Pecten solarium, *Lamk.*
116. —— flabelliformis, *Brocchi.*
117. —— Malvinæ, *Dubois.*
118. —— Sarmenticius, *Goldf.*
119. Ostrea cymbularis, *Münster.*
120. Explanaria astroites, *Goldf.*

[W. J. H.]

On Dorycrinus. By Dr. Ferd. Roemer.

[Wiegm. Arch. 1853, Jahrg. 19. pt. 1. pp. 207–220, with a plate (X.); Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1854, p. 253.]

The *Dorycrinus*, a new genus of Crinoids, is established by Dr. F. Roemer on specimens from the Carboniferous Limestone of North America, sent with others (of *Actinocrinus*, *Amphoracrinus*, *Platycrinus*, &c.) to Europe by Dr. Krantz, from the neighbourhood of Warsaw on the Mississippi, in the northern part of the State of Illinois.

The only described species is the *D. Mississippiensis* (F. Roemer).

The most striking character of this Crinoid is the presence of six strong tapering processes or spines, sometimes $2\frac{1}{2}$ inches in length, which radiate upwards and outwards from the upper half of the calyx: the latter is about $1\frac{3}{4}$ inch in height.

The generic characters are as follows:—

Calyx spheroidal or subcuboidal, perforated by a single excentric lateral opening (mouth), and bearing some long spines on its surface.

Basal pieces three, unequal, forming a flattish disc; the larger two equal, the suture connecting them leading towards the mouth.

Radial pieces of first, second, and third order five; radial pieces of third order axillar, each bearing two distichal pieces of first order, and these again two distichal pieces of second order. The last emarginate on their upper border, and forming, with the next pieces above them, the apertures leading into the calyx for the supply of nutriment to the bases of the arms (lost in the fossil state).

Inter-radial piece of first order single, inserted between two radial pieces of first order on that side of the calyx on which the mouth is; inter-radial pieces of second order seven, three irregularly six-sided placed on the side on which the mouth is, one regularly hexagonal on each of the four remaining sides, placed between the two neighbouring radial pieces of first order. Inter-radial pieces of third order thirteen, five on the side on which the mouth is situated, two on each of the four other sides of the calyx, between two neighbouring radial pieces of third order.

Top of the calyx: the upper half of the calyx above the places of the arms is composed of numerous pieces. Six larger pieces, five of which are placed above the arms and around the circumference of the top of the calyx, and one at the highest point of the calyx excentrically and over the mouth, are produced into subulate spines 2 inches long.

Mouth oval, lateral, surrounded with several small pieces, and placed under the isolate spine and between two of the other peripheral spines, which are thicker than the others.

Column cylindrical, articulated, perforated by a cylindrical canal, the surfaces of the joints with fine radial marking.

The relations of *Dorycrinus* are best shown in the accompanying tabular arrangement of the genera which form with it a natural group or family.

Base of the calyx formed of four basal pieces			*Melocrinus.*
Base of the calyx formed of three basal pieces.	Mouth at the summit, and central		*Actinocrinus.*
	Mouth lateral, excentric.	Plates of the calyx top all similar	*Amphoracrinus.*
		Plates of the calyx top dissimilar, five larger ones above the arms and an excentric one over the mouth produced into long spines	*Dorycrinus.*

The author remarks, also, that some other Crinoids bear spines, such as *Acanthocrinus* (from the Posidonomya-schist of the Hartz), Jahrb. 1850, p. 679. t. 6, B.

[T. R. J.]

On the Cretaceous Sands *of* Aix-la-Chapelle. By Dr. Ferd. Roemer.

[Neues Jahrb. f. Min. u. s. w. 1854, pp. 167, 168. In a letter to Prof. Bronn, Jan. 1854.]

In the past autumn I had the advantage of a renewed examination of the Aix-la-Chapelle district. With regard to the age of this cretaceous formation, I have not found occasion to offer any essential modifications of the opinion I published several years since (Jahrb. 1845, p. 385–394), even after seeing the large collections of organic remains since made chiefly by Dr. Jos. Müller and Dr. Debey. Indeed I feel convinced now, as I did then, that all these Aix cretaceous deposits belong to the *étage senonien* of D'Orbigny, and that none of them are so low down as the horizon of the *pläner*.

Passing over the many assertions of the occurrence of the Gault, the Neocomian (Lower Greensand), or indeed of the Wealden at Aix-la-Chapelle,—assertions which entirely rest on mere lithological similarities, and are destitute of palæontological support,—I need only notice the opposite view, according to which the Sand of the Aachen-Wald and of Lonsberg, or at least a portion of it, should be paralleled with the well-known fossiliferous beds of Blackdown, in England.

It is not denied that at first sight this latter parallelism attempted by Dr. Jos. Müller appears to have much value. The condition of the fossils of the Aix sand in one locality fortunately discovered by Dr. Müller, in the neighbourhood of Vael, is similar to that of the Blackdown fossils as to their metamorphism; and a suite of Gasteropoda and Acephala is very nearly analogous to a series from Blackdown.

These very analogous or apparently identical species (although as yet no critical comparison of specimens from the two localities has been made) are, however, only such as have not a greater distribution; whilst, on the other hand, species of more general range, and which hence have a greater importance in the determination of age, are not common to both localities, but are peculiar to one or other of the two. Neither *Cardium Hillanum*, *Exogyra conica*, nor *Ammonites varicosus*, which are frequent at Blackdown, have been found in the Aix sand, whilst, on the other hand, *Inoceramus Cripsi* (a small specimen of which I recognized among the fossils from Vael in Dr. J. Müller's collection), *Belemnitella mucronata*, and many other upper chalk fossils, which are well known to occur in the very fossiliferous bands in the Aix sand, have not been met with at Blackdown.

In short, I regard the Blackdown beds, which are perhaps on the horizon of the quader-sandstone of Saxony and Bohemia, as being decidedly older than perhaps a part of the Aix sand; and this last must be placed in the *étage senonien* of D'Orbigny.

I have attempted to give more exact proof of this and other views relating to the cretaceous formation of the Aix-la-Chapelle district in a detailed report to the Supreme Prussian Mining Court, and which I intend to prepare for the press. Lastly, we may look forward to a speedy and important enlargement of our knowledge of the numerous and valuable organic contents of the Aix cretaceous beds, since Dr. Debey * is preparing for publication the results of his long-continued researches on the plant-remains of the Aix Sand, and Dr. Jos. Müller will soon have ready a new part of his work † describing the animal remains of this formation.

[T. R. J.]

On a Tertiary Plant Bed *in the* Taurus. By Prof. F. Unger.

[Sitzungsberichte d. K. Ak. d. Wissensch. M.-N. Cl. Band XI. S. 1076–1077.]

In the summer of 1853 M. Theodore Kotschy discovered a fossil plant-bed on the south slope of the Cilician Taurus, in a lateral valley of the lower part of the Cydnus valley, west of the great pass, at a height of about 4000 feet above the sea.

Eight species of plants have been distinguished by M. Unger; who remarks that all these plant-remains belong to the eocene period, and agree with the fossil flora of Sotzka and the plant-bed of southern Steiermark.

[T. R. J.]

* See also Quart. Journ. Geol. Soc. vol. vii. part 2. Miscell. p. 109.

† Monographie der Petrefacten der Aachener Kreide-formation. 4to.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Silurian Cephalopoda *of* Bohemia. By M. J. Barrande.

[Leonhard u. Bronn's N. Jahrb. für Min. u. s. w. 1854, pp. 5–12.]

The following notices of the Silurian *Cephalopoda* of Bohemia form part of a memoir by M. Barrande, a translation of the chief portion of which appeared in No. 38 of the Journal, Miscell. pp. 5–10.

M. Barrande enumerates ten genera of Cephalopods as occurring in the Silurian rocks of Bohemia, viz.

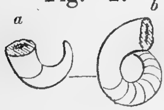
Nautilus.	Gyroceras.	Orthoceras.	Gomphoceras.	Ascoceras.
Lituites.	Trochoceras.	Cyrtoceras.	Phragmoceras.	Goniatites.

The author's tabular view of the distribution of these genera in the Stages D, E, F, G, and H of this formation is given at p. 8, Journ. No. 38, Miscell.

1. *Nautilus.*—Although this genus has long been known to occur in the Silurian formation, I do not know of any of its species occurring at a lower level than the base of my upper division (Stage E). Here it makes its first appearance; but it then disappears, and is not found throughout the higher limestone groups.

This Silurian genus has afforded me the opportunity of observing the development, so to say, of three species from the embryonic condition up to maturity. The embryo (fig. 2 *a*), which I will now describe, has the form of a little hook, having a diameter of about 10 millim., with its two extremities distant from each other by nearly the length of a third of the circumference of the whorl. We can distinguish in individuals of this age, besides the body-chamber, another division of the shell which represents the air-chambers. The crystalline condition, however, of the limestone prevents us from recognizing in this second division the septa which without

Fig.* 2.



Nautilus Bohemicus, Barrande. *a*, *b*, young stages of growth.

* The illustrations in the original form a lithographed plate (Taf. 1), fig. 1 of which is the *Theca* noticed at p. 6 of Journ. No. 38, Miscell. The remaining figures are here reproduced as woodcuts, and retain their original numbering for the sake of uniformity of reference.—Transl.

doubt once existed there. In the next stage of growth (fig. 2 *b*) one whorl is complete. As the shell increases, there is added gradually a second and a third whorl.

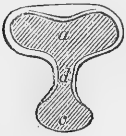
In *N. Bohemicus* and *N. Sternbergi*, when the third whorl is attained, the diameter reaches 20–25 centim.; and this appears to be the full growth of the shell. In the third species which afforded me the opportunity of studying this development, the diameter of the shell does not surpass 7–8 centim.

It is a singular fact, that we must recur to the Silurian rocks and to the relics of the earliest species of *Nautilus* to discover the developmental forms of a genus, which presents itself in so many species throughout all the geological formations, and which even exists in our present seas.

Among the other cephalopodous genera of Bohemia, *Trochoceras* is the only one that has afforded me embryonic individuals, but I have not yet been able to collect a perfect series of the transitional forms from the embryo to the adult. Such also is the case with *Orthoceras*; sometimes we meet with very fine and almost needle-like casts of the shell, which, however, have no decided specific characters about them.

2. *Lituites.*—In comparison with the northern species, the Bohemian *Lituites* are all very small, and their straight portion has barely a width of a few centimetres in the tangential direction. Two of these, in which I found the mouth well preserved, exhibit an in-bending of the two opposite lateral margins, as in *Phragmoceras* and *Gomphoceras*. We see here that the aperture consists of the same parts as those which some years since I pointed out in these two genera, namely the main opening, fig. 3, *a*, the siphuncle, *c*, and the fissure, *d*, which unites them. As I have not seen the northern *Lituites*, I do not know whether they possess a similar conformation, or, like *Orthoceras*, have an uncontracted aperture.

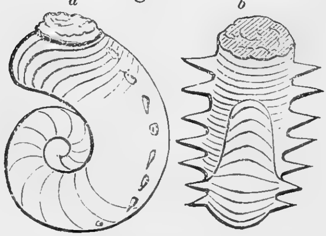
Fig. 3.



Mouth of a Lituite.

3. *Gyroceras.*—Four or five species of *Gyroceras* occur in this district; and nearly all are provided with lateral processes of the shell, which mark the stages of its periodical growth. The species that best exhibits this ornamentation is my *G. mirum*, fig. 4, *a, b*. It is very difficult to obtain specimens with the processes of the shell perfect; but I have succeeded in working out a great part of the last whorl. It is not, however, on account of the ornament that I have named this species as above; but the mouth of the shell appears to me very wonderful, being neither round nor elliptical, as in other allied forms, but half-closed by a bending-back of the shell on itself. Looking at the mouth of this shell, one might think that for half of its extent it had been closed

Fig. 4.

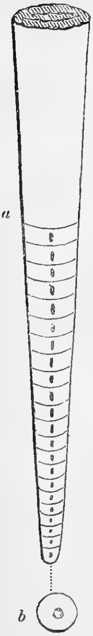


Gyroceras mirum, Barrande.

by a septum, the direction of which is symmetrical and inverse to that taken by the septum at the base of the body-chamber. On first examining these specimens, I was inclined to think that half the aperture was closed by a loosened septum; but further observations in eight or ten individuals showed that it could not be an accidental condition; and, lastly, I found a specimen in which the whole circumference of the mouth could be traced with certainty. This semiclosure of the orifice of the shell in *Gyroceras* appears therefore to be analogous to the contraction of the mouth in *Phragmoceras*, *Gomphoceras*, and *Lituites*, above mentioned; but it is peculiar, in that it is not the lateral margins that are bent towards each other, as in these genera, but only the inner (under) margin is pressed back.

4. *Trochoceras.*—I have before mentioned (*loc. cit.* p. 7) that some few turreted species appear to form transitions between this genus and *Lituites* and *Gyroceras*. I must, however, add, that there is always a certain absence of symmetry sufficient to distinguish the new type, and on which it depends. So also with some other species, the shells of which do not form a complete whorl, and which without this [want of?] symmetry would readily be referred to *Cyrtoceras*. The position of the siphuncle in *Trochoceras* is very variable,—sometimes dorsal, sometimes central, and sometimes intermediate. Most of the Bohemian species have strongly ornamented shells; in contrast to the *Cyrtocerata*, which are mostly inornate.

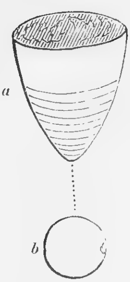
Fig. 5.



Orthoceras.
Elongate form.

5. *Orthoceras.*—This genus supplies nearly half the Silurian species of Cephalopods in Bohemia. The species of *Orthoceras*, however, are characterized with difficulty. I hope, however, to conquer this by means of the numerous specimens I have collected, by which I can recognize the chief elements of several specific forms, such as the circumference of the mouth of the shell, the body-chamber, the air-chambers, the siphuncle, the shell, and its ornamentation. Without this it would be easy indeed to confound very distinct species, fragments of which in rock-specimens (especially the chambered portions), and destitute of the outer shell, present very similar features. Thus we still have grouped under the name of *O. regulare* species which would probably prove very distinct, were we acquainted with all their characters.

Fig. 6.



Orthoceras.
Short form.

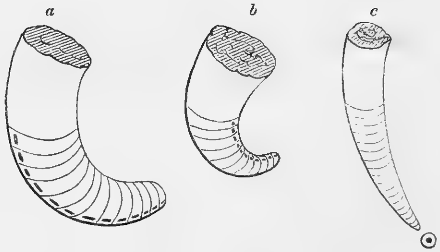
I will not now enter upon the classification of the *Orthocerata*; but I may remark that the species belonging to my Third Stage may be arranged by the general form of the shell into two chief groups; viz. 1. the elongate tapering forms, with an apex of only 2° to 15° ∠ (fig. 5 *a*, *b*); 2. the proportionately short forms resembling the phragmocone of the Belemnite in shape, the apex of which forms an angle of at least 16°, and even of 70° (fig. 6 *a*, *b*), which latter proportion gives but little length to the shell. In fact, the Bohemian species which has such an apex is at the most only 6 to 7 centim. in length.

In the elongate species the siphuncle is very seldom marginal; it is sometimes central, and sometimes intermediate. In the short species, on the contrary, it is nearly always marginal, as in the phragmocone of the Belemnite; the central position being quite an exception.

I believe I have said on another occasion * that we do not find in Bohemia, either amongst the *Orthocerata* of my "Third Fauna," nor the few species of my "Second Fauna," the large and generally excentric siphuncle which characterizes many species of the "Second Fauna" in Sweden, Russia, and North America. The *Orthocerata*, therefore, as well as the Trilobites, can furnish general characteristics for the distinction of the different Silurian Faunas.

6. *Cyrtoceras*.—I have already indicated that the species of this genus can be divided according to the position of the siphuncle

Fig. 7.



Cyrtoceras.

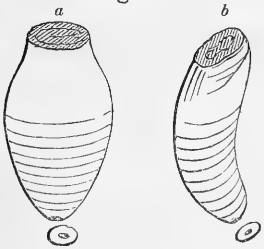
a. Siphuncle dorsal: *b*. Siphuncle ventral. *c*. Siphuncle central.

(fig. 7)—dorsal, ventral, or central—into three groups, which have, however, so little difference in external aspect, that one must see the siphuncle itself to be able to determine the place of a species. The shells of the *Cyrtocerata* of the Third Fauna have in general but little ornamentation, although in a few cases it is sufficient to characterize the species. The other elements for specific distinction are of the same nature as those which I have already mentioned in the case of *Orthoceras*. The species belonging to the group with central siphuncle have generally a circular cross-section, wherein they ap-

* [See Quart. Journ. Geol. Soc. vol. viii. Miscell. p. 33.—Ed.]

proximate to *Orthoceras*, and form a transitional group between the two genera. The mouth in nearly all my species of *Cyrtoceras* is analogous to that of *Orthoceras*, *i. e.* it is not contracted, but corresponds in shape to the cross-section of the shell. Still, I have met with a small number of species in which the body-chamber is swollen in the middle and again narrows towards the mouth, such as *C. heteroclytum* (fig. 8 *a*, *b*); nevertheless the mouth preserves the same shape as the transverse section of the shell. Thus there is a transition from *Cyrtoceras* to *Phragmoceras*; and these genera also approximate in their style of curvature.

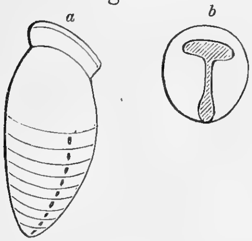
Fig. 8.



Cyrtoceras heteroclytum, Barr.

7. *Gomphoceras*.—This genus differs from *Orthoceras* chiefly in the contraction of its mouth to a small aperture (fig. 9 *a*, *b*). All the species known to me are but slightly elongate, and therein they approach the second division of the *Orthocerata* above described. Like these also the *Gomphoceras* has an inclination to curve, especially in the chambered portion: fig. 9 *a* shows one of the sides nearly straight, and the other somewhat arched. This analogy, however, does not extend beyond the external form; for in the Bohemian *Gomphocerata* the position of the siphuncle is very variable. Sometimes we find it in the centre, often between the centre and the convex or dorsal border, sometimes between the centre and the ventral or straight border. In respect of external ornamentation this genus has but little variety, since most of the species are marked merely by the lines of growth. Nevertheless they are easily distinguished by the form of the mouth, the position of the siphuncle, &c.

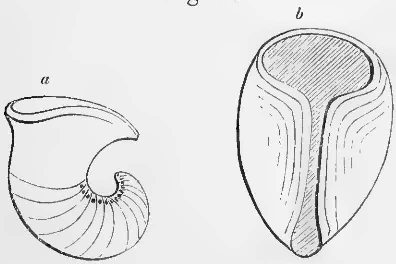
Fig. 9.



Gomphoceras.

8. *Phragmoceras*.—For a long time I held a conviction that this genus totally differed from *Gomphoceras* on account of the curvature and especially the constant position of the siphuncle on the concave or ventral border. Circumstances have changed my views, for in 1851 I discovered, to my great astonishment, a *Phragmoceras* very well characterized by the contraction of its mouth and the curvature of its shell, but possessing a dorsal siphuncle. Since then I have obtained many specimens with this anomalous position of the siphuncle; and, although

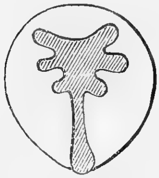
Fig. 10



Phragmoceras Broderipii, Barr.

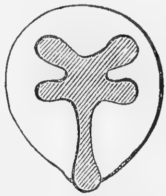
they all belong to one species (*P. perversum*), they serve to establish (from the position of the siphuncle and the slight curvature of the shell) an evident transition from *Phragmoceras* to *Gomphoceras*.

Fig. 11.



Phragmoceras callistoma, Barrande.

Fig. 12.

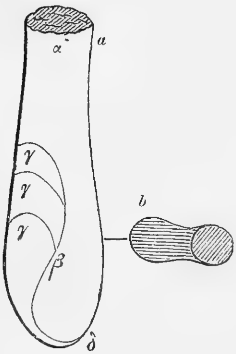


Phragmoceras Loveni, Barrande.

The Bohemian species of *Phragmoceras* have but little ornament on the shell. They are chiefly characterized by the general form and the manifold conditions of the mouth of the shell. Thus *P. callistoma* (fig. 11) has three notches on each side of the larger aperture of the mouth; and *P. Loveni* (fig. 12) has only two notches on each side.

9. *Ascoceras*.—The form of this singular Cephalopod (fig. 13) presents some slight analogy to *Ptychoceras* among the *Ammonitidæ*.

Fig. 13.



Ascoceras.
a, outline.
b, transverse section.
α β, the body-chamber.
γ γ γ, the air-chambers.
δ, place of the siphuncle.

In *Ascoceras* the shell is bent quite back upon itself, as in *Ptychoceras*. In the former, however, the chambered portion (fig. 13 γ γ γ) is very short, and contains only 3–7 chambers, and the reflected portion, instead of merely running back parallel to the body-chamber, α β, lies close to it, and indeed is recessed in it; so that the whole forms a cylindrical body, covered by one shell, instead of there being two distinct and parallel branches, as in *Ptychoceras*. The shell, covering at the same time both air-chambers and body-chamber, hinders one from recognizing the nature of this fossil so long as the shell is perfect; but when this is partly removed, the two enclosed parts can be distinguished.

The siphuncle, passing from the body-chamber to the air-chambers, can be easily seen at the extremity of the fossil (δ); still it was not possible to detect how the several chambers communicated one with another. The mouth (*a*) is always nearly circular and without contraction, as in *Orthoceras*. Nearly all the species have a somewhat ornamented shell, which, together with the difference of general form, serves for specific distinction. They are generally small in size, not exceeding 5–10 centimetres in length.

10. *Goniatites*.—This genus, the solitary representative of the *Ammonitidæ*, has furnished at least six species, all of which belong to the *Nautilini* group of MM. Sandberger. I have already pointed out* the great analogy existing between these *Goniatites* and the *Nautili* of my Stage E. It is also worthy of remark that all the

* [Quart. Journ. Geol. Soc. vol. x. Miscell. pp. 7 & 8.—Ed.]

Goniatites I have yet found are confined to my Stage F, and to a few localities.

The state of preservation of these fossil remains often leaves much to be desired, since they lie in a more or less argillaceous limestone where the shell has disappeared. Their ornamentation, therefore, is not easily recognized, and exhibits in well-preserved fragments much uniformity. The dorsal position of the siphuncle leaves no doubt as to the generic relations of these cephalopods, which from the form of their septa might readily be confounded with the *Nautilidæ*. One species, which I term *G. Bohemicus*, has a diameter of 25 centimetres. [T. R. J.]

On some Metals *occurring in the* Auriferous Sand *of* Transylvania. By K. Zerrenner.

[Sitz. Bericht. d. math. nat. Kl. d. Wiener Akad. vol. xi. pp. 462–464. Leonhard u. Bronn's N. Jahrb. 1854, p. 68.]

In the washing of at least 15,000 cwts. of the auriferous sand of Olahpian in the Siebenbürgen there were found only three very small grains of platinum—a flattened morsel of native copper (observed elsewhere only in the gold-washings at Goroblagodatski in the Ural), —native lead in rather larger quantity, occurring sometimes as small scales and grains in the gold-sand of the Tiskur range, and since 1839 it has been occasionally met with in the Bogolowsk district of the Ural, in the Leontjewskoi mine, and in the auriferous sand of Velika, near Pozega, in Southern Slavonia, in somewhat larger grains, $\frac{1}{10}$ Loth [$\frac{1}{20}$ ounce] in weight;—cyanite and felspar-porphyry occur as ingredients in the Olahpian gold-sand. [T. R. J.]

The Geology *of* Northern Persia. By Dr. C. Grewingk. 8vo, pp. 148. With Woodcuts and Geological Map. St. Petersburgh. 1853. Die geognostischen und orographischen Verhältnisse des nördlichen Persiens.

This work is the result of M. Grewingk's examination of the geological specimens collected by Dr. F. Buhse, in his travels in 1847–49, and forwarded by him to the author, and of the collection made by M. Woskoboinikow, together with the examination and collation of the accounts of these and other earlier travellers. This first attempt of a general view of the geological conditions of Northern Persia is illustrated by a coloured lithograph map, sketched by the author according to the latest geographical information.

The geographical description of the district occupies pp. 2–30; the geological notices of the several localities, with full references to numerous authorities, occupy pp. 31–119; and the general view of the geology of the whole region is given in pp. 120–148.

The formations recognized by the author are—

Granite and quartziferous porphyry.

Diorite, serpentine, diorite-porphyry, porphyritic breccia.

Diabasic porphyry, melaphyre, and breccias; amygdaloid, dolerite, and basalt.

Andesite, porphyritic trachyte, pearlstone, tuffa, and breccias.

Lavas. (In treating of these the author enumerates the earthquakes and hot-springs of the district.)
Travertine and alluvium.
Diluvial and tertiary formations. (The latter with gypsiferous marls and nummulitic rocks.)
Cretaceous formation.
Jurassic formation. (Including Hippurite-limestone.)
Coal formation.
Silurian formation. [T. R. J.]

On Fossil Species *of* Rhinoceros*. By M. Duvernoy.

[Archives du Muséum d'Hist. nat. tome vii. livr. 1, 1853. *Comp.* Compt. Rend. vol. xxxvi. 1853, and Leonhard u. Bronn's N. Jahrb. 1854, pp. 243–248.]

M. Duvernoy's memoir consists of four parts, and an introduction. In the latter the author enumerates the sources of the materials of his essay, and briefly reviews the Cuvierian species of fossil Rhinoceroses and the subsequent labours of Blainville, Lartet, Laurillard, and Gervais. The essay itself treats successively of—the recent Rhinoceroses and their osteology,—the miocene species,—pliocene species,—and those of the diluvium and caverns.

The fossil species described and illustrated (with eight plates) in this memoir are thus arranged by the author:—

Miocene. From the valleys of the Allier and of Haute-Loire (Gannat and Randan); and from the basin of the Garonne (Simorre, Sansan, &c.).

1. Rhinoceros incisivus, *Cuvier*. From Sansan.
   R. Schleyermacheri, Kaup.
   R. Sansaniensis, Lartet.
2. R. minutus, *Cuvier*. From Moissac, dep. Tarn et Garonne.
3. R. brachypus, *Lartet*. From Simorre.
4. R. pleuroceros, *Duv.* n. sp. From Gannat.
5. R. Randanensis, *Duv.* n. sp. From Randan.
6. Acerotherium typus, *Duv.* From Sansan.
   A. incisivum, Kaup.
   R. tetradactylus, Lartet.
7. A. Gannatense, *Duv.* n. sp. From Gannat.

Pliocene.

1. Rhinoceros leptorhinus, *Cuvier*. From North Italy, Montpellier, &c.
   R. de Montpellier, Marcel de Serres.
   R. megarhinus, De Christol.
2. R. protichorhinus, *Duv.* From Clacton, Essex.
   R. leptorhinus, Owen.

Diluvium and Caverns.

1. R. tichorhinus, *Cuvier*. From Siberia, France, England, &c.
2. R. Lunellensis, *Gervais*. From Lunelvieil, near Montpellier.
3. Stereoceros Galli (*vel* typus), *Duv.* (=Elasmotherium, *Fischer*, according to *Kaup* and *Laurillard.*) From the Rhine valley. [T. R. J.]

* [See also M. Giebel's paper, Q. J. G. S. vol. viii. Miscell. p. 9 *et seq.*]

ALPHABETICAL INDEX

TO THE

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

[The fossils referred to are described, and those of which the names are printed in italics are also figured.]

END OF VOL. X.