THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

VOLUME THE ELEVENTH.

1855.

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.

MDCCCLV.

List

OF THE

OFFICERS

OF THE

GEOLOGICAL SOCIETY OF LONDON,

ELECTED FEBRUARY 21, 1855.

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J. W. Salter, Esq.
D. Sharpe, Esq., F.R.S. & L.S.

Assistant-Secretary, Curator, and Librarian.

T. Rupert Jones, Esq.

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— 58, — 19 & 7 from bottom, }
— 59, — 4 & 13 from top, } *for* in the Bákhtiyari Mountains on the Turco-Persian Frontier, *read* a little north of Hakim-Khan, on the road to Hassan Chelebi, in Asia Minor, about lat. 38° 40′, long. 37° 50′.

— 86, — 10 from top, *for* Transactions *read* Proceedings.

— 86, — 10 from bottom, *for* Liebig's *read* Leibnitz.

— 88, — 20 from top, *for* part 3 *read* 3 parts.

— 88, — 26 from top, *for* elephant's *read* seal's.

— 88, — 32 from top, *for* Dervalque *read* Dewalque.

— 250, — 5 from top, *for* extinct *read* existing.

— 284, — 18 from top, *for* A′mi *read* A′mír.

— 285, note. *for* Púlim *read* Púlún.

— 352, line 15 from top, *for* had *read* have.

— 352, — 2 from bottom, *for* south-west *read* south-east.

— 363, — 8 from top, *for* Mandla *read* Mandu.

— 363, note, }
— 364, note, } *for* Malcolmson *read* Malcolm.

— 364, line 20 from top, *for* hill part *read* hill-fort.

— 364, — 28 from top, *for* Jib *read* Jihur.

— 380, — 15 from top, *for* Halyadoba *read* Halyadoho; *and for* Umred *read* Umred.

— 380, — 3 from bottom, *omit* at Masulipatam.

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PLATE

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 21, 1855.

REPORT OF THE COUNCIL.

The Council have much pleasure in making a Report which indicates that progressive prosperity of the Geological Society which must be satisfactory to its Members. It will be seen that during the past year 32 new Fellows have been elected, and that two elected in former years have completed their Fellowship, making an addition of 34 Ordinary Fellows. One Foreign Member has also been elected. On the other hand, the diminution which the Society has sustained from deaths and resignations amounts to 22, leaving for 1854 a total increase of 13 Ordinary Members, a result which contrasts favourably with many former years. At the close of 1853, the Geological Society numbered 871 Members; at the close of the past year it consisted of 884.

The Council have to report that the current expenditure of the Society during the past year has exceeded the income by the sum of £9 11*s*. 11*d*., not including in this calculation the sum of £189 received for compositions, nor the sum of £199 15*s*. 3*d*. invested in Exchequer Bonds. The Council think it right to explain that this circumstance, apparently so contradictory to the Reports of the two preceding years, can be most satisfactorily accounted for.

In the first place, the sum invested in Exchequer Bonds exceeds the sum received for compositions by a larger amount than the excess of expenditure over income. But the principal circumstance to which the Council have to call the attention of the Fellows is, that, in consequence of the very large excess of income over expenditure last year, it was determined to apply £50 to the purchase of Books for the Library, and a further sum of £30 for the purpose of procuring assistance in the Museum. The sum actually expended under these two heads amounts to £40 13*s.* 3*d.*

The Council adopted this temporary mode of investing the surplus balance at their Banker's in the purchase of Exchequer Bonds, while they were considering the propriety of continuing to invest the amount received for Composition Fees, or of expending that amount in furthering the objects of the Society; it having been suggested by the Treasurer that the sum already invested far exceeded the present life-interest of the surviving Compounders in their compositions.

The number of Compounders at the close of 1853 was 134, and at the close of 1854 it was 137, three having died during the interval, and six newly elected Fellows having compounded, the amount of whose compositions, with one remaining unfunded at the close of 1853, is £220 10*s.* Of this, the sum of £199 15*s.* 3*d.* has been laid out in the purchase of two Exchequer Bonds of £100. The amount of the funded property of the Society therefore (exclusive of the Exchequer Bonds) remains the same, viz. £4014 15*s.* 8*d.* The amount received from the 137 existing Compounders is £4315 10*s.*

The Council have further to report that the 10th volume of the Journal of the Society has been completed. The first part of Vol. XI. is ready for publication; and a new Part of the Transactions, forming the 4th part of the 9th volume, is in an advanced state.

The Supplement to the Library Catalogue, to which reference was made in the Report of last year, is being executed by Mr. Rupert Jones in a manner which must render it exceedingly valuable to all the working members of the Society:—it will be found also to contain a list of such original Maps, Sections, and Illustrations as have accompanied communications, and have been left in the possession of the Society.

The Council desire to call the attention of the Society to the improved List of the Donations to the Library of the Society, published in the Journal, as prepared by Mr. Jones, acting on the suggestion of some Members of the Council; it now contains a complete list of the titles of all the various notices and original memoirs comprised in the numerous Transactions and Journals, British as well as Foreign, which the Society has received.

They have further to report, that in March last it was deemed advisable, as a temporary measure, to authorize Mr. Rupert Jones to obtain an Assistant in the Museum. The services of Mr. Gawan were engaged; and in December last the engagement was, by consent of the Council, continued down to the present Anniversary. The charge in respect of this increase amounts to £34 10*s.*

The Award of the Wollaston Palladium Medal for the year has been made to Sir Henry Thomas De la Beche, C.B., Director-General of the Geological Survey of Great Britain, F.R.S., F.G.S. &c., for his many valuable contributions to Geological Science during a long series of years; and more especially for the establishment of the Museum of Practical Geology; for the very accurate Geological Survey of the United Kingdom now in progress, illustrated by Maps, Sections, and Specimens; and for the skill and impartiality displayed by him in the selection of his many able coadjutors in that great national work.

The balance of the proceeds of the Wollaston Donation Fund has been awarded to Drs. Guido and Fridolin Sandberger, of Wiesbaden, for their valuable work on the Fossils of the Rhenish Palæozoic rocks in Nassau, and to assist them in its completion, and in the publication of their intended work on the Fossils of the Mayence basin.

Report of the Library and Museum Committee.

Library.

Since the last Annual Report, 12 volumes, exclusive of periodicals, have been added by purchase, and about 90, also exclusive of periodicals, have been received as donations, making a total increase of above 100 volumes. Amongst the purchased books may be mentioned as more particularly valuable, Bischoff's Geologie, Grewingk's Geology of North Persia, Goldfuss' Coal Flora, Meyer's Palæontology of Wurtemberg, Dr. Hooker's Himalayan Journals: and it may be added that the set of Annals of Natural History has been completed by purchase, and the serials continued regularly to the present time. Of the books received as donations, Jardine's Ichnology of Annandale, presented by Sir R. I. Murchison, F.G.S.,—Siluria, presented by Sir R. I. Murchison, F.G.S.,—Seale's Geognosy of St. Helena, presented by A. Morant, Esq., F.G.S.,—Conchologia Iconica, several parts, presented by L. Reeve, Esq., F.G.S.,—Darwin's Cirripedia, and other works, presented by the Ray Society,—deserve to be specially named, in addition to the 63 volumes presented by Mr. Lonsdale, out of which the Society's set of the Edinburgh New Philosophical Journal has been completed, with the exception of a few parts. All these books have been catalogued, arranged in their proper places, and bound so far as necessary: in referring, however, to this section of our Report, it is right to observe that the great want of additional shelves, pointed out by the Committee of last year, is now still more strongly felt, as no addition has as yet been made, notwithstanding the continued increase of books. The arrangement of serials is much embarrassed by this deficiency of space, as sets are frequently obliged to be arranged in more than one place, and the difficulty of reference is thereby much increased.

The preparation of the new Catalogue steadily progresses, and one and a half sheet of the supplementary portion, including the serials, are now in the printer's hands, this being the part most difficult of arrangement. The Catalogue of the Maps is also in hand, but this has not been prepared without much difficulty, as many of the charts already catalogued have had to be disturbed and separated when cataloguing the new. The arrangement of manuscript Sections and Drawings is also in progress; and as many Maps are now ready, the new Case is also required. In respect to the Ordnance Maps, the revised Maps have not been applied for, as it would be useless to obtain them until cases for their reception had been purchased; but the Maps already in possession are put into cases as quickly as they can be prepared for them. Generally it may be stated that the accommodation for the reception of Maps and Drawings is limited and inconvenient, and more especially for those which are kept in portfolios.

Notices of Donations and of Papers received, as well as of purchases, are regularly published in the Quarterly Journal.

Museum.

Two new tables have been purchased for supporting the drawers of cabinets when under examination.

Mr. Gawan has been principally employed in cleaning fossils, securing the loose specimens and labels, and labelling in paint the larger specimens of rocks and boulders, exhibiting glacial action or the footprints of animals. He has also commenced the re-arrangement of the Tertiaries, under the direction of Mr. Jones. Everything thus labelled has been catalogued by Mr. Jones, who has also acted upon the suggestion of the last Committee by preparing the interleaved copy of Mr. Morris's "Catalogue," presented by the author for the use of the gentlemen willing to assist in the respective palæontographical departments, and whose aid would therefore be now of the greatest advantage.

Of British specimens the donations have principally been connected with the carboniferous and cretaceous formations; and have been placed in the respective drawers.

Of Foreign specimens, those of Mr. Loftus, received in 1853, have been examined, separated, and put into drawers; duplicates having been prepared for presentation to the British Museum. The St. Domingo specimens of Col. Henneker have been examined, arranged, and put into drawers; the duplicates having been sent to the British Museum and the Museum of Economic Geology in Jermyn Street. Mr. Townsend's specimens from Ascension, received in 1853, have been sorted and put into drawers, and the duplicates sent to Jermyn Street.

In the Upper Museum, the arrangement of the Brazilian, Ceylon, and Chinese specimens has been continued: the specimens of auriferous rocks from Victoria, New South Wales, and New Zealand, presented by Sir T. Mitchell, Mr. Milner Stephens, and Sir George Grey, have been partly arranged; and a second series of fossils from Central India, presented by the Rev. Messrs. Hislop and Hunter, is in course of arrangement for illustration in the Journal. In addition to the above, fossils from Prome have been presented by Lieut.-Col. Turton through Lieut.-Col. Cautley.

As the specimens here referred to necessarily occupy much space whilst under examination, it is very desirable that duplicates of the Nagpoor specimens, now much in the way, should be presented at once to public Institutions. In referring generally to the Museum, it should be observed that much labour has been expended upon it by Mr. Jones, which does not at first arrest attention; such, for example, as that required to reduce to order, or, as it were, sift out, local specimens from Foreign Countries which had been put promiscuously into drawers without reference to the papers they were intended to illustrate. Mr. Jones has done much to correct this evil, and, by properly arranging these specimens, to enable a reader to compare an author's statements with the specimens on which he founds his reasonings.

Mr. Jones speaks most favourably of the assistance he has received from Mr. Gawan, and the Committee is satisfied from its own observation that his services have been most valuable, and that it is desirable that they should be continued: indeed, from the arduous duties performed by Mr. Jones, he is fully entitled to every assistance it is in the power of the Society to afford him.

The Committee in closing their Report think it right to point more especially to the valuable donation by Mr. Greenough of his Map of India, and to the equally valuable donation by Mr. Griffiths of his new Map of Ireland; donations which must be the more cordially received as coming from two of the oldest Members of the Society.

J. E. Portlock.
S. P. Pratt.

January 23, 1855.

Comparative Statement of the Number of the Society at the close of the years 1853 *and* 1854.

	Dec. 31, 1853.		Dec. 31, 1854.	
Compounders		134		137
Residents		204		203
Non-residents		463		475
		801		815
Honorary Members	16		15	
Foreign Members	50		50	
Personages of Royal Blood	4	—70	4	—69
		871		884

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1853 *and* 1854.

Number of Compounders, Residents, and Non-residents, December 31, 1853			801
Add, Fellows elected during former years, and paid in 1854	Non-resident	2	
Fellows elected, and paid, during 1854	Resident	16	
	Non-resident	16	
		—32	
		—	34
			835
Deduct, Compounders deceased		3	
Residents ,,		4	
Non-residents ,,		9	
Resigned		4	
		—	20
Total number of Fellows, 31st Dec. 1854, as above			815

Number of Honorary Members, Foreign Members, and Personages of Royal Blood, December 31, 1853		70
Add, Foreign Member elected during 1854		1
		71
Deduct, Foreign Member deceased	1	
Honorary Member ,,	1	
	—	2
As above		69

Number of Fellows liable to Annual Contribution at the close of 1854, *with the Alterations during the year.*

Number at the close of 1853		204
Add, Elected and paid in 1854		16
		220
Deduct, Deceased	4	
Resigned	4	
Compounded	6	
Became Non-resident	3	
	—	17
As above		203

Deceased Fellows.

Compounders (3).

Rev. H. M. De la Condamine. | James Hall, Esq.
J. E. Winterbottom, Esq.

Residents (4).

Arthur Aikin, Esq.
G. W. Aylmer, Esq.
John Evans, Esq.
Prof. E. Forbes.

Non-Residents (9).

E. S. Barber, Esq.
Isaiah Deck, Esq.
Rev. Thomas Egerton.
Capt. Sir J. Franklin.
Joseph Martin, Esq.
G. A. M'Dermott, Esq.
J. M. Scobie, Esq.
Dr. William Stanger.
Charles Walker, Esq.

Honorary Member (1).

Professor Robert Jameson.

Foreign Member (1).

Professor F. S. Beudant.

The following Persons were elected Fellows during the year 1854.

January 4th.—Charles Moore, Esq., Bath; Robert Hunt, Esq., Australia; Robert W. Hall, Esq., Cirencester; Joseph Hobbins, M.D., Wednesbury; and Edward S. Jackson, Esq., M.A., Totteridge.

—— 18th.—Alfred Wm. Morant, Esq., Camden Town; and John B. Denton, Esq., Gravely, Stevenage.

February 1st.—Charles Robert des Ruffières, Camden New Town; Edward H. Sheppard, Esq., Clifton; Alexander G. Gray, Jun., Esq., Newcastle-on-Tyne; and George M. Stephen, Esq., Maida Hill.

—— 22nd.—Charles Lindsay, Esq., Doctors' Commons; C. H. B. Hambley, Esq., Brixton; and James A. Caley, Esq., Clifton.

March 8th.—N. S. Maskelyne, Esq., M.A., Oxford; B. Waterhouse Hawkins, Esq., Norwood; S. P. Woodward, Esq., Islington; and Charles W. Dilke, Esq., Sloane Street.

—— 22nd.—Edward O'Riley, Esq., Toungoo, Burmah; Frederick J. Bigg, Esq., Strand; Samuel Minton, Esq., Freyberg; and Samuel H. Beckles, Esq., St. Leonards.

April 5th.—Robert Etheridge, Esq., Bristol.

May 3rd.—John Petherick, Esq., Waterford; and John Coode, Esq., Portland.

—— 24th.—Edward Bretherton, Esq., Liverpool; and William Ferguson, Esq., Gower Street.

June 7th.—Thomas Wynne, Esq., Longton, Staffordshire.
November 1st.—John H. Murchison, Esq., Porchester Street; Wm. Henry Mortimer, Esq., Harley Street; John W. Dawson, Esq., Pictou, Nova Scotia; and William Cunnington, Esq., Devizes.
—— 15th.—Francis Galton, Esq., Victoria Street, Westminster.
December 13th.—James Colquhoun, Esq., Harley Street; George Burnand, Esq., Sussex Square, Hyde Park; and R. B. Grindrod, M.D., Great Malvern.

The following Person was elected a Foreign Member.

May 3rd.—M. Joachim Barrande, Prague.

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

British Specimens.

Specimens of Flints with Fish-remains from Norfolk; presented by Capt. Alexander.
Slab of Stone with Footprints, from the Old Red Sandstone of Elgin; presented by Capt. L. Brickenden, F.G.S.
Specimens of Impressed Sandstones from the Lower Carboniferous rocks of Yorkshire; presented by H. C. Sorby, Esq., F.G.S.
Shells from the Mammaliferous Gravel-beds of Orton; presented by J. Trimmer, Esq., F.G.S.
Echinodermata from the Chalk of West Norfolk, and Fossils from the Nar Clay; presented by C. B. Rose, Esq., F.G.S.
Fossils from the Green-grained Chalk of Chardstock; presented by Rev. T. Walrond and J. Wiest, Esq.
Fossils from the Lower Carboniferous rocks of Scotland; presented by W. Ferguson, Esq., F.G.S.
Specimen of Slate from Westmoreland, and a Specimen of Coked Straw; presented by Mr. J. Jameson.

Foreign Specimens.

Specimens of Rocks from Victoria; presented by G. M. Stephen, Esq., F.G.S.
A second Series of Fossils from Central India; presented by the Rev. Messrs. Hislop and Hunter.
Suite of Auriferous Rocks, with Specimens of Gold, from New Zealand, collected by Mr. Heaphy; presented by Sir George Grey.
Specimen of Nummulitic Rock from near Varna; presented by W. J. Hamilton, Esq., Pres. G.S.
Collection of Fossils from Prome; presented by Lieut.-Col. Turton.

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. 17 and 18. Horizontal Sections, Nos. 31, 32, 33, 34, and 37; presented by Sir H. T. De la Beche, F.G.S., on the part of Her Majesty's Government.

Geognostische Karte von Kurhessen und den angrenzenden Landern, zwischen Taunus-, Harz- und Weser-Gebirge, von Adolph Schwarzenberg und Heinrich Reusse; presented by the Authors.

Carte Géologique de la Belgique, in 9 sheets, par André Dumont; and

Carte Géologique de la Belgique et des Contrées voisines, par André Dumont; presented by the Author.

Geological Map of the United States, by Jules Marcou, and Text; presented by the Author.

General Sketch of the Physical and Geological Features of British India, in 9 sheets, by G. B. Greenough, Esq., F.G.S.; presented by the Author.

Geognostische Karte der Umgebungen von Kraus und vom Mauhardsberge; presented by the Imperial Academy of Vienna.

Geological Map of Norway, by M. Keilhau; presented by D. Forbes, Esq., F.G.S.

Miscellaneous.

Model of Volkmannia Morrisii, a fossil plant, from Carluke; presented by W. J. Gourlie, Esq.

Model of Mont Rosa, and Model of the Zugspitze; presented by MM. Schlagintweit.

Lithograph of the Remains of a young Iguanodon; presented by J. S. Bowerbank, Esq., F.G.S.

Coloured Drawing of a Specimen of Quartz Crystal; presented by Miss C. Sowerby.

Lithographic Portrait of the late Prof. E. Forbes; presented by Prof. Tennant, F.G.S.

Specimen Lithograph of Fossils; presented by G. B. Sowerby, Esq.

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.

Alexander, Capt.
American Academy of Arts and Sciences.
Art-Union of London.
Asiatic Society of Great Britain.
Athenæum Journal, Editor of.
Babbage, C., Esq.
Basel Natural History Society.
Belgium, Royal Academy of Sciences of.
Bellardi, M. L.
Bengal, Asiatic Society of.

Berlin, German Geological Society at.
Berlin, Royal Academy of Sciences at.
Berwickshire Naturalists' Club.
Bianconi, Signor J. J.
Binney, E. W., Esq., F.G.S.
Bland, T., Esq., F.G.S.
Bologna Academy of Sciences.
Bombay Geographical Society.
Boston Natural History Society.
Bowerbank, J. S., Esq., F.G.S.
Breslau, Silesian Society at.
Brickenden, Capt. L., F.G.S.
British Association for the Advancement of Science.
Buckman, Prof., F.G.S.

Caen, Linnean Society of Normandy at.
Cambridge Philosophical Society.
Canadian Journal, Editor of the.
Carter, H. J., Esq.
Cautley, Lieut.-Col., F.G.S.
Chemical Society of London.
Cherbourg Society of Sciences.
Civil Engineers' Journal, Editor of the.
Colonial Office.
Copenhagen, Royal Academy of Sciences at.
Cox, A., Esq.

Daubeny, Prof., M.D., F.G.S.
Davidson, Thomas, Esq., F.G.S.
Deslongchamps, M. E.
Dijon, Academy of Sciences of.
Dublin Geological Society.
Dumont, Professor André, For. M.G.S.

East India Company, The Hon.
Edinburgh, Royal Society of.
Ehrenberg, Prof., For.M.G.S.
Erfurt, Royal Academy of Sciences at.
Escher, M. A.

Fairbairn, Wm., Esq., F.G.S.
Ferguson, W., Esq., F.G.S.
Ferrari, Signor Silvio.
Fitton, Dr., F.G.S.
Forbes, D., Esq., F.G.S.
France, Geological Society of.
Frankfort, Senckerberg Natural History Society at.
Franklin Institute.

Geneva Natural History Society.
Giebel, Prof. C.
Greenough, G. B., Esq., V.P.G.S.

Haarlem, Society of Sciences at.
Hamilton, W. J., Esq., Pres. G.S.
Hanau, Wetterau Society of Natural Science at.
Hargraves, E. H., Esq.
Harkness, Prof., F.G.S.
Hauer, M. J. Ritter von.
Hausmann, Prof. J. F. L., For. M.G.S.
Hébert, M. E.
Hislop, Rev. S.
Hopkins, Evan, Esq., F.G.S.
Horticultural Society of London.
Howard, Luke, Esq.
Hunter, Rev. R.

Indian Archipelago Journal, Editor of the.
Institute of Actuaries.
Istituto Lombardo de Scienza.

Jameson, J., Esq.
Jones, T. R., Esq., F.G.S.
Jukes, J. Beete, Esq., F.G.S.

Kelaart, E. F., M.D., F.G.S.
Koninck, Prof. L. de, For. M.G.S.
Kopp, M. H.

Layton, T. W., Esq.
Leeds Philosophical Society.
Leidy, J., M.D.
Leymerie, M. A.
Liebig, Prof. J.
Liège Royal Society of Sciences.
Lille Society of Sciences.
Linnean Society of London.
Liverpool Literary and Philosophical Society.

Lonsdale, Wm., Esq., F.G.S.
Lyell, Sir Charles, F.G.S.

Madrid Royal Academy of Sciences.
Mallet, R., Esq.
Manchester Philosophical Society.
Marcou, M. Jules.
Martin, P. J., Esq., F.G.S.
Medical Circular, Editor of the.
Monthly Journal of Medicine, Editor of the.
Morris, J., Esq., F.G.S.
Moscow, Imperial Society of Naturalists of.
Munich, Bavarian Academy of Sciences at.
Murchison, Sir R. I., F.G.S.
Museum of Practical Geology.

Neufchâtel Society of Sciences.
Nicol, Prof. J., F.G.S.

Oldham, T., Esq., F.G.S.

Pardo, Signor Lorenzo.
Paris, Academy of Sciences at.
Paris, Muséum d'Histoire Naturelle de.
Philadelphia Academy of Natural Sciences.
Philadelphia, American Philosophical Society at.
Photographic Society.
Pictet, Prof. F. J.
Puggaard, M. C.

Quekett, J., Esq.

Ray Society.
Redfield, W. C., Esq.
Redman, J. B., Esq.
Reeve, L., Esq., F.G.S.
Renevier, M. E.
Reusse, M. H.
Roemer, Dr. Ferd.
Rose, C. B., Esq., F.G.S.
Royal Astronomical Society.
Royal College of Surgeons.
Royal Cornwall Polytechnic Society.
Royal Geographical Society.
Royal Institution of Great Britain.
Royal Society of London.

Schlagintweit, Dr. A.
Schlagintweit, Dr. H.
Schrenk, M. A. G.
Schwarzenberg, M. A.
Sedgwick, Rev. Prof., F.G.S.
Silliman, Prof., M.D., For. M.G.S.
Smithsonian Institution.
Society of Arts.
Sorby, H. C., Esq., F.G.S.
Sowerby, Miss C.
Sowerby, G. B., Esq.
State of New York.
Statist, Editor of the.
Statistical Society.
Stockholm Royal Academy of Sciences.
Strasbourg Society of Natural History.
Studer, Prof. B., For. M.G.S.
Suess, M. Eduard.

Taylor, R., Esq., F.G.S.
Tennant, Prof. J., F.G.S.
Thiollière, M. Victor.
Treasury, Her Majesty's.
Trimmer, J., Esq., F.G.S.

Van Diemen's Land, Royal Society of.
Vaud Society of Natural Sciences.
Verneuil, M. de, For. M.G.S.
Vienna Geological Institute.
Vienna, Imperial Academy of Sciences at.
Villa, Signor Giov. Battista.

Walrond, Rev. T.
Wiest, J., Esq.

Yates, J., Esq., M.A., F.G.S.
Yorkshire (West Riding), Geological Society of.

Zepharovich, M. Ritter von.

List of Papers *read since the last Anniversary Meeting, February 17th,* 1854.

1854.

Feb. 22nd.—On the Tertiary Formations of the Mayence Basin, by William John Hamilton, Esq., Sec. G.S.

March 8th.—On the Geology of the Gold District of Victoria, Australia, by A. Selwyn, Esq.; communicated by Prof. A. C. Ramsay, F.G.S.

——— On the Gems and Gold Crystals of Victoria, by G. M. Stephen, Esq., F.G.S.

——— On the Gold and Cinnabar regions of California, by J. S. Wilson, Esq.; communicated by Sir R. I. Murchison, V.P.G.S.

——— On the Gold of Coromandel, New Zealand, in a letter from Charles Heaphy, Esq., to His Excellency Sir G. Grey; communicated by Sir R. I. Murchison, V.P.G.S.

——— On the Geology of Victoria, Australia, by Evan Hopkins, Esq., F.G.S.

March 22nd.—On the Geology of a part of Madeira, by Sir Charles Lyell, F.G.S.; extracted from letters to Leonard Horner, Esq., F.G.S.

——— On Fish-remains in Chalk-flints, by Capt. Alexander; in a letter to the Secretary.

——— On some Valleys in Yorkshire, by H. C. Sorby, Esq., F.G.S.

April 5th.—On the Geological Structure and Erratic Phænomena of part of the Bavarian Alps, by M. Adolph Schlagintweit; communicated by the President.

——— On the Mammaliferous Deposits of the Valley of the Nene, near Peterborough, by Joshua Trimmer, Esq., F.G.S.

May 3rd.—On some intrusive Igneous Rocks in Cawsand Bay, near Plymouth, by Leonard Horner, Esq., F.G.S.

——— On the May Hill Sandstone, and on the Classification of the Palæozoic Rocks of England and Wales, by the Rev. Prof. Sedgwick, F.G.S.

May 10th.—Postscript to Palichthyologic Note, No. 4, On some Pycnodont Fishes hitherto referred to Tetragonolepis; Palichthyologic Notes, No. 6, On a new Fossil Fish from the New Red Sandstone; No. 7, On some new Fossil Fishes from India; No. 8, On some Fossil Fishes from Egypt; by Sir P. G. Egerton, Bart., M.P., F.G.S.

——— On some Fossil Insects from the Purbecks and the Oolite, by J. O. Westwood, Esq.; communicated by the Rev. P. B. Brodie, F.G.S.

——— On Pegmatite in Ireland, by M. A. Delesse; communicated by Sir H. T. De la Beche, F.G.S.

1854.
May 24th.—On the Structure and Affinities of the Rudista, by S. P. Woodward, Esq., F.G.S.
———— Geological Notice of the Isle of Sheppey, and its outlier of Bagshot Sand, by C. H. Weston, Esq., F.G.S.
———— On the Dimensions of the London Clay, and its most Fossiliferous Strata; and on an outlier of the Bagshot Sands in the Isle of Sheppey, by Joseph Prestwich, Jun., Esq., F.G.S.
June 7th.—On some Fossil Mammalia and Reptilia from the Purbeck beds of Durdlestone Bay, Swanage, by Prof. Owen, F.G.S.
———— On a Section exposed in Excavations at the West India Docks, by W. Blanford, Esq.; communicated by Prof. E. Forbes, F.G.S.
———— On the Distinctive Characters, founded on Palæontological and Physical Evidences, of the London Clay and the Bracklesham beds, by Joseph Prestwich, Jun., Esq., F.G.S.
June 21st.—On the Relations of the London Tertiaries with th Lower Tertiaries of France and Belgium, by Joseph Prestwich, Jun., Esq., F.G.S.
———— On Fossil Foot-tracks in the Wealden at Hastings, by S. H. Beckles, Esq., F.G.S.
———— On the Geology of the Turco-Persian Frontier, by W. K. Loftus, Esq., F.G.S.
———— On the Geology of the Nagpoor District, Central India, by the Rev. Messrs. Hislop and Hunter; communicated by J. C. Moore, Esq., F.G.S.
———— On a Labyrinthodont Reptile from Mangali, near Nagpoor, India, by Prof. Owen, F.G.S.
———— Additional Notes on Sand-pipes, by Joshua Trimmer, Esq., F.G.S.
November 1st.—On the Occurrence of Gold in South Africa, by Dr. Rubidge; communicated by Sir R. I. Murchison, F.G.S.
———— On the Occurrence of Copper in Tennessee, by W. Bray, Esq.; communicated by the President.
———— On the Occurrence of a Reptilian Skull in the Coal at Pictou, by J. W. Dawson, Esq.; communicated by Sir C. Lyell, F.G.S.
———— On some Nummulitic Limestone from Varna, by W. J. Hamilton, Esq., Pres. G.S.
November 15th.—On the Geological Structure of Mont Blanc, and the Cleavage of the rocks in its vicinity, by Daniel Sharpe, Esq., Treas. G.S.
———— On Glacial Traces on the Surface of the Rock of Dumbarton, by Capt. L. Brickenden, F.G.S.
November 29th.—On a new Pterichthys from the Old Red Sandstone of Morayshire, by Capt. L. Brickenden, F.G.S.
———— On the Gold-field of Coromandel in New Zealand, by C. Heaphy, Esq.; forwarded by Sir George Grey.
———— On the Geology of the Vicinity of Nice, by Major Charters, F.G.S.

1854.
December 13th.—On a Fossiliferous Deposit in the Drift near Salisbury, by Joseph Prestwich, Jun., Esq., F.G.S. and John Brown, Esq., F.G.S.
——— On a Fossiliferous Drift at Wear Farm, between Grove Ferry and the Reculvers, by Joseph Prestwich, Jun., Esq., F.G.S.
——— On a Fossiliferous Gravel near Stoke Newington, by Joseph Prestwich, Jun., Esq., F.G.S.
——— On the Terrestrial Surfaces beneath the Drift, by R. A. Godwin-Austen, Esq., Sec. G.S.

1855.
January 3rd.—On a Submerged Forest at Fort Lawrence, Nova Scotia, by J. W. Dawson, Esq., F.G.S.
——— On some additional small Reptilian remains from Purbeck, by Professor Owen, F.G.S.
——— On a large Fossil Cuttle-fish, from the Kimmeridge Clay, by Professor Owen, F.G.S.
——— On the Tertiary Beds of Hesse Cassel and its vicinity, by W. J. Hamilton, Esq., Pres. G.S.
January 17th.—On Vertical and Meridional Lamination of Primary Rocks, by Evan Hopkins, Esq., F.G.S.
January 31st.—Notes on a Geological Map of Christiania by M. Th. Kierulf, by Sir R. I. Murchison, V.P.G.S.
——— On the Foliation of the Rocks of Norway, by David Forbes, Esq., F.G.S.

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

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

It was afterwards resolved,—

1. That the thanks of the Society be given to John Carrick Moore, Esq., and Colonel Portlock, retiring from the office of Vice-President.

2. That the thanks of the Society be given to R. A. Godwin-Austen, Esq., retiring from the office of Secretary.

3. That the thanks of the Society be given to G. B. Greenough, Esq., J. S. Bowerbank, Esq., Capt. Strachey, and P. N. Johnson, Esq., retiring from the Council.

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

OFFICERS.

PRESIDENT.

William John Hamilton, Esq.

VICE-PRESIDENTS.

Sir P. De M. G. Egerton, Bart., M.P., F.R.S.
Sir Charles Lyell, F.R.S. and L.S.
Sir R. I. Murchison, G.C.St.S., F.R.S. and L.S.
Prof. John Phillips, F.R.S.

SECRETARIES.

John Carrick Moore, Esq., M.A.
Joseph Prestwich, Jun., Esq., F.R.S.

FOREIGN SECRETARY.

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

TREASURER.

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

COUNCIL.

John J. Bigsby, M.D.
Col. P. T. Cautley, F.R.S. and L.S.
Sir P. De M. G. Egerton, Bart., M.P., F.R.S.
Earl of Enniskillen, D.C.L., F.R.S.
Thomas F. Gibson, Esq.
R. A. Godwin-Austen, Esq., B.A., F.R.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.
Sir Charles Lyell, F.R.S. and L.S.
John C. Moore, Esq., M.A.
John Morris, Esq.
Sir R. I. Murchison, G.C.St.S., F.R.S. and L.S.
R. W. Mylne, Esq.
S. R. Pattison, Esq.
John Percy, M.D., F.R.S.
Prof. John Phillips, F.R.S.
Col. Portlock, R.E., F.R.S.
Joseph Prestwich, Jun., Esq., F.R.S.
Samuel Peace Pratt, Esq., F.R.S. and L.S.
Prof. A. C. Ramsay, F.R.S.
J. W. Salter, Esq.
D. Sharpe, Esq., F.R.S. and L.S.

TRUST ACCOUNTS.

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance at Banker's, 1st of January 1854, on the Wollaston Donation Fund	29	1	6			
Balance at Banker's, Geological Map Fund	11	15	0			
Total at Banker's, Jan. 1st, 1854				40	16	6
Received on account of the Geological Map (sold)	7	15	0			
Dividends on the Donation Fund of 1084*l.* 1*s.* 1*d.* Red. 3 per Cents.	31	2	0			
				38	17	0
				£79	13	6

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

J. S. BOWERBANK, ALFRED TYLOR, } *Auditors.*

Feb. 6, 1855.

PAYMENTS.

	£	s.	d.
Award to Mr. S. P. Woodward	28	16	6
Cost of Engraving Wollaston Medal, awarded to Mr. R. Griffith		5	0
Paid on account of Geological Map:			
Mr. Greenough, Balance of 1853	11	15	0
Balance at Banker's, Trust Account	38	17	0
	£79	13	6

VALUATION *of the Society's Property; 31st December*, 1854.

PROPERTY.

	£	s.	d.	£	s.	d.
Due from Messrs. Longman and Co., on Journal, Vol. X.				59	18	10
Due for Subscriptions to Journal				67	5	6
Due for Authors' Corrections in Journal				36	12	6
Balance in Banker's hands				383	4	3
Balance in Clerk's hands				22	16	6
Funded Property, 4014*l.* 15*s.* 8*d.* Consols, at 90				3613	0	0
Exchequer Bonds				199	15	3
Arrears of Admission Fees (considered good)	67	4	0			
Arrears of Ann. Contributions prior to 1854 (considered good)	15	15	0			
Arrears of Annual Contributions of 1854	50	8	0			
				133	7	0
				£4515	19	10

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

Feb. 1, 1855. DANIEL SHARPE, *Treas.*

DEBTS.

	£	s.	d.
Balance in favour of the Society	4515	19	10
	£4515	19	10

INCOME.

	£	s.	d.	£	s.	d.
Balance at Banker's, January 1, 1854	412	11	2			
Balance in Clerk's hands	13	16	9			
				426	7	11
Compositions received				189	0	0
Arrears of Admission Fees	21	0	0			
Arrears of Annual Contributions	18	18	0			
				39	18	0
Admission Fees of 1854				268	16	0
Annual Contributions of 1854				611	2	0
Dividends on 3 per cent. Consols				115	3	6
Dividends on Exchequer Bonds				3	5	11
Publications:						
Longman & Co. for Sale of Journal in 1853	62	4	5			
Sale of Transactions	18	6	9			
Sale of Proceedings	1	18	1			
Sale of Journal, Vol. II.	3	15	0			
Sale of Journal, Vol. III.	4	2	6			
Sale of Journal, Vol. IV.	5	12	6			
Sale of Journal, Vol. V.	5	6	6			
Sale of Journal, Vol. VI.	7	7	0			
Sale of Journal, Vol. VII.	12	0	6			
Sale of Journal, Vol. VIII.	15	8	6			
Sale of Journal, Vol. IX.	45	2	0			
Sale of Journal, Vol. X.*	135	16	11			
				317	0	8
Sale of Library Catalogue				1	0	0
				£1971	14	0

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

Feb. 6, 1855. J. S. BOWERBANK, ALFRED TYLOR, } *Auditors.*

	£	s.	d.
* Due from Messrs. Longman and Co., in addition to the above, on Journal, Vol. X.	59	18	10
Due from Fellows for Corrections	36	12	6
Due from Fellows for Subscriptions	67	5	6
	£163	16	10

Year ending December 31*st*, 1854.

EXPENDITURE.

	£	s.	d.	£	s.	d.
Invested in Exchequer Bonds				199	15	3
General Expenditure :						
Taxes	33	13	0			
Fire Insurance	3	0	0			
House Repairs	7	3	6			
Furniture Repairs	10	8	10			
New Furniture	20	3	10			
Fuel	38	3	0			
Light	29	12	5			
Miscellaneous House Expenses, including Postages	50	9	7			
Stationery	14	10	3			
Miscellaneous Printing	19	5	0			
Tea for Meetings	23	6	8			
				249	16	1
Salaries and Wages :						
Assistant Secretary and Curator	200	0	0			
Clerk	120	0	0			
Porter	80	0	0			
House Maid	27	13	4			
Occasional Attendants	16	15	0			
Collector	18	7	6			
				462	15	10
Library				42	3	6
Museum, including Assistant				32	15	6
Diagrams at Meetings				13	12	0
Miscellaneous Scientific Expenses				3	17	7
Publications :						
Transactions	1	5	4			
Transactions, Vol. VII. Pt. 4	16	18	6			
Journal, Vol. VII.	1	6	10			
Journal, Vol. VIII	0	6	6			
Journal, Vol. IX.	4	16	1			
Journal, Vol. X.	536	4	3			
				560	17	6
Balance at Banker's, Dec. 31, 1854	383	4	3			
Balance in Clerk's hands	22	16	6			
				406	0	9
				£1971	14	0

Estimates *for the Year* 1855.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Due for Subscriptions on Quarterly Journal...	67	5	6			
Due for Authors' Corrections....................	36	12	6			
				103	18	0
Arrears (See Valuation-sheet)				133	7	0
Ordinary Income for 1855 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....................				113	8	4
Dividends on Exchequer Bonds				6	11	10
Sale of Transactions, Proceedings, Library Catalogue and Supplement				30	0	0
Sale of Quarterly Journal	280	0	0			
Due by Messrs. Longman and Co. in June, for sale of Journal in 1854....................	59	18	10			
				339	18	10
				£1619	14	0

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
General Expenditure :						
Taxes	48	0	8			
Fire Insurance....................	3	0	0			
House Repairs....................	10	0	0			
Furniture Repairs	15	0	0			
New Furniture	20	0	0			
Fuel	35	0	0			
Light	30	0	0			
Miscellaneous House Expenses	50	0	0			
Stationery	20	0	0			
Miscellaneous Printing	20	0	0			
Tea for Meetings....................	22	0	0			
				273	0	8
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.				80	0	0
Museum, including Assistant				50	0	0
Diagrams at Meetings				15	0	0
Miscellaneous Scientific Expenses				10	0	0
Publications : Quarterly Journal				500	0	0
,, Transactions, &c.				75	0	0
Balance in favour of the Society				153	9	4
				£1619	14	0

DANIEL SHARPE, Treas.

Feb. 1, 1855.

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

16th FEBRUARY, 1855.

Award of the Wollaston Medal and Donation Fund.

After the Reports of the Council had been read, the President, W. J. Hamilton, Esq., on delivering to Sir Roderick I. Murchison the Wollaston Medal, awarded to Sir Henry T. De la Beche, addressed him as follows :—

Sir Roderick Murchison,—In the absence of Sir Henry De la Beche I address myself to you for the purpose of saying that it is with much pleasure that I now proceed to give effect to the resolution of the Council already announced, awarding the Wollaston Palladium Medal for this year to our old associate and fellow-labourer, Sir Henry De la Beche. In requesting you to undertake the task of conveying to him this mark of the high opinion entertained by the Council of his labours, I trust you will inform him how sincerely we regret that he should be prevented by indisposition from being personally present amongst us to-day, and that you will also communicate to him the considerations by which the Council of the Geological Society have been influenced in making this award.

The necessary brevity of a resolution did not admit of our entering fully into the details of these considerations; I will therefore now state that, in the first place, the Council desire to record their opinion of the merit of those communications which, as a private independent geologist, Sir Henry De la Beche has for a period of more than thirty-five years made to this Society, and which, printed in our Transactions, will ever remain a monument of his zeal, his energy, and his perseverance. The very earliest volumes of our Transactions show that since the year 1819 we have been chiefly indebted to him for the careful examination of the secondary formations of our southern coasts, particularly that of Dorsetshire, and for a description of the geology of the vicinity of Bridport, Lyme Regis, and Weymouth. It is difficult at the present day to estimate the effect of those communications, which at the time gave such a stimulus to the study of our science. The nature and the abundance of the fossils contained in these beds gave them in those days an importance and an interest which has now been, in a great measure, transferred to the more ancient deposits of the Palæozoic formations.

In addition to these papers, which left but little remaining for future explorers, and in some of which he was assisted by Dr. Buckland, we are indebted to Sir Henry De la Beche for a valuable paper on the Geology of Southern Pembrokeshire, in which I think we may trace the commencement of that system of geological illustration which he has subsequently perfected in the maps of the Ordnance Geological Survey, and of those views which have been lately confirmed by Mr. Salter. In Foreign Geology, Sir Henry De la Beche has contributed some interesting papers on the Northern and Southern coasts of France, particularly that of Nice. I must also mention his paper on the Geology of Jamaica, published in the 2nd volume of the 2nd series of our Transactions, as containing the first detailed information we have received respecting the geological structure and formations of that island; and when we consider the difficulties attendant on such explorations, under a tropical climate and in the midst of a tropical vegetation, we cannot estimate too highly the merits of Sir Henry De la Beche.

At a subsequent period, he added to his claims on our consideration by the publication of two admirable works; 'The Manual of Geology,' and 'Researches in Theoretical Geology.' It is impossible to peruse the lucid development of geological phænomena contained in these works, and particularly in the Researches in Theoretical Geology, without admiring the bold grasp and comprehensive view of the subject taken by the author; and, although during the more than twenty years which have elapsed since those works were first published vast progress has been made in the knowledge of geological detail and the subdivision of formations, by none more than by yourself, Sir Roderick, in your investigation of the older palæozoic rocks, the general principles contained in that volume have remained unaltered and unshaken. Some indeed appear to be absolutely prophetic. Every day's experience confirms and extends the remark that "the supracretaceous group apparently passes so insensibly into the present order of things, still viewing the subject on the large scale, that probably no line of demarcation will ever be drawn between them, particularly when we regard the whole superficies of the world, and not a particular portion of it*."

But in awarding this Medal to Sir Henry De la Beche, the Council are also desirous of expressing their admiration of what he has done in his public capacity as Director of the Museum of Practical Geology, and Director General of the Geological Survey of the United Kingdom.

They trust that it will never be forgotten that it is to the zeal and exertions of Sir Henry De la Beche that this country is indebted for the recognition by the Government and by Parliament of the importance of establishing in the metropolis both a Museum of Practical Geology and a School of Mines upon an enlarged and liberal scale. Urged by his recommendations chiefly, backed by the support of many other men of science, the Government at length consented, about fifteen years ago, to establish, at first on a moderate scale, a Museum for the purpose of demonstrating the importance of geological studies and of their application to agricultural and other purposes. The admirable paper on the formation of the Rocks of South Wales

* Researches, &c. p. 365.

and South-Western England, published in the first volume of the Memoirs of the Geological Survey, is the best evidence of the fitness of Sir Henry to conduct the establishment over which he was appointed, and to carry out the geological survey entrusted to his superintendence.

The success of this first experiment emboldened the Government to listen to his suggestions, that the Institution should be made worthy of the country. By pointing out the importance, not to say the absolute necessity, of establishing, in a country where mineral wealth was so abundant as in our island, an office where mining records might be preserved, there being previously nothing of the kind in existence, he succeeded in inducing the Government to erect a special building for this purpose, and in having a School of Mines attached to the Museum of Practical Geology, where all the details and phænomena of these important operations might be preserved*. To the duty of superintending these Establishments was added the geological survey of Great Britain, based on the Ordnance maps; and not the least of Sir Henry's merits is the skill and impartiality he has displayed in the selection of the able staff of naturalists, geologists, palæontologists, chemists, and mineralogists, who have assisted him in this great national work. With such a staff, the introduction of lectures for the purpose of teaching the application of these branches of science was not a work of difficulty. It became almost a necessary consequence, and the success which has attended them, the frequency with which they are followed by artisans and other working classes, is the best possible evidence of the propriety of their institution. But I cannot dwell any longer on this subject,—and yet there is one point in the career of Sir H. De la Beche to which, on such an occasion as the present, I must for one moment allude. One of his greatest merits, and which I have little doubt has mainly contributed to his success in this achievement, has been, that in pursuing the fascinating charms of geological inquiries, he has at the same time cultivated the more exact and mathematical study of mineralogical investigations. I cannot but regret that, as a body, English geologists have neglected them. It is Sir H. De la Beche's greatest praise that he has never abandoned his first love for mineralogy.

In requesting you, Sir Roderick, to convey this Medal, which I now place in your hands, to Sir H. De la Beche, I have only to ask you to assure him of the hearty good wishes of the Geological Society of London for his future prosperity and health.

Sir Roderick Murchison replied,—

Mr. President,—You have so truthfully and ably enunciated the services rendered to Geological Science by my valued friend Sir Henry Thomas De la Beche, that any one, however little acquainted with our pursuits, must at once perceive that this Society has truly done honour to itself in bestowing its highest reward upon so eminent a man. Permit me, in returning you his grateful thanks, to seize this

* See Hopkins' Address, 1852, Quart. Journ. Geol. Soc. vol. viii. p. lxxix.

opportunity of recording some sentiments of my own, which are entertained, I feel certain, by all geologists who have witnessed the rise and progress of our associate, and which, if acted upon, will assuredly be most grateful to his feelings.

The earlier years of Sir H. De la Beche having been spent in those labours in the field, and in the composition of many of those works to which you have adverted, the remaining portion of his life has, as you have stated, been devoted to the foundation, arrangement, and successful completion of a great National Establishment.

Let me add, that this design, entirely his own conception, was begun, carried out, and matured by the combination of scientific skill with those *practical* evidences of the value of his project, in the absence of which he never could have commanded success in an undertaking which, though applauded by ourselves, was alien to the pursuits of the great body of Englishmen.

And how did he succeed?—At his own expense he traced the boundaries and relations of certain rock-formations, and, laying them down on the Ordnance Survey Maps, accompanied by illustrative Sections, he thus took the first step in leading public men (otherwise little versed in our science) to see the good which must result from the extensive application of such a scheme, in making all proprietors alive to the importance of obtaining a better acquaintance with the subsoil of their estates.

Having gradually attracted the notice of the Government, and having obtained the use of rooms in Craig's Court, and the employment of a limited sum of the public money, Sir H. De la Beche then attached to his new-born establishment able men of science, who could decipher formations in the field, describe the fossils they contained, or chemically analyze the structure of the rocks and their associated minerals. Soon filling to repletion the small space allotted to him with models of mines, illustrative drawings, and specimens of fossils, ores, and building-stones, he convinced our rulers, and particularly that illustrious statesman Sir Robert Peel, that the dignity and interests of the country required that an adequate and appropriate building should be erected, and exclusively devoted to the fulfilment of a project so lucidly devised, and thus far so well realized.

Then arose, and very much after the design of the accomplished Director himself, that well-adapted edifice in Jermyn Street, *which, to the imperishable credit of its author, stands forth as the first Palace ever raised from the ground in Britain, which is entirely devoted to the Advancement of Science!*

Once possessed of halls worthy of so noble an object, Sir Henry De la Beche next rendered them practically useful to the public, and on a vastly extended scale, by embracing, as necessary adjuncts, metallurgy and mechanical science in addition to the branches of knowledge previously cultivated. When we reflect on the eminence of the men of science with whom he surrounded himself, including our last and deeply lamented President Edward Forbes, and have seen how admirably they presided over their schools, what solid instruction they imparted, and all directly supporting geology,—when we visit the galleries in which the shells, fossils, and minerals are so arranged as to illustrate the value of the maps, sections, and publications of the Survey, we geologists must feel more strongly than any other class of men the deep obligations of our country to Sir Henry De la Beche.

In speaking of this Museum as a School of Mines, and in recollecting that the value of raw mineral produce extracted annually from the subsoil of Britain is not less than 25 millions sterling, you must be reminded of the practical and efficient manner in which Sir H. De la Beche was enabled, from long residence in mining tracts, to convey to many individual proprietors much useful knowledge in their own local language, and to send them away well pleased with his cheerful and friendly explanations. Here, however, we must extend our vision beyond our Islands, and, whether we look to Canada, Australia, the Cape, or Hindostan, we see that well-trained geologists have been sent or are going thither from our National School of Mines;—thus making our vast Colonial Possessions keep pace with the advancement of the mother-country.

Now, as Sir Henry himself and many of his best officers have sprung from our own ranks, let me, Sir, as a former President of this body, and as a warm well-wisher to the progress of our Science, express my conviction, that it is our bounden duty to cleave closely to our offspring, Her Majesty's Geological Museum,—nay, more,—to use our most strenuous endeavours to have it maintained by the British Government in that lofty position to which it has been raised. We must, in short, not only hold firmly to, but act upon the faith which is in us, and see that an Establishment like this, though it naturally branches off into highly useful and collateral subjects of Art, be never rendered subsidiary to them, but be permanently and independently sustained on its own solid basis of pure *Science*. This, our view, will also be taken, I feel confident, by every enlightened Statesman who may be placed in a station to enable him to provide for the future well-being of the admirable Museum, founded and completed by our Wollaston Medallist.

The state of his health having alone prevented Sir Henry De la Beche from being present to-day, I am charged on his part to declare that, but for the knowledge he acquired, the friendships he formed, and the aid he received from his associates in this Society, he never could have realized his scheme.

In returning to you, Sir, and the Council, his grateful thanks, I have only further to assure you, that this affectionate tribute from his old friends has cheered him up in his present feeble state of health, and that your appreciation of his services has made the deepest impression on his heart; whilst on my part, allow me to say that I consider it a high and gratifying distinction to have been requested by my eminent friend to receive for him this Wollaston Medal.

On delivering to the Secretary the Balance of the Proceeds of the Wollaston Fund, the President addressed him as follows :—

Mr. Godwin-Austen,—In the absence of the Drs. Sandberger, to whom the Council of the Geological Society have this year awarded the balance of the proceeds of the Wollaston Fund, I must request you to inform them that the Council have come to this resolution in consideration of their valuable work on the Fossils of the Palæozoic Rocks of the Rhine, in Nassau, and to assist them in its completion, as also in the publication of their intended work on the Fossils of the Mayence Basin.

You, who with myself, have had an opportunity of appreciating the labours of these gentlemen, can testify to the zeal and industry, and the real scientific enthusiasm with which they pursue their geological investigations. You will, I trust, inform them that we are desirous of expressing our admiration at the manner in which the fossils illustrating their work have been represented, and at the accuracy with which they have been drawn. No one is better able than yourself to judge of and to appreciate this accuracy. At the same time, the Council also wish to testify their opinion of the talent and judgment shown in the description of the fossils, and in referring them to their respective formations. By this work they have greatly added to our knowledge of the Devonian System in Germany, and of the various forms of organic life by which the different members of that system are characterized in the Rhenish districts. The Council trust that by this award they will be better enabled to complete without much delay a work on which they have already expended so much labour, time, and thought; and of which one part only is, I believe, still wanting. They also trust that they may look forward to the commencement, at no distant period, of the work, already announced, on the Fossils of the Mayence Basin. The labours of Dr. Fridolin Sandberger on this subject are already so well known to the cultivators of tertiary geology, that the Council entertain the fullest confidence that it will prove no less important and creditable to its authors than that which is now so near completion. I have now only to request, that in forwarding to these gentlemen this donation, you will express to them our hope that they will see in it, however small, an earnest of our good wishes for their future prosperity, and an evidence of our appreciation of what they have already done.

Mr. Godwin-Austen replied as follows:—

Sir,—I have much pleasure in accepting the balance of the proceeds of the Wollaston Donation Fund on behalf of the Messrs. Sandberger, inasmuch as I am one of the few Members of the Society who have the pleasure of being personally acquainted with these gentlemen. It is this which enables me to assure you, with peculiar confidence, of the high estimation in which they will hold the recognition by this Society of their services to geological science; whilst, at the same time, I feel satisfied that the award was never made in stricter conformity with the views of the founder, than in the present instance. The work of the Messrs. Sandberger which has been more particularly noticed,—the 'Systematische Beschreibung und Abbildung der Versteinerungen des Rheinischen Schichten-Systems in Nassau,' is not exceeded, for the beauty of its illustrations, by any work of the kind which has appeared; and, in common with one or two other Members of this Society, I can add my testimony to the fidelity with which the objects represented have been described and reproduced. Such works as these necessarily involve a considerable expense to their authors,—an expense which is often greatly disproportionate to the slender endowments of foreign academical professorships. With reference to what may be hoped from the future labours of the Messrs. Sandberger, I may state that they belong to a band of young and zealous brothers in science, whose object it is to investigate and make known the Geological and Natural History of the Middle Rhenish Provinces, and towards which they next purpose to contribute a critical work on the fossil forms of the tertiary basin of Mayence.

THE ANNIVERSARY ADDRESS OF THE PRESIDENT.

Gentlemen,—It now becomes my duty, in accordance with the practice uniformly adopted by my predecessors in this chair, to address to you some observations on the losses we have sustained during the past year, and it is with unfeigned sorrow that I have first to allude to one whose name can never be mentioned in these rooms without emotion. I need not say that I allude to Edward Forbes, who was endeared to us by every tie of social friendship and scientific merit, and who has been snatched away from us at the moment when he had reached the highest position his ambition could have coveted, or his admiring countrymen could have bestowed on him. Scarcely had a few short months intervened since he had been called by the universal voice of the science of Great Britain to fill the chair of Professor of Natural History in the University of Edinburgh, and while we were still regretting his departure from the metropolis, before we were astounded and overwhelmed by the unexpected announcement of his death. We felt not only individually that we had lost a valued friend, but that those anticipations of a brilliant scientific career, justified by the position he had attained and by the opportunities placed within his reach, were doomed to bitter disappointment. These reflections are most painful, and, were I to follow my own inclinations, I would willingly forego all further allusion to the subject; but such a course would be a betrayal of duty towards our departed friend, and would disappoint the justly-founded expectations which you entertain of hearing a more detailed account of the distinguished and amiable man whose loss we so deeply deplore.

Edward Forbes was born in the Isle of Man, in the month of February 1815. He evinced, at a very early age, an unusual taste for the study of natural history, and began to form a small museum when scarcely seven years old. A few years later he commenced his geological studies with the perusal of Buckland's 'Reliquiæ Diluvianæ,' Parkinson's 'Organic Remains,' and Conybeare's 'Geology of England,' exhibiting at the same time a more than usual taste for drawing.

He visited London at the age of sixteen, and was then engaged in studying drawing under Sass, but this was not enough to occupy his eager and ardent mind. He proceeded in 1831 to Edinburgh, where he devoted his whole time and energies to the pursuit of his favourite subject of natural history, while professing to overcome his repugnance for the study of medicine, the ostensible object of his matriculation. But medicine as a profession had no charms for one whose whole soul was filled with a love of the beautiful, and with an intense admiration of the works of Nature in every varied form. He cultivated his taste for natural history under the able teaching of such men as Professors Jameson and Graham. He delighted particularly in the botanical excursions of the latter, who was accustomed periodically to lead forth his pupils to the Highlands; thus making Nature herself, in her truest and loveliest garb, afford the practical illustrations of the teaching of the class-room.

At this period of his life, scarcely a year passed without some botanizing or dredging excursion, and long before he arrived at manhood, he had made himself well acquainted with the Fauna of the Irish Sea, on the shores of his native island. At the age of eighteen, in company with a fellow student, he made an excursion to Norway, where he spent some weeks exploring the wild and romantic districts of the country, adding to his zoological and botanical observations. Already, at this time, Edward Forbes began to direct his attention to botanical geography, the forerunner of those deep and philosophical views respecting the geographical distribution of the Flora and Fauna of the world which he subsequently developed, and which constitute one of the most interesting and leading features of all his writings.

In 1835, Edward Forbes visited the Alps; in 1837 he was prosecuting his studies at Paris under Prévost, Beudant, Geoffroy St. Hilaire, and De Blainville, and in May of the same year we hear of him at Algiers; the result of this expedition was an account of the land and freshwater mollusca of Algiers and Bougia, published in the 'Annals of Natural History' for May 1839.

With the same view of prosecuting his researches in natural history, he visited Styria and Carniola in 1838, his remarks on which were published in the 'Proceedings of the Botanical Society.' In the summers of 1839 and 1840 he delivered at Edinburgh, whilst still a student, a course of scientific lectures on zoology, as well as one of a more popular nature, in which he pointed out the bearings of zoology on geology. I mention this as a subject of peculiar interest to us, as indicating the commencement of those views which, by their subsequent development and their growing importance in the hands of Edward Forbes, have exercised such a beneficial and practical influence on the study of geology.

The time was now fast approaching when Edward Forbes was to find a wider sphere for the exercise of his brilliant genius. In 1841 he published his 'History of British Star Fishes and other Echinoderms,' a delightful volume, charmingly illustrated by his own pencil and from his own designs. There are many in this room who will recognize in these illustrations the same ingenious and playful fancy, and the same ready pencil which never allowed a sheet of paper to lie unused before him, while he had a chance of transferring to it the humorous and graceful forms which he realized without an effort, and almost without a thought. In this same year he obtained the appointment of naturalist to H.M. surveying ship *Beacon*, Captain Graves, then employed in completing the survey of the coast of Asia Minor and the adjacent islands: an appointment more suited to his tastes and to his talents could not have been devised. He had here full play for the prosecution of his favourite pursuits of botany, zoology, and geology. Already well acquainted with the flora and fauna of the European Continent and their geographical distribution, he had now an opportunity of tracing their further extension to the East, and of examining the first appearance of that Oriental *facies* which they put on in the eastern portions of the Mediterranean. Nor was Edward Forbes the man to neglect such an opportunity. During this and the following year he pursued his botanical and zoological researches with unwearied energy, assisted by Captain Graves, who omitted no opportunity of enabling his scientific friend and companion to avail himself of every occasion for observation which the service afforded. It was during his various excursions in the *Beacon* and her boats that Edward Forbes followed out those researches with the dredge, amongst the islands of the Ægean Sea and on the adjacent coast of Asia Minor, which alone would have immortalized his name. At the same time he neglected no occasion of studying the geology and botany of the regions which he visited, but the dredge and its results will ever remain the chief glory of this expedition. The results of these researches were made known to the public in the 'Report on the Mollusca and Radiata of the Ægean Sea and on their distribution, considered as bearing on Geology,' made to the British Association at their meeting at Cork in 1843. From this report it appears that the data on which it was founded were entirely derived from personal researches during a voyage of eighteen months in the Ægean, when but a few days passed by without being devoted to natural history observations. The calculations were based on more than 100 fully-recorded dredging operations in various depths from 1 to 130 fathoms, and in many localities from the shores of the Morea to those of Asia Minor. And with that modesty which ever characterized Edward Forbes in all his works, he adds, that the merit of the results is mainly due to Captain Graves. The chief objects of the report, as stated by the author, were, "to give an account of the distribution of the several tribes of mollusca and radiata in the Eastern Mediterranean, exhibiting their range in depth and the circumstances under which they are found; to inquire into the laws which appear to regulate their distribution, and to show the bearings of the investigation on the science of geology."

I shall not attempt to give an analysis of this valuable report; I shall content myself with reminding you of some of the more important conclusions, as bearing on geological investigations, which are embodied in it. The most important fact which has resulted from them respecting the development and distribution of animal and vegetable life in the depths of the ocean is, that of the almost uniform occurrence of particular species in particular zones of depth below the surface. This distribution of marine animal life is determined by three primary, modified by several secondary influences. The primary are climate, sea composition, and depth ; of the many secondary influences, the most important is the character of the sea bottom. According as rock, mud, sand, weedy or gravelly ground prevails, so will the number of the several genera and species vary. The outline and geological nature of the coast is also an important feature in modifying the marine fauna. Other secondary influences are tides and currents, the influx of fresh water, &c.

We have then a full description of eight well-marked regions of depth in the Eastern Mediterranean, each characterized by its peculiar fauna, and when there are plants by its flora. These regions are distinguished from each other by the association of the species they severally include. Certain species in each are found in no other, several are found in one region which do not range into the next above, whilst they extend to that below, or *vice versâ* ; certain species have their maximum of development in each zone, being most prolific in individuals in that zone in which is their maximum, and of which they may be regarded as especially characteristic. Every zone has also a more or less general mineral character, the sea bottom not being equally variable in each, and becoming more and more uniform as we descend. Again, the deeper zones are greater in extent, so that whilst the first or most superficial is but 12, the eighth, or lowest, is above 700 feet in perpendicular range ; its horizontal extent increases in a somewhat similar proportion. Another significant feature is, that as we reach the eighth zone the number of species and of individuals diminishes as we descend, pointing to a zero in the distribution of animal life as yet unvisited. Species disappear in depth which do not seem to be replaced by others. From other observations the following general inference is deduced ; that the extent of the range of a species in depth is correspondent with its geographical distribution.

But these eight regions are themselves the scene of incessant change ; not only are the depths modified by the addition of fresh matter, but the very animals themselves, by their own increase, so modify the nature of the sea bottom as to render it unfit for their own existence, until a new layer of sedimentary matter, uncharged with living organic contents, has formed a fresh soil for similar or other animals to thrive on. It is impossible to overlook the importance of these observations in explaining many of the daily recurring phænomena which are brought under the notice of the geologist ; in the last observation we may see an explanation of the phænomenon of interstratification of fossiliferous and non-fossiliferous beds.

I must refer you to the report itself for an account of the phænomena which would be presented to us were the bottom of the Ægean Sea to be elevated and converted into dry land, or to be filled up by a long series of sedimentary depositions. He concludes by observing, that, "supposing such an elevation to have taken place, a knowledge of the association of species in the regions of depth would enable us to form a pretty accurate notion of the depth of water in which each bed was deposited. A beautiful illustration of this argument is given from observations made on the island of Santorin, and under different circumstances the contrary observations might be made; the geologist is thus enabled, by a careful examination of the successive overlying groups of species, to ascertain whether, in any given locality brought under his notice, the sea bottom was being elevated or depressed."

But I have already dwelt too long on this report; I must hasten to other scenes in the life of Edward Forbes. During his stay in the Mediterranean he made several excursions into Lycia, where he had an opportunity of combining his love of art with the pursuit of natural history. On one occasion, in company with Mr. Hoskyn, they discovered and fixed the sites of two of the Cibyratic cities. A second excursion undertaken with the Rev. Mr. Daniell and Captain, then Lieutenant, Spratt, was still more important; the sites of eighteen ancient cities hitherto unknown to geographers were explored and determined, and the names of fifteen were identified by inscriptions found amongst the ruins. During this expedition Mr. Daniell fell a victim to the malignant malaria of the country, and the life of Edward Forbes himself was at one time in danger. Indeed there can be little doubt that at this time were sown the seeds of that disease which has eventually deprived us of his services. He, however, gradually recovered, and was on the point of proceeding to Egypt and the Red Sea on a dredging excursion, when he was informed that he had been elected to fill the Chair of Botany in King's College, vacant by the death of Professor Don. He returned immediately to England, and, on the 8th May 1843, delivered his inaugural lecture in that institution.

But previously to this event, Professor Forbes had become intimately connected with this Society. At the close of 1842 Mr. Lonsdale, who for so many years had been the curator of our museum, resigned his office in consequence of the state of his health. In the report of the Council read at the Annual General Meeting on February 17, 1843, I find the following passage, after alluding to the loss sustained by the resignation of Mr. Lonsdale:—"In recording the election of his successor, the Council cannot omit to congratulate the Society on having secured the services of such a distinguished naturalist as Mr. E. Forbes." I may appeal to the recollection of every member of the Society for a confirmation of my statement, that the expectations then entertained, great as they unquestionably were, were more than fulfilled by the manner in which Edward Forbes conducted the business entrusted to him during the period that he held this important office. The report of the Museum Committee for 1844 will show how his labours were appreciated by the Council. But before the close of the same year his talents as a naturalist and a palæontologist called him to a more extended sphere of action. On the establishment of the Museum of Practical Geology in connection with the Ordnance Geological Survey under the direction of Sir H. De la Beche, Professor Forbes was appointed palæontologist to that institution, and resigned the curatorship of the museum of this Society. On the removal of the Museum to Jermyn Street he was appointed its Professor of Natural History.

Here then his talents had full space for their development, and Edward Forbes was not slow in bringing to bear on his numerous avocations the knowledge he had so industriously collected. Combining as he did a lively and vivid imagination with a mature and well-disciplined judgment, he was enabled to employ with effect that power of generalization and abstraction which he so eminently possessed. His enlightened and comprehensive views on the numerous branches of natural history which he cultivated, and which were founded mainly on his own experience, caused him from henceforth to be looked up to as one of the first of British naturalists, and the works which he now published bear ample testimony to his well-founded reputation. Nor was it in England alone that his merits were recognized. In France, in Germany, in Italy, wherever men of science were to be found, the name of Edward Forbes was equally acknowledged as deserving a place in the first rank of scientific merit.

Towards the end of 1846, he published with Lieut., now Captain, Spratt an account of his travels in Lycia, a work in which we are at a loss to know whether most to admire the admirable details of archæology and art, or the equally graphic description of the botany, geology, and zoology which it contains. About this time appeared in the Proceedings and Transactions of our Society his Monograph on the South Indian Fossils sent to this country by MM. Kaye and Cunliffe and the Rev. W. H. Egerton. The report itself, independently of the description of the fossils, is short, but it is not the less important, and is eminently characteristic of the author. He points out the general resemblance of the *facies* of the fossils to that of the Cretaceous period of Europe, and more particularly the lower portions of that series. His arguments are drawn rather from similarity, than from identity of species; a subject to which he had particularly directed his attention during his researches in the Ægean Sea. The report is pre-eminently suggestive, and I would particularly mention that portion of it which refers to the occurrence in these Cretaceous beds of certain forms which are usually considered as characteristic of Tertiary formations, and which very forms are now found in their greatest assemblages living in those eastern seas,—a fact, which, he observes, goes far to support the theory, that genera, like species, have geographical birthplaces as well as geographical capitals.

About this time, also, he wrote one of the most remarkable contributions to the science of Geology which has appeared in this country. It is published in the first volume of the Memoirs of the Geological Survey of Great Britain, and is entitled "On the Connexion between the Distribution of the existing Fauna and Flora of the British Isles, and the Geological changes which have affected their area." "In this work," to use words already printed, "the happy combination of great botanical and zoological knowledge is made to bear on some of the most intricate inquiries with regard to the age and relationship of the rocks of Great Britain."

Mr. Horner, when President of this Society, has borne his ready testimony to the merits of this work, when he says in his Anniversary Address in 1847, that this Essay "is an admirable example of the light to be derived from other branches of natural history in the prosecution of geological inquiries; of the application of animal and vegetable physiology, and a knowledge of the habits and distribution of animals and plants to the elucidation of very difficult problems in geology." Mr. Horner, in the Address from which I have quoted these words, has given an admirable account of this interesting and attractive memoir, so suggestive as it is of great and enlightened views. I will therefore here only observe, that the principal theory which it is the object of this Essay to establish, is based on the assumption of the existence of *specific centres*, that is, of certain geographical points from which the individuals of each species have been diffused, involving their consequent descent from a single progenitor, or from two, according as the sexes might be united or distinct. Prof. Forbes further declares, as his opinion, that the "abandonment of this doctrine would place in a very dubious position all evidence the palæontologist could offer to the geologist, towards the comparison and identification of strata, and the determination of the epoch of their formation." Having assumed the truth of the doctrine of specific centres, the problem which he proposes to solve is the origin of the assemblages of the animals and plants now inhabiting the British Islands. Within this limited area he considers that the united labours of British naturalists have shown that there are a great number of animals and plants which are not universally dispersed, but are congregated in such a way as to form distinct regions or provinces. The vegetation, for instance, presents five well-marked Floras, four of which are restricted to definite provinces, whilst the fifth, besides exclusively claiming a part of the area, overspreads and commingles with all the others.

Prof. Forbes considers that, of the three given modes by which an isolated area may become peopled by animals and plants, "immigration before isolation" of the area was the mode by which the British Isles have chiefly acquired their existing flora and fauna, terrestrial as well as marine, and that it took place subsequently to the Miocene epoch. It follows from this argument, that previous to the isolation of this area, it must have been in direct union with those portions of the European continent the floras of which are shown to be identical with one or other of the five floras of the British isles. I will briefly mention the five distinct floras which he has noticed, and the districts with which he considers they prove our former connexion.

1. The West Irish Flora.—The high lands in the north of Spain present the nearest point where a vegetation occurs identical with

that which is characteristic of the mountainous district of the west and south-west of Ireland. Consequently, at some period or other, continuous dry land must have existed from the coast of Spain to that of Ireland.

2. The Devon Flora, connected with that of the Channel Islands and the neighbouring parts of France.

3. The Kentish Flora.—The vegetation of the south-east of England is distinguished by the presence of a number of species common to this district and the opposite coast of France.

4. The Alpine Flora.—On the tops of some of our most lofty mountains, particularly in Scotland, are plants not found elsewhere in the British islands, but which are identical with those of the Scandinavian Alps, thus pointing to a former connection in that direction.

5. The General Flora.—This universal flora is almost identical as to species with the flora of central and western Europe, and may be properly styled Germanic.

The arguments by which these views are maintained are clearly and satisfactorily developed, but must be read and studied to be appreciated. That portion of the paper, however, which relates to the distribution of the marine plants and animals now inhabiting the British seas is still more deserving of careful study. The account of the distribution of the British Mollusca is particularly so: it contains a mass of information on the subject, not to be found, at the time of its publication, in any one work, and of the greatest value to the student of Tertiary geology. I will only mention one or two of the more interesting points with which the memoir concludes.

"That the flora and fauna, terrestrial and marine, of the British Islands and seas have originated, so far as that area is concerned, since the Miocene epoch.

"The greater part of the terrestrial animals and flowering plants now inhabiting the British Islands are members of specific centres beyond their area, and have migrated to it over continuous land, before, during, or after the glacial epoch.

"All the changes before, during, or after the glacial epoch appear to have been gradual and not sudden, so that no marked line of demarcation can be drawn between the creatures inhabiting the same element and the same locality during two proximate periods."

Of the many scientific papers of great merit which Prof. Forbes subsequently published, in our own and other Journals, I will only allude to one, which in this room cannot be passed over in silence. In his paper 'On the Fluvio-marine Tertiaries of the Isle of Wight,' published in the 9th Vol. of our Quarterly Journal, the result of the laborious investigations of several months, he has established, on data which cannot be questioned, the true order of superposition of the upper tertiary beds of that typical locality, correcting the errors of previous inquirers, and confirming a suggestion made by Mr. Prestwich, that the strata composing a part of Hempstead Hill were probably higher than any beds hitherto noticed. The result of Prof. Forbes's inquiries has been to show that, taking the Whitecliff Bay section for an example, the Headon Hill beds, instead of constituting the highest portion of the series, are overlaid by several other distinct formations, consisting of the St. Helen's or Osborne beds and the Bembridge series, the latter consisting of several distinct divisions, all characterized by peculiar fossils, chiefly, however, freshwater or brackish. He has, moreover, distinctly ascertained that the Hempstead Hill series constitutes another subdivision overlying the uppermost bed of the Bembridge Series, and characterized by a fresh set of fossils. "Thus," to use the author's words, "we find that the fluvio-marine Eocenes of the Isle of Wight are more than twice as thick as they have hitherto been regarded, and that the additional beds are even of greater geological importance than those hitherto recognized."

The remarkable feature in this section is, that from the Barton series upwards there is no break in the series of deposits; and as Prof. Forbes identifies the Hempstead series with the middle, and possibly the upper Limburg beds of Belgium, he is logically led to the conclusion, that the Limburg beds, and consequently the Weinheim beds of the Mayence basin, which are unquestionably of the same age as the Middle Limburg, must be also Eocene. Other continental beds are also referred to as necessarily belonging to this Eocene period. This is not the place to offer any criticism on Edward Forbes's conclusions, but I may perhaps hereafter allude to the question, for the purpose of testing whether there may not exist some flaw in the argument, by which so many of the younger continental beds are drawn into this Eocene vortex.

During this period Prof. Forbes was not only most industrious with his pen, but he was unwearied in his arrangement and classification of the vast accumulation of fossils collected by the Ordnance Geological Survey, and now exhibited in the Jermyn Street Museum. He was no less active in the field with his hammer and his note-book. He not only explored various parts of England, Wales, and Ireland, but he visited, with the same observant eye and comprehensive glance, many portions of Belgium and of France, carefully comparing their various aspects and phænomena, and procuring materials for his philosophical generalizations.

It is unnecessary for me to remind you of the satisfaction with which we hailed his appointment to the Presidentship of this Society, looking forward to the influence of his profound knowledge of palæontology on the future progress of our science. But scarcely had he occupied this chair for half the allotted term, when the death of his old master, Prof. Jameson, was announced in this metropolis. The universal voice of science was not slow in recognizing Edward Forbes as the man who, above all others, both as a naturalist and a geologist, was most fitted to succeed him. At the same time, I am bound to say, that while we were all ready to congratulate him on the prospect of thus reaching the highest goal which a true naturalist could desire, we looked forward with regret to the prospect of his removal from our circle. Nor was this grief altogether free from a feeling of shame, that this vast city, with its wealth, its display, its riches, its public and private associations, its great collections, its lavish expenditure, and in many respects its unbounded liberality, could propose no prize, no reward to the scientific man worthy to be placed in competition with that offered by the northern capital. Little did we then imagine that the regret we felt at his departure from amongst us was destined to be so soon merged in another, as overwhelming as it was altogether unexpected. Little did we imagine that the fond anticipations of a long and glorious career for our friend, in which we then indulged, were doomed to be so speedily destroyed.

Prof. Forbes was appointed to the vacant Chair of Natural History in the University of Edinburgh. He had thus obtained the great object of his life. An intimate friend, writing in one of the Edinburgh journals, says that he considered all his plans, excursions, observations, &c., as preparatory to this one object. During his active and laborious life, all his hopes and future plans pointed to Edinburgh as the only appropriate place for developing that vast amount of natural history acquirement he had obtained. There he looked forward, amongst other things which his eager fancy had prepared for him, to the formation of a magnificent museum, arranged according to that system which for years he had been zealously maturing. Nor can there be any doubt, but that with the liberal support of Government, assisted by that of private individuals, he would have been enabled in a few years to carry out his plans. But alas! scarcely had he reached that goal which he had spent his whole life in endeavouring to attain, and which he was anxiously preparing to adorn with all the ornaments of science collected from every quarter of the globe, when he was suddenly carried off by the inscrutable decrees of Providence; and the glorious fabric he had erected,—that mental storehouse filled with the treasures of many years' collecting, fell to pieces before our eyes, and nothing remained but the broken fragments and the shattered scaffolding, to be again dispersed and scattered, without system and without order, until they should be again hereafter collected together with infinite labour and fatigue by some future master-mind.

The fate of Sir John Franklin has long been a mystery to his countrymen: he has probably long ceased to be a member of this Society. It is, however, only during the course of the past session that any authentic information has reached this country that the gallant explorer of the Arctic regions, with his adventurous followers, had ceased to exist. Far from their ships, which, in the extremity of danger and a hard struggle for life, they must have abandoned, and after vainly endeavouring to reach a more southern and hospitable region through a trackless desert, their remains were discovered by travelling Esquimaux, from some of whom portions of their property were obtained. These were rescued by the intrepid Dr. Rae, who had gone in search of them overland, and who brought back the melancholy certitude of their fate. Their bones now lie whitening on the Arctic shore, or beneath fields of eternal snow. By what means they reached that spot, or how they perished, will probably never be known; but their memories will ever be cherished as of men who risked and sacrificed their lives in the performance of duty and of scientific inquiry, and I trust I may also add, as the last instalment of valuable lives sacrificed to a vain and chimerical attempt to discover that which, could it ever be discovered, would be alike unprofitable and unavailable.

Rear-Admiral Sir John Franklin was born at Spilsby in the year 1786, and performed his earliest service in the navy in the first year of this century, as a midshipman on board of the Polyphemus at the battle of Copenhagen. Sailing afterwards with Capt. Flinders to Australia, he acquired that skill in surveying and that power of observation which characterized his subsequent career. After serving in the engagement against Admiral Linois in the Straits of Malacca, he next acted as signal-midshipman of the Bellerophon in the glorious victory of Trafalgar; and, lastly, towards the conclusion of the great war, his gallantry was again displayed conspicuously in the naval attack upon New Orleans, for which conduct he obtained his lieutenancy.

A peace being established which promised a long duration, Franklin sought to be employed in the most adventurous service in which a seaman could then be engaged. He obtained, through the patronage of Sir Joseph Banks, the command of the surveying vessel, the Trent, being one of two ships under the orders of Capt. Buchan, destined to penetrate into the Polar seas; on that occasion Franklin not only reached the high latitude of 84° 34″ N. lat. in the meridian of Spitzbergen, but evinced a strong desire to be allowed to proceed onwards alone, in the endeavour to effect a thorough passage.

The undaunted and inflexible perseverance which he exhibited in his explorations off the coast of North America, between the years 1819 and 1822, both inclusive, is well known to the public through the clear and emphatic productions of his own pen. As geologists, however, we must specially remember, that the rock-specimens then brought home by Franklin and his associate, the eminent naturalist, Richardson, first revealed to us the structure of those distant and inaccessible regions.

On his return to England, however, Franklin felt so strongly the want of better geological knowledge on his own part and on that of his officers, that when appointed to the command of the next Arctic expedition, on which he sailed in 1825, he took his first lessons in our science at the museum of our Society, accompanied by his distinguished companions, Back and Richardson. At these morning meetings our much-respected former President, Dr. Fitton, was the instructor, assisted by Mr. T. Webster, then our secretary; Sir Roderick Murchison, who has informed me of these circumstances, being then also one of the learners.

The intimacy thus commenced continued till Franklin's last departure from the shores of Britain in 1845; for whether he was treading unknown tracts of North America, or commanding the Rainbow frigate in the Mediterranean, or performing the duties of Governor of Van Diemen's Land, our deceased member, having been knighted by his sovereign and duly honoured by various public bodies, never ceased to correspond with his scientific friends, including Mr.

Robert Brown, the enlightened botanist, and the old officers of this Society, Fitton and Murchison; sending to them also any specimens or descriptions which might, he thought, advance human knowledge.

As Sir John Franklin united the warmest heart and kindest manners to a solid understanding, it naturally followed that his friends took an intense interest in promoting all those endeavours to rescue him and his followers from their last perilous voyage, and in encouraging every effort directed to that end, whether made by the Government or by the magnanimous Lady of the missing chief. The successive Presidents of the Royal Geographical Society, and particularly Sir R. Murchison, stimulated our rulers to make every possible research which might lead to the timely discovery of the absent voyagers. How some one of the earliest of these efforts might have succeeded, had it taken a southerly direction from Barrow's Straits, is indeed now established by the melancholy announcement made by Dr. Rae; for, although the party was supplied with provisions for three years only, we now know that a large remnant of the force had certainly sustained life for five years.

The late PROFESSOR JAMESON was the third son of Thomas Jameson, Esq., and was born at Leith on the 11th July, 1774. In his early years he showed a strong desire to become acquainted with natural objects, the study of which he evidently preferred to that of books and letters. His first attempts were made in stuffing birds, and in collecting animals and plants on the beach of Leith and its vicinity. A strong desire to travel was the result of his favourite pursuits, and his father ultimately yielded to his often-repeated wish to enter on the profession of a mariner; but his friends interposed, and suggested that by adopting the study of medicine, he might equally be enabled to study the works of nature. He yielded in his turn, and was appointed assistant to the late John Cheque Esq., surgeon in Leith. He commenced his study of natural history in 1792, under Dr. Walker, then Professor of Natural History in the College of Edinburgh, and soon became a favourite pupil. In 1793 he visited London, and became acquainted with the principal scientific men of the metropolis, and ever after spoke of the pleasure and benefit he had derived from his intercourse with Sir Joseph Banks, Mr. Dryander, Dr. Shaw, and other leading members of the Linnæan Society. With the exception of comparative anatomy, he now abandoned all idea of pursuing his medical studies. His attention was directed to that of ornithology and entomology, then of chemistry, and subsequently of mineralogy and geology, including a thorough knowledge of analytical chemistry. In 1797 Prof. Jameson paid his first visit to the island of Arran, and in the following year he published his work on the 'Mineralogy of the Island of Arran and the Shetland Islands, with Dissertations on Peat and Kelp.' It was the first good geological account of these places and formations, and soon acquired a well-merited celebrity. He subsequently visited other portions of Scotland, and in 1800 published his 'Mineralogy of the Scottish Isles,' in two vols. 4to, illustrated with maps and plates. This work contained the first sketch of the geology of the Hebrides and the Orkneys.

But the real period of Jameson's celebrity as a mineralogist and a geologist dates from the year 1800, when he left his native country for Freyburg, where he remained nearly two years studying mineralogy and geology under the famous Werner. Jameson fully acknowledged that it was from him he first derived clear and distinct views of the structure and classification of rocks. This opinion is confirmed by Conybeare, who says, "We are chiefly indebted to the reports of Werner's pupils, especially to those of Jameson, for our knowledge of Werner's general views, so fully developed in his lectures, and there only." Jameson also observed, in a passage which is too important not to be quoted on this occasion, pointing as it does to the very fundamental principle of all our modern geological investigations, that "Werner taught that mineralogical and geological characters, and characters derived from organic remains, were to be employed in determining formations, and that probably the same general geological arrangements would be found to prevail throughout the earth. But," he added, "the truth or falsity of this view in regard to the similarity of formations, can only be determined by the united labours of geologists continued for a long series of years." This, it may be observed, is the very position our science now occupies, tracing out geological formations from one hemisphere to the other, referring the fossils of India to the age of the Chalk of England, and comparing the Palæozoic fossils of Australia with those of Great Britain and America. Thus, as Prof. Jameson admitted, it is to Werner that we are principally indebted for our present highly interesting views of the natural history of fossil organic remains; and in confirmation of this opinion, Prof. Jameson at a subsequent period vindicated the geognosy of Werner from the attacks made upon it by the Edinburgh Review.

In 1804 Jameson returned to England in consequence of the state of his father's health. Shortly afterwards, on the death of Dr. Walker in the same year, Jameson was appointed Professor of Natural History; and from that period, by his admirable lectures, founded in a great measure on the sound mineralogical and geological views of his friend and master the Professor of Freyburg, he raised the Edinburgh school of Natural History to the proud pre-eminence it has occupied for the last half-century. In the same year, he published the first part of the first volume of his 'Mineralogical Description of Scotland;' his other labours, however, prevented the completion of the work. In 1808 he founded at Edinburgh the Wernerian Natural History Society, of which he was elected perpetual President.

In 1809 he published the 'Elements of Geognosy,' a work which contributed more to introduce the doctrines of the Wernerian school into England than any other publication; and from this time may be dated the antagonism between the Wernerian and the Huttonian doctrines, as advocated by the northern geologists. Nor was the spirit of partisanship thus engendered altogether useless, inasmuch as its final effect was to call attention to the study of, and to diffuse a more general taste for geology. Independently of this, the modification of the Neptunian theory as adopted by Werner, and in which form Prof. Jameson introduced it to the notice of his countrymen, has been proved by the test of modern science to be more consistent with the phænomena of Nature than the Plutonian views of its adversaries. It has served to introduce a more methodical study of the different formations of the earth's crust, in harmony with the numerous organic remains which they contain, and which never could have been reconciled with the doctrines of the Huttonian theory.

In 1813, at the suggestion of Professor Jameson, a translation of Leopold von Buch's 'Travels through Norway and Lapland in 1806, 1807, and 1808,' was published by Mr. Black,—Jameson himself adding to the interest of the work by an account of the author, and by various notes illustrative of the natural history of Norway. In 1816, another edition of the 'System of Mineralogy' made its appearance in three volumes; and at the same time a new edition of his 'Characters of Minerals' was called for. Other editions of both works followed. In 1819, he commenced the 'Edinburgh Philosophical Journal.' For the first six years he conducted it with Sir David Brewster, but since that period he was the sole editor. It extends to seventy volumes, and is one of the most valuable repositories of scientific information in Britain. It will ever form one of the most durable monuments of his talents and industry.

But while Jameson was thus exerting himself in Edinburgh to propagate sound and correct views respecting the geological phænomena of the earth's crust, another distinguished naturalist was labouring in another capital to bring about the same results by the help of comparative anatomy.

In 1821, the immortal Cuvier published his 'Discourse on the Theory of the Earth,' as an introduction to his 'Researches on Fossil Bones.' To Professor Jameson we are indebted for the publication of a translation of this work made by Mr. Kerr. On this work Jameson observes:—"The notes I have added will, I trust, be found interesting, and the account of Cuvier's 'Geological Discoveries' which accompanies them will be useful to those who have not an opportunity of consulting the great work." This popular work produced an excellent effect in this country, for Cuvier was but partially known in England until this essay appeared. It rapidly ran through five editions: in the fifth, Professor Jameson entirely remodelled it, extending it from 190 to 550 pages.

During this period he also contributed many articles to the 'Enclopædia Britannica' and to the 'Edinburgh Encyclopædia;' and on the return of Captain Parry from his Polar Expedition he drew up, from the specimens brought home, a sketch of the geology of the different coasts discovered and touched at by that enterprising navigator. But it would be occupying too much of your time, to enumerate the various works which flowed from his ever-ready pen. I cannot, however, conclude this notice without briefly alluding to one point respecting which Professor Jameson deserves the greatest praise, both for what he effected and for what he endeavoured to effect. The present Museum of Natural History in Edinburgh is the result of Jameson's unceasing industry and efforts. The collections which existed before his time were almost entirely removed by the Trustees of his predecessor Dr. Walker; and the nucleus of the present magnificent collection was Professor Jameson's private property, when he was called to fill the chair of Natural History. He laboured incessantly to render it worthy of the place; but the means placed at his disposal, both by the Town Council and the Government, were inadequate to the task, and it was not without great private outlay that Professor Jameson raised it to its present state. In fact it may be said that the present Museum was founded, created, arranged, and exposed for public exhibition by the head and the industrious hands of Jameson alone. Professor Jameson died in Edinburgh, at the age of eighty, on the 19th of April, 1854.

The name of Arthur Aikin is associated with the earliest days of the existence of our Society. In that Charter which forms the basis of our constitution, his name occurs as one of the founders of this Society. He was born at Warrington, in Lancashire, on the 19th May, 1773. The grandson of John Aikin, D.D., eminent for his learning and abilities, he evinced at an early age a decided love for literature and science, and from his father derived a taste for Zoology, for Chemistry, and for English Botany. An early acquaintance with Dr. Priestley, of whom he subsequently became a favourite pupil, and whom he assisted in the arrangement of a new laboratory, confirmed him in his predilection for Chemistry. In 1797 he published an account of a tour in North Wales, made in the previous year in company with his brother Charles and another friend, under the title of 'Journal of a Tour in North Wales and part of Shropshire, with observations in Mineralogy and other branches of Natural History.' At a subsequent period, in conjunction with his brother, he delivered lectures on Chemistry and Chemical Manufactures, of which a syllabus appeared in 1799. In 1807 he published 'A Dictionary of Chemistry and Mineralogy,' 2 vols. 4to; and in 1814, 'An account of the most recent discoveries in Chemistry and Mineralogy.'

But before this time Arthur Aikin had become conspicuous as one of that distinguished band of scientific men who contributed to the formation of the Geological Society of London, and founded it in 1807; soon afterwards his knowledge of mineralogy and chemistry must have contributed to his being appointed one of the Secretaries of the Society. In the first volume of the first series of our Transactions, published in 1811, his name appears as one of the Members of Council. In the second volume, published in 1814, he appears as one of the Secretaries, as well as in the third volume, published in 1816; but there is reason to believe that he became one of the Secretaries at a still earlier period. In the first volume of the first series there is an interesting paper by him, entitled "Observations on the Wrekin and on the Great Coal Field of Shropshire;" and in the third volume is another with the title of

"Some Observations on a Bed of Trap occurring in the Colliery of Birch Hill, near Walsall, in Staffordshire." These papers, like all those published by the Society at that period, were of a much more mineralogical character than those now constituting the bulk of our publications. Palæontology had then made but little progress. Its value and importance in assisting our knowledge of the relative ages of rocks was hardly recognized, nor amongst the illustrations which accompany the early volumes are there any figures of organic remains. At a subsequent period he was appointed to the Secretaryship of the Society of Arts; this circumstance is supposed to have led to his retirement from the office of Secretary to this Society; but he continued for many years longer to serve on the Council, of which he was a member for the last time in 1830. One of the earliest members of the Society who knew him well thus writes to me of him:—"He had a very logical head, and a calm and imperturbable temper, and drew up abstracts of the papers read at the meetings with a precision that might stand in comparison with those of Dr. Wollaston at the Royal Society." As an instance of character it is mentioned that in early life he had been a minister of the Unitarian persuasion, but resigned his cure on conscientious grounds. He was a corresponding member of the Academy of Dijon, &c. He died in London, on the 15th April, at the advanced age of eighty.

Dr. Stanger, the able and energetic naturalist of the ill-fated Niger Expedition, was born at Wisbeach, in Cambridgeshire, in 1812. He took his degree of Doctor of Medicine at Edinburgh, and subsequently visited Australia. He afterwards superintended, under the direction of the Government, the construction of roads near Cape Town, then returned to England, and settling in London, commenced the practice of his profession.

But the pursuit of natural history had greater charms for his enterprising character. In 1841 he joined the Niger Expedition under Captain H. Trotter, R.N., and was one of the few of that gallant but unfortunate band who were not struck down by the devastating fever of the country. It was mainly owing to his energy, assisted by Dr. M'Williams, that one of the steamers was brought down the river. In 1845 he was appointed Surveyor-General to the new colony of Natal, where, with the exception of a short interval of two years passed at home, he continued until his death. In this young colony his time was spent between the conscientious discharge of the duties of his office and a zealous investigation of the natural history of the district. But the pressing calls of his official duties did not permit of his reducing to order his many observations on natural history. One of his last contributions to botanical science, to which he was particularly devoted, was the discovery of a plant belonging to the family of the Cycadeæ, combining many peculiar characters, and named after him *Stangeria*. There is now a plant of it in the Royal Gardens at Kew, producing fruit. Exhausted by fatigue and cold, after travelling from Maritzburg to Natal on horseback, he died on the 21st March, 1854, and was honoured with a public funeral as a mark of the respect in which he was held by the authorities and inhabitants of the district. His loss is the more to be regretted, inasmuch as it disappoints those hopes held forth by my predecessor last year, in allusion to the geological discoveries to be expected from Dr. Stanger, who was to have undertaken an official geological exploration of the province of Natal.

The Rev. H. M. De la Condamine was a member of the Council at the period of his decease. In him we have to deplore the loss of one who was taking an active interest in the progress of the Society, and who had communicated to us only a short time previously some interesting papers on the superficial deposits and drift beds in the neighbourhood of London. Mr. De la Condamine's first paper read before this Society was, "On the Tertiary Strata and their Dislocations in the neighbourhood of Blackheath." In this paper, read January 5th, 1850*, it was stated that the cuttings of the North Kent Railway had yielded some good sections of the plastic clay series, and had disclosed an important line of dislocation at Deptford. After describing the effects produced by this dislocation, he states that we have thus a distinct line of demarcation between the lower and middle Eocene periods; and then observes that the date of the dislocation of the strata must have been posterior to that of the partial denudation of the London clay.

A second paper was read by Mr. De la Condamine on the 10th March, 1852, "On a reversed fault at Lewisham." It is accompanied by diagrams illustrating the action of the forces which may have produced the dislocation. The profound mathematical knowledge of the Author, for which he was remarkable, is well exemplified in this paper. On the 4th May, 1853, Mr. De la Condamine read another paper, "On a Freshwater deposit in the Drift of Huntingdonshire."

He was actively engaged in preparing other papers for our Society, when we were suddenly deprived of his assistance. One great merit of Mr. De la Condamine was, his taking up some of those minute points which, while they involve very abstruse subjects, offer less apparent attraction, but are not less necessary in solving important geological problems, than the grand phænomena of igneous action, or the still more interesting labour of working on older beds abounding in the well-preserved remains of organic life.

Mr. James Hall was the third son of the late Sir James Hall of Dunglas Castle, the President of the Royal Society of Edinburgh, whose name can never be referred to without calling forth the gratitude of geologists for his valuable experiments respecting the fusion of rocks under pressure. Our departed associate was the brother of the present Sir John Hall, and of the late Capt. Basil Hall, R.N. Instead of following his father's footsteps in the pursuit of natural science, he devoted himself to the study of the arts, and was more practised in the use of the brush and easel than of the geological hammer. He was, however, a constant attendant at our meetings. His pictures were exhibited at the British Institution and at the

* Journal, vol. vi. p. 440.

Royal Academy, of which he was a student. He was the author of some speculative letters on Binocular Perspective, published in the Art Journal; but I am not aware that he contributed any papers to the Journal, or to the Transactions of our Society. He died on the 26th October last, at the age of fifty-seven.

I can only briefly mention the names of other Members of our Society whom we have lost during the past year, and many of whom have done good service in the pursuit of geology. We deeply regret the loss of such men as the Rev. Thomas Egerton; Mr. G. W. Aylmer; Mr. W. Winterbottom; Mr. Scobie; Sir T. Frankland Lewis, &c.

The only loss we have sustained amongst our Foreign Associates is that of Dr. Gotthelf Friedrich Fischer de Waldheim, Professor of Natural History in the University of Moscow. He was born at Waldheim, in Saxony, on the 15th October, 1771, and studied mineralogy at Freyberg, with Leopold von Buch and Baron von Humboldt, completing his medical studies at the University of Leipzic. At Paris he subsequently attended the lectures of Cuvier, and carefully studied the natural-history collections of the French Museum. He had already given evidence of his extensive learning by numerous publications, when, in 1800, he was appointed Professor of Natural History at the Central School of Mayence. On his arrival there, however, he found that the chair had been given to another; and with that power of adaptation which belongs to true genius, he at once accepted the office of Librarian, which for a time led him away to other studies, particularly typographical antiquities. On this subject he published several valuable works until 1804. But he did not, in the mean time, neglect his favourite pursuit; he founded at Mayence a Natural History Society, of which he became the Secretary, and in 1804 published his 'Anatomie der Maki und der ihm verwandten Thiere.' In the same year he was appointed Professor and Director of the Museum of Natural History at Moscow, where a new field was opened to his talents, in which he laboured with zeal and energy during the remainder of his life. In the year 1805 he founded the Society of Naturalists of Moscow, and published the first volume of his 'Description du Muséum d'Histoire Naturelle,' the copper-plates of which he engraved with his own hands. This Museum, for the establishment and improvement of which he had so strenuously exerted himself, was destroyed during the conflagration of the city in 1812. Such a calamity would have gone nigh to overwhelm an ordinary man. Dr. Fischer rose above the circumstances, and with redoubled ardour immediately set to work to replace, as far as possible, the treasures which had been lost. Such were his efforts, and such was the success with which they were attended, that in a very few years the new Museum had again acquired a valuable collection of objects of natural history. He had now begun to direct his attention more exclusively to the study of fossil zoology, or as it is now called, Palæontology. In the 'Bibliographia Zoologiæ et Geologiæ' of Agassiz, published by the Ray Society, there are no less than 150 notices of separate works and memoirs in journals and

Transactions published by him during the course of his long and laborious life. Among these are many bearing directly on our science, and which must have had considerable influence in directing the attention of the Russian Government to the mineral riches of the country, and of making its geological features better known beyond the limits of his own district. I will only mention a few of his more important works :—"Oryctographie du Gouvernement de Moscou," 1837 ; "Bibliographia Palæontologica Animalium Systematica," 1810 ; a second edition in 1834 ; "Notice des Fossiles du Gouvernement de Moscou," 1809–1811 ; "Notice sur quelques Animaux fossiles de la Russie," 1829 ; "Ueber verschiedene fossile Elephanten-species, die man unter dem Namen Mammouth begreift," 1831 ; "Recherches sur les Ossemens fossiles de la Russie," 1824 ; "Lettre à M. Murchison sur le Rhopalodon, genre de Saurien fossile du Versant occidental de l'Oural," 1841 ; "Revue des Fossiles du Gouvernement de Moscou," 1846 ; and many others. He was elected a Foreign Member of this Society, and of the Linnean Society, in 1820. He died at Moscow, on the 6th of October, 1853, having nearly completed his eighty-second year.

Gentlemen,—In proceeding to lay before you, in accordance with the established usage of our Society, a sketch of the progress of Geology during the past session, I shall not attempt, as some of my distinguished predecessors have done, to single out any particular subject for discussion, and to lay it before you in all its bearings ; I shall endeavour rather to bring together the principal events in the history of geology which have lately occurred, and to remind you of its general progress. Time, however, would be wanting to allude to every publication of interest on the subject which has appeared in our own or in foreign journals and publications. A mere list of names would be altogether unprofitable. I cannot even pretend to refer to all the papers read at our evening meetings ; I must refer you to the Journal itself for most of them, while I can only briefly allude to some which appear to me of more than ordinary interest. If I have devoted a more than usual proportion of space to the works of foreign, and particularly German geologists, I trust I shall be excused for doing so, on the ground that I thought such information would prove more acceptable to the majority of my hearers, and because my own attention had been more particularly turned in that direction.

British Geology and our own Proceedings.

Adopting then the ascending order, and commencing with the progress of Palæozoic Geology in our own country, I must first congratulate you on the appearance of that truly standard work on this subject which has been lately published ; I allude to the 'Siluria' of my old friend Sir Roderick Murchison. Every one who was acquainted with the previous labours of the author in this difficult and extensive field, was looking forward to its appearance with eager interest ; nor have our expectations been disappointed. I am satisfied that I but give utterance to the sentiments of all present, when I say that we owe a debt of gratitude to the author for having laid before us in such a comprehensive manner the vast amount of information contained in his two former works, 'The Silurian System,' and 'Russia and the Ural Mountains,' enhanced by the addition of the results of subsequent investigations up to the time of publication. Our thanks are due to him, moreover, for having published his book in a form and at a price which make it accessible to every geological student. By a judicious method of condensation, which, while diminishing the bulk, has preserved the essence and character of the subject-matter, the author of 'Siluria' has brought before us in one comprehensive glance the whole phænomena of the Palæozoic rocks throughout the world.

In alluding to this publication, however, I am happy to find that I have no occasion to tax my own powers, or to be suspected of partiality in analysing a work which has been so generally approved of. If the Geological Society had not been deprived of the services of my eminent predecessor by his removal to the University of Edinburgh in the middle of his presidency, and if his valuable life had not been so prematurely cut short, it would have been his duty to perform a task for which he was so much better qualified than myself. Fortunately, however, as respects 'Siluria,' we have the record of the deliberately formed judgment of our late President, as published last autumn, and which is the more valuable, inasmuch as some of his theoretical views were not in unison with those of the author.

After giving a summary of the Silurian formations, the words of our lamented President, which, had he been alive, he would assuredly have addressed to ourselves, are these:—

"Now, when it is recollected that the 'Silurian System,' that great work in which its author fully stated and co-ordinated the results of his researches on the Welsh border, was given to the world only fifteen years ago, and that the very epithet 'Silurian' was itself assigned to these formations no longer ago than in the year 1835, the influence of Sir Roderick Murchison's labours and generalizations in stimulating discovery, and leading to a clear understanding of the earlier sedimentary rocks, must be regarded as great indeed. And, be it observed, in this short sketch of foreign primæval geology, we have used the word *Silurian* constantly, not of our own choice, or to do honour to its inventor, but because it is the term applied to the rocks in question by their explorers in all countries. The geologists of the continent, of Australia, and of America, have identified the older palæozoic formations, whose structure and fossil contents they have so admirably described, with the 'Silurian' system of our own country, and with the types of its greater sections as defined by its first investigator. In fact, they have adopted as a standard that system which, being definite in its details, enabled them to obtain a distinct scale for the purposes of comparison. They have not chosen their nomenclature on account of its author, but because the model he had set before them is perspicuous and intelligible.

"We question whether any practical geologist now living would doubt for a moment that one of the greatest advances ever made in the descriptive section of his science was the establishment of the Silurian system. It matters not whether we hold, with its author, that the earliest manifestations of life and the commencement and inauguration of animated nature are included within it; or, with Sir Charles Lyell, more cautiously interpret the relics of primæval beings, and regard the Silurian fauna as the earliest yet demonstrated, though not necessarily the first. Whichever view we take, the importance of the discovery and definition of the Silurian system cannot be called in question. It was a grand reward of sagacity, perseverance, and well-directed skill—no lucky chance, but a discovery deliberately sought, which threw a flood of daylight around a realm of geological darkness, and made the obscurest of rock assemblages one of the clearest and most instructive. A single man did this great and worthy task. The definition of the Silurian system, and the several members or sections of which it is composed, the invention of a nomenclature for the subdivisions, which, though essentially local, has become of universal application, the determination of a scheme of organic types upon which comparisons and identifications could be conveniently based—all these good works were done by one investigator, the illustrious author of the volume now before us*."

I have also to notice a paper by Professor Sedgwick, "On the May Hill Sandstone and the Palæozoic System of the British Isles." I am not about to attempt any discussion of the *vexata quæstio* between Professor Sedgwick and Sir R. Murchison respecting the nomenclature of the earliest palæozoic formations, or to explain what amount of error or of truth there may be in the respective views of these two distinguished men; I will only observe that, in support of his views, Professor Sedgwick endeavours to show in this paper that there is no continuous unbroken section ascending from the Cambrian to the overlying Silurian groups, but that there is a physical break between them exactly on the horizon of the May Hill Sandstone, and that, in co-ordination with that break, there is a great change in the fossil species. The value of this evidence depends on its being shown to be general, and not a merely local phænomenon.

The Ordnance Geological Survey has been satisfactorily progressing during the past year, and it is gratifying to know that Sir H. De la Beche and his able staff have at length been enabled to direct their attention to the survey of some parts of Scotland. This has been rendered possible by the Trigonometrical Survey having now completed a sufficient portion of the map to admit of the geological features being laid down. In England the survey is being extended to the central counties, and here also we may expect some results of more than ordinary interest, inasmuch as its extension involves the question of the distribution of the Coal under the New Red Sandstone. One of the most interesting results of the labours of the Survey during the past year has been Mr. Salter's investigation of the lower Carboniferous rocks in Pembrokeshire and North Devon, confirming views formerly held by Sir H. De la Beche, viz. that the upper part

* Quarterly Review, No. cxc. Sept. 1854, p. 385.

of the Devonian formation, as shown in North Devonshire, is identical with the lower beds of the Carboniferous formation in Western England. The probability of this being the case was pointed out by Sir H. De la Beche in the 'Report on Devonshire and Cornwall,' but the subsequent working-out of the fossils by Professor Phillips and Mr. Sowerby showed so many peculiar species identical with those from strata below the Carboniferous limestone on the Continent, that the beds in question (the Pilton group of Professor Phillips,—the fifth group of Professor Sedgwick and Sir R. Murchison) have been regarded as the upper portion of the Devonian rocks, with which, however, they have very few fossils in common. A careful examination of the Lower Limestone Shale by Mr. Salter during the past summer, in East and West Pembrokeshire, has led him to the conclusion that these beds, interposed as a shaly series between the carboniferous limestone and the true old red sandstone, should be considered as a part of the Carboniferous system, all the more abundant fossils being characteristic of that formation. In East Pembrokeshire these beds repose on the Old Red Sandstone, which contains but few fossils, and which in West Pembrokeshire loses its red colour, and consists of yellow sandstones and limestones, with *Avicula Damnoniensis* and *Cucullæa trapezium* overlaid by a peculiar series of shales and sandstones, with frequent fish- and coprolite-beds. When Mr. Salter crossed the Bristol Channel and examined the upper beds of the Devonian rocks, where the red colour has been absent from a still larger portion of the upper Old Red, he found that the yellow sandstones and associated limestone were identical with those which he had seen in West Pembrokeshire. Here also the beds containing *Avicula Damnoniensis*, *Cucullæa*, and a peculiar trilobed *Bellerophon* were overlaid by a great shaly and slaty series full of the same Carboniferous fossils (*Spirifer*, *Terebratula*, &c.), with fish beds containing the same species, and made up of arenaceous limestone and shales, which, but for their more complete slaty cleavage, could not be distinguished from those of Pembrokeshire. Mingled, however, with the mass of carboniferous fossils, Mr. Salter found in abundance those peculiar species *Strophalosia caperata* and *Phacops latifrons*, which characterize this district, and are not known in Pembrokeshire. The latter species, indeed, is a decidedly Devonian type, rising up in this instance for a considerable thickness (many hundred feet at least) into the lower carboniferous deposits. Mr. Salter therefore considers that, as already suggested by Mr. D. Sharpe, on fossil evidence alone, this group should be cut off from the Devonian and included in the Carboniferous system. It is the Carboniferous slate of Dr. Griffith, and occurs in great thickness in Ireland, with a highly cleaved structure.

It will be a subject of congratulation to those who take an interest in the geology of Ireland, to learn that the Government has at length determined on introducing the one-inch scale of maps for the use of the Ordnance Geological Survey of that country.

The six-inch scale, however useful for a survey of landed property, or for registering minute geological features, is far too unwieldy and expensive for the practical purposes of the geologist. I am able to state, that the maps are now being engraved on the smaller scale, and that a commencement has already been made in the use of them. Mr. Jukes announced to the Geological Section at Liverpool that the northern part of the county of Wicklow was already completed and coloured geologically.

The last Number of the Memoirs of the Geological Survey (Decade III.) is devoted to the figures and descriptions of Trilobites, which, as our late President observes in the Introduction, are remarkably characteristic of well-defined geological horizons. The study of these forms is consequently of great importance to the geologist whose labours are directed to the investigation of the more ancient rocks, to which they exclusively belong. The figures and descriptions in this Decade are by Mr. Salter.

The question of the cleavage and foliation of the older crystalline rocks is one which has on several occasions occupied our attention at the evening meetings, and has given rise to many interesting discussions. To judge from the various opinions entertained on this subject, the question still requires much careful examination, not only in a theoretical point of view as to the causes which may have produced these effects, but even as to the facts themselves on which these theories are to be founded. It would therefore be premature to enter fully into this question, but I will endeavour briefly to lay before you the evidence which has been brought forward, and the different views entertained upon the subject. Three papers have been lately read before the Society, describing the various phænomena observed by the different authors; the first was a paper by Mr. Sharpe, "On the Structure of the Crystalline Rocks in the neighbourhood of Mont Blanc;" the second was by Mr. Evan Hopkins, "On the Laminated Structure of the Primary Rocks;" and the third was read at our last meeting by Mr. David Forbes, "On the Foliated Rocks of Norway."

The universality of the views entertained by Mr. Evan Hopkins, and the fact of his having already, in 1850, stated them partially to the Society, induce me to notice them first. On the former occasion, in his paper on the "Structure of the Crystalline Rocks of the Andes, and their Cleavage Planes," Mr. Hopkins endeavoured to show that in a section of many hundred miles, the crystalline rocks of South America were universally characterized by vertical or almost vertical lines of cleavage, and that these cleavage planes had a uniform meridional direction or strike, thereby separating innumerable varieties of granites, gneiss, schists, hornblende, chloritic slates, porphyries, &c., into great meridional bands. In his paper of this session, Mr. Evan Hopkins has endeavoured to show, that in all countries, in all regions, in all quarters of the globe, the old crystalline rocks have a vertical cleavage, with a north and south direction. This view he lays down with absolute universality, illustrating it by sections of many thousand miles made by himself in various parts of the world. Mr. Hopkins subsequently admitted exceptional cases, but maintained the generality of his law, stating that when these crystalline rocks were overlaid by horizontally or nearly horizontally-stratified sedimentary deposits, the latter exhibited at their point of contact with the older rocks evidence of undergoing the process of vertical cleavage or lamination, and that the lines of stratification were gradually obliterated. Mr. E. Hopkins does not, as far as I can understand, draw any distinction between cleavage and lamination.

Mr. Sharpe, avoiding the universality of Mr. E. Hopkins, confined his remarks to those portions of the chain of Mont Blanc which he had visited during the past summer. Having disposed of the erroneous views of former authors, who, not sufficiently attending to the differences of stratification and cleavage, had asserted that the gneiss or stratified granite of Mont Blanc overlaid the secondary rocks seen in the Valley of Chamounix and in Val Ferret, Mr. Sharpe pointed out that the chain of Mont Blanc consists of two lines of vertical foliation, about one mile and a half apart, having a strike parallel to the major axis of the chain, extending along its whole length, and separated by a narrow anticlinal axis. This anticlinal axis, however, appears to me to be the result of the fan-shaped arrangement of the two systems of radiation. The planes of foliation, which are vertical along the highest ridges of the mountain, radiate as it were outwards as they recede from the central vertical line. Thus, where there are, as here, two lines of foliation running parallel to each other, the southern radiations of the northern line diverge towards the northern radiations of the more southern line, and thus produce the appearance of an anticlinal axis. Mr. Sharpe also pointed out that where the crystalline rocks are overlaid on their line of strike by slates of sedimentary origin, the cleavage of the slates is on the continuation of the planes of foliation of the gneiss and mica schist, and that where the slates lie against the sides of the crystalline mass, their cleavage planes combine with the planes of foliation of the crystalline rocks to form anticlinal axes of considerable regularity; thus confirming the opinion originally pronounced by Mr. Darwin, and subsequently confirmed by Mr. Sharpe himself, by observations in the Highlands of Scotland, that the cleavage of the slates and the foliation of the crystalline rocks were owing to the same cause.

The observations contained in Mr. D. Forbes's paper derive additional importance from the many opportunities the author has had of studying the structure of the crystalline rocks in Norway and elsewhere, and from the corroborative evidence he has acquired in producing artificial gneiss out of clay-slate by long exposure to great heat, but not at such a degree as would produce fusion. Mr. Forbes insists strongly on the difference between cleavage and foliation, considering cleavage to be the result of mechanical action, whilst foliation can only be accounted for as the result of chemical forces, but not necessarily requiring such a temperature as to produce fusion, or even semi-fusion. The following views are considered by Mr. D. Forbes as the result of his inquiries:—1. That foliation and cleavage are two distinct processes not necessarily connected; 2. That foliation is the result of chemical action combined with a simultaneously acting arranging molecular force, generally developed at temperatures below the fusion or semi-fusion of rocks; also that when we find rocks which we know have been previously in a state of fusion, possessing a foliated structure, this structure has been induced subsequently to their solidification; 3. That the arrangement of foliation may often be due to the intrusion or approach of igneous rocks; and 4. That there is reason to suppose that the foliated rocks may be altered fossiliferous strata, from their chemical composition, from the presence of certain minerals, and on account of the changes known to take place in other fossiliferous rocks.

Notwithstanding certain points of agreement between the respective authors of these papers, there is still such an amount of difference of opinion amongst them as to make it desirable that more information, based on careful and accurate observation in different districts, should be obtained on the subject, before we can venture to say that any satisfactory explanation of the many varied phænomena connected with the cleavage and foliation of rocks has been obtained.

The paper by Mr. O. Westwood, entitled "Contributions to Fossil Entomology," is one of great interest, and which, taken into consideration with another paper to which I shall briefly allude, is of importance in enabling us better to understand the progressive changes of organic life, and to unravel some at least of the causes which have led to the modifications of animal life during the different periods of geological time. Not being an entomologist, I have no pretension to speak about the details of the paper; but I must at least call your attention to the admirable execution of the plates by which it is illustrated, and to the care which Mr. Westwood has bestowed on the description of the different remains submitted to him for examination. By far the largest portion of these numerous suites of fossil insects were obtained by Messrs. Brodie and Willcox from the lower Purbeck beds of Durdlestone Bay. They leave no doubt, whatever may have been the nature of the climate which they are supposed to indicate, that a vast assemblage of insect life must have existed in the immediate vicinity of the spot where they were entombed and preserved. This fact is peculiarly interesting when taken in connexion with the discovery by Mr. Brodie of mammalian remains in some of the members of the Purbeck formation, also at Durdlestone Bay. These remains were at first supposed to be reptilian, differing only in species from those of lizards of a somewhat similar size with which they were associated. We are indebted to Prof. Owen, to whom they were submitted, for the important discovery, after a careful removal of the matrix which concealed their most characteristic features, that they belonged to the Mammalian class.

Guided by that accurate knowledge of osteology and comparative anatomy which he ever brings to bear on subjects of this kind, Prof. Owen was not slow to discover, on proceeding to examine the characters and forms of the teeth, that these interesting remains not only belonged to the Mammalian class, but that they exhibited the general condition of the molar teeth of small insectivorous mammalia. Let me call your attention to the important conclusions which he draws from the occurrence of this insectivorous mammal, to which he has given the name of *Spalacotherium tricuspidens*, in the very same formation in which such abundant remains of insect life had been already found by Mr. Brodie and Mr. Willcox. "The chief interest," says Prof. Owen, "in the discovery of the Spalacotherium is derived from its demonstration of the existence of Mammalia about midway between the older oolitic and the older tertiary periods," thus helping to fill up that enormous hiatus between these two periods in which mammalian remains had hitherto been found. He then alludes to the interesting fact of these insectivorous animals being found in such close neighbourhood to the insects themselves on which they fed. He adds, "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 cooperated 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." We may here trace another beautiful instance of the adaptation of organic life to the conditions and circumstances in which it is to be placed. These adaptations are of two kinds: the one which shows us how those forms of life which have existed during long periods of time, cease when the conditions necessary for their existence undergo such a change as to render them no longer suited to the life they have hitherto maintained,—a phænomenon which is constantly brought under the notice of the attentive geological observer. The second form of adaptation is that which points to the commencement or creation of new forms, when new conditions have been brought about agreeing with the requirements of their respective existences. No doubt these latter are also of frequent occurrence, but they more easily escape observation. It is seldom that the palæontologist or the zoologist has such an opportunity of seeing cause and effect brought into such immediate juxtaposition as in this case, where we find the insectivorous mammal there making his appearance where insect life was swarming, and when we may conclude that the laws which regulated the existence of animal life required the introduction of a fresh force to keep down the too rapid increase or development of another, and to counteract its tendency to exceed the functions for which it was intended.

Our indefatigable colleague, Sir Philip Egerton, has contributed even more than his usual quota of palichthyological information; he has in several papers described new species from various parts of the world. Amongst these, his account of the fish remains from the nummulitic limestone of the Mokattam Hills, near Cairo, is particularly deserving of attention, as pointing out the union of the typical characters of several families in one species, so as to render it doubtful to which it should be referred. The fish in question had, as Sir Philip Egerton observes, 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 in the opercular apparatus and osteology of the cranium, it more nearly approaches the Percoids. The dentition differs from both, and resembles that of some of the Sparoids.

To the continued exertions of Mr. Prestwich we are indebted for several papers containing much valuable detail respecting the Tertiaries of the London and Hampshire basins. The first paper, on the thickness of the London Clay, is full of information obtained from the most authentic sources; and the manner in which Mr. Prestwich has tested and checked the information he received, is deserving of the highest praise. The position and distribution of the organic remains throughout the whole series are carefully given, and the different zones in which they occur are well worked out. The value of this portion of the paper has been materially enhanced by the publication for the first time of the separate lists of fossils contained in these different zones. The principal zones referred to by Mr. Prestwich are,—1. Isle of Sheppey. 2. Highgate. 3. Primrose Hill, Copenhagen Fields, Whetstone, Islington, Haverstock Hill, Hornsey, Holloway, and Hampstead. 4. Bognor. It must be borne in mind, however, that Mr. Prestwich restricts the term "London Clay" to one of the lower deposits of London and of Hampshire, excluding therefrom the Bracklesham and Barton beds.

The next paper by Mr. Prestwich is on the distinctive physical and palæontological features of the London Clay and Bracklesham Sands, and on the independence of these two groups of strata. The object of this paper is to confirm, chiefly on the evidence of the organic remains, the opinion already pronounced by the author in a former communication, that these two formations are not synchronous; and to endeavour to disprove the opinions of other geologists, especially those on the continent, who have considered that the differences in the characters of the fauna of these several beds were dependent on geographical distribution, depth of water, or variations of sediment. The author points out the confusion which has arisen in the comparison of the London and Paris basins, in consequence of this distinction not having been sufficiently attended to, and the characteristic fossils of the London Clay proper and the Bracklesham Sands having been grouped together as belonging to one formation. After describing the different lithological characters of the two groups, Mr. Prestwich enumerates the number of species of the different classes of organic remains occurring in the two formations, and points out how few species are common to both. Thus—

	London Clay.	Bracklesham.	Common.
Mammalia	2	1	0
Birds	4	1	0
Reptiles	21	7	2

	London Clay.	Bracklesham.	Common.
Fish	83	28	10
Mollusca	224	372	56
Articulata	27	13	4
Echinodermata	17	1	0
Zoophyta	10	16	0
Foraminifera	23	9	0
Plantæ	106	3	2
Total	515	450	72

In a second portion of this paper the author draws attention to a very remarkable and significant circumstance; viz. the amount of agreement between the lower London Tertiaries and the upper beds of the underlying Chalk. He particularly instances the Thanet Sands and the lower Landenian system of Dumont in Belgium, the faunæ of which have a general *facies* so closely resembling that of analogous groups in some of the cretaceous strata, that they, and particularly the Belgian beds, have by some been considered as cretaceous rather than tertiary. Other cretaceous fossils are shown to range upwards into still younger formations of the London basin.

I shall not pretend to go through the arguments brought forward by Mr. Prestwich; the paper is one which deserves the particular attention of every palæontologist. I will only make one observation on the concluding statement, "that the London clay presents in many of its generic forms a closer approach to those now existing in our climate than the Brackleshan sands." This remark appears to me to offer additional difficulties to our endeavours to define with anything like accuracy, on palæontological grounds alone, the respective limits of the different tertiary epochs. If we find, in consequence of the physical and geographical features of the seas in which these tertiary organisms were deposited, that the fossils of the older formations resemble living forms more closely than those deposited during the intervening period, how can we attempt, on fossil evidence alone, where superposition does not come to our assistance, to determine the relative ages of formations situated at a distance from and independently of each other? Physical changes influencing the conditions of life must have occasioned numerous oscillations of the earth's surface; and if this observation is confirmed, we must conclude that they have so modified the character of the ancient seas as to have brought back forms of an older date, hitherto supposed to have died out. We have thus imposed upon us a task of more than ordinary difficulty, and one requiring no ordinary caution before we can hope satisfactorily to unravel the order of creation, or to define the relative periods in which many of the European tertiary formations were deposited.

In a subsequent paper, of which as yet a short abstract only has been published, Mr. Prestwich has communicated to us his views on the correlation of the lower tertiaries of England with those of France and Belgium. The author is known to have had so many opportunities of examining these different formations, that his opinions are entitled to the greatest consideration; they are put forward with a clearness which ensures attention, and with a simplicity which disarms all criticism. For my part, at least, I must disclaim all idea of such a proceeding. I will merely state the principal conclusions at which he has arrived. Beginning with the lowest tertiaries, he correlates the Thanet Sands of the south-east of England with the Lower Landenian, and the Woolwich and Reading series with the Upper Landenian of M. Dumont in Belgium. The former of these is wanting in the Paris basin, and of the latter the middle division only, the *Argile plastique*, is represented at Paris lying immediately on the Chalk. The London Clay corresponds with the Lower Ypresian of M. Dumont, and occurs near Dieppe, but dies out southward towards Lille. This is succeeded by the Bagshot series, the lower portion of which is represented by the sands below the Bracklesham beds in Hants, by the lower Bagshots of the London district, by the upper Ypresian and Panisilian combined in Belgium, and by the *Lits coquilliers* 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, which itself rests on the *Argile plastique*.

Mr. Prestwich does not appear as yet to have carried his comparisons any further. I trust he will not omit to complete a work which he has so well begun, although in some respects, I fear, he will find a difficult task before him in proportion as he approaches those beds which are supposed to mark the limits between the Eocene and Miocene periods.

I am bound, however, to state, that, although Mr. Prestwich does not recognise the existence of the lower division of the Woolwich beds in the Paris basin, I am informed by M. Deshayes that in the course of last summer he found at Rilly, near Epernay, a bed of brackish water and other shells, underlying the great marine deposits, exactly corresponding with our author's Woolwich beds. M. Deshayes has not yet published the results of his last year's excursions, but I hope we shall soon have from him the evidence on which this identification has been founded.

I regret that in consequence of some delay in the preparation of the plates, the volume of the Palæontographical Society for 1854 should not have yet made its appearance. It would be premature to allude to the works which it will contain; but there can be no doubt that when it shall be in the hands of the members it will be found fully to maintain the high reputation acquired by its predecessors, and will be a valuable assistance to the students of British geology. I will only mention that it is to contain the first part of the Mollusca of the London Clay, the publication of which has been undertaken by Mr. F. Edwards. This has been long expected by the subscribers, as it must be in the recollection of many who first came forward as promoters of this publication, and as I know it was the prevailing idea in the minds of some who first suggested it, that this was one of the great desiderata which led to the formation of the Society.

It is a subject of hearty congratulation to all students of Palæontology that the second edition of Mr. Morris's Catalogue of British Fossils, on which he has been so long and laboriously employed, and respecting which my predecessor in this chair so fully expatiated last year, has been at length published. Its contents fully justify those remarks. Independently of the vastly increased number of species recorded in this volume as compared with the first edition, the addition of synonyms which the author has given in a great majority of instances has infinitely increased its value; and yet even in this respect much still remains to be done, which I trust the author will not forget when he shall be called on for another edition.

Foreign Geology.

Since the publication of his great work 'Siluria,' Sir R. Murchison has again visited some of the Palæozoic formations in the north of Germany, of which he proposes to give a full account to the Society, in continuation, as it were, of his fourteenth chapter, in which he has discussed the Primæval Succession of Rocks in Germany. A short account of his recent observations, made in company with Mr. Morris, was laid before the Geological Section of the British Association during the last meeting at Liverpool, from which I make the following extracts. After alluding to M. Barrande's great work on the Silurian System of Bohemia, so ably described by my predecessor in this chair last year, the author stated that in the Southern Thüringer Wald, and in parts of Saxony further east, the great unfossiliferous base (chloritic and quartzose grauwacke slate) is succeeded in ascending order by Lower Silurian beds, described as such by Naumann, Geinitz, Richter, Engelhardt, and other local geologists, because it is charged with *Nereites*, *Graptolites*, *Ogygia*, and other Silurian fossils, which occur in black slates, with some limestone and shale. Mr. Salter, having examined the fossils, stated that one of the remarkable Annelides was identical with a species which Professor Harkness had discovered in the Lammermuir Hills, and that even the *Protovirgularia* of the same tract of Scotland occurs also in Thüringia. As several of the species of Graptolites of the two countries are identical, there can be little doubt that the Lower Silurian of Saxony is the equivalent of the graptolitic series of Dumfries and Kirkcudbright. Here the ascending series in the Thüringer Wald ceases, there being no traces of Upper Silurian or even of Lower Devonian. The Lower Silurian rocks are there at once covered by the Upper Devonian, viz. the Cypridina-schist and the Clymenia-limestone; and these are surmounted by a considerable expansion of the Lower Carboniferous strata, viz. micaceous brown and yellowish sandstones, with plants well known in the deposits of that age.

The sedimentary rocks of the Hartz, the chief object of their visit this year, and which Professor Sedgwick and one of the authors had examined together on two previous occasions in 1828 and 1839, are so dislocated and are so often inverted in position, that their physical order can but seldom be detected amid the confusion which has been produced by the eruption of granites, porphyries, diorites, hypersthenic and other igneous rocks, as well as by the metamorphism which large masses have undergone. Sir R. Murchison, however, expressed his belief that all the members of the Devonian group of the Rhenish Grauwacké of the Germans, from the Spirifer Sandstone and Slate upwards, through the Stringocephalus and Eifel Limestone, to the Upper or Clymenia Limestone, are there present; and that they are succeeded by schists often in the siliceous state of Kiesel Schiefer, and by others containing the well-known *Posidonomya Becheri* of Herborn; whilst rocks of this Lower Carboniferous age occasionally contain a dark limestone, with characteristic fossils of the Mountain Limestone. M. Adolphe Roemer, who has partly worked out this comparison, is still engaged on that work, and in completing a geological map of the district.

The chief object of Sir R. Murchison's last visit to the Hartz was to determine whether certain rocks in its eastern extremity, which have been laid down and mapped as Silurian by M. A. Roemer, were really of that age or not; an interesting question, inasmuch as it was precisely in this portion of the district that Professor Sedgwick and the author anticipated fifteen years ago that the oldest rocks of the chain would be found. It appears that in one small boss of limestone, not exceeding ten feet in thickness, and subordinate to the slates on the north-east flank of the mountain, M. Jasche of Elsinberg has discovered many fossils of the genera *Orthis, Terebratula, Leptæna, Spirifer, Pentamerus, Trilobites*, &c., some of which are undoubtedly British Upper Silurian species, while others are identified with Bohemian fossils described by Barrande as belonging to his uppermost stages. Looking to the mineral aspect of these schists and limestones, which differ from all others in the Hartz, and judging from the fossils, the greater number of which are of types apparently more ancient than those of any known Devonian rock, Sir R. Murchison suggests that the grauwacké round Harz-gerode may be referred to the uppermost Silurian rock of the Continent, and be placed on the same parallel as one of the highest stages of M. Barrande.

In the Rhenish country Sir R. Murchison and Prof. Morris found that the Wissenbach and Caub Slates had been perfectly identified by Dr. Sandberger and his brother by means of a community of fossils, and that *Clymenia* had been detected in the Cypridina Slates of Nassau, thus identifying these rocks with the Krammenzel-stein of Westphalia. But the most striking new discovery in this region was one which Sir R. Murchison regretted he was unacquainted with when he published his 'Siluria,' viz. that the quartz rocks of the Taunus, about whose true place in the series there has been so much discussion, prove to be the youngest of all the older rocks on the right bank of the Rhine. In their trend to the E.N.E. they part with this highly metamorphosed character, and, being regularly bedded and interstratified with shale, have been there shown by M. Ludwig of Nauheim to overlie the series of Devonian rocks, consisting in ascending order of slates, Spirifer sandstones, Wissenbach slates, Eifel limestones, &c. In these overlying quartzites large plants like Calamites have been discovered, and as they lie transgressively on the Devonian rocks, they are probably of the Lower Carboniferous age.

The author then proceeded to give an account of the Permian rock round the Hartz and the Thüringer Wald, specially pointing out the enormous thickness of their base or bottom rock, the rothe todte Liegende or Lower red sandstone of England. No coal of any consequence is found in this deposit, although thin seams have been found in Saxony, which have afforded the remarkable Permian flora described as such by Gutbier and Geinitz. On the other hand, these rocks have been pierced at Rotheburg, near Eisleben, to a depth of 1200 feet, and at Eisenach to a still greater depth, without reaching the carboniferous rocks or finding any trace of coal. The uppermost beds of this rothe todte Liegende are well exposed in natural sections on the N.E. flank of the Thüringer Wald, where they are overlaid by bituminous schists, and by the Kupfer Schiefer with its fossil fishes.

Alluding then to the Zechstein or Magnesian Limestone, the author explained why, in proposing the word Permian, from the spread of these rocks over the Russian province of Perm, he had also included in this group a certain portion of schistose and partly calcareous red rocks which everywhere overlie the Zechstein, and often constitute ridges separated from the Bunter Sandstein, properly so called, or the base of the Trias. Thus he considered the Permian (which in Russia has copper-bearing sandstones, with plants and conglomerates far above the Zechstein) to be an under-Trias, having the Zechstein limestone intercalated in a great red formation.

After commenting on the spread of the Triassic formation through Europe, the author specially called attention to the recent discovery, by M. de Verneuil, of true Muschelkalk in several parts of Spain, containing numerous fossils.

This communication concluded with a general *résumé*, in which the author directed attention to a map showing, that, whilst the rocks of the Silurian basin of Bohemia, the Silurian and Devonian troughs of Saxony, and the great Palæozoic region of the Rhenish provinces (composed of Devonian and Lower Carboniferous rocks) have a main strike from N.E. to S.W., coincident with the major axes of their geographical range, the sedimentary deposits of the same age in the Hartz, the North Thüringer Wald, and the Riesen Gebirge have been thrown by great subterranean forces into transverse geographical chains, accompanied by the eruption of granites, porphyries, greenstones, &c., which have not only wrenched the original strata into abnormal directions, but have also metamorphosed them in a remarkable manner.

Nor can I omit, whilst alluding to these remarks by our own countryman on the structure of the palæozoic rocks of Northern Germany, to notice an interesting memoir on the geology of the Thüringer Wald by Prof. Credner of Gotha, whose geological map of the Thüringer Wald was so highly spoken of by Sir R. Murchison at the meeting at Liverpool. The memoir to which I allude will be found in the Transactions of the Royal Academy of Sciences of Erfurt, published on the centenary anniversary of its foundation, 19th July,

1854. It is entitled "An attempt at an historical account of the geognostic conditions of the Thüringer Wald." It describes in a clear and easy manner the different formations which occur in that district, and the many disturbances which have been effected in the stratified beds by the protrusion of igneous rocks. The author divides this history into three periods, the first two of which are the most important. The first period commences with the oldest deposits, extending to the commencement of the deposition of the Carboniferous rocks; the second extends from the commencement of the Carboniferous period to the commencement of the Trias formation; the third period embraces all the changes which the Thüringer Wald has undergone since the commencement of the Trias formation.

With regard to this latter period, however, the author observes, that the great catastrophes on which depended the chief outline and extent of the Thüringer Wald ceased at the close of the Zechstein formation. At this time the Thüringer Wald stood as an island in the midst of the Secondary Ocean, round the shores of which were gradually deposited the various Triassic beds, and from which the ancient sea was gradually retreating. Other minor changes subsequently took place, which influenced the form of the surrounding hills and the formation of its valleys. I may here also mention, that in the forthcoming geological map of Germany, one of the chief objects to which the attention of the German Geological Society is now directed, and the preparation of particular districts of which has been allotted to those members best acquainted with the respective localities, and who are all working on a given scale and with a fixed system of colouring, M. Credner has undertaken the difficult task of preparing the Geological Map of the Thüringer Wald.

I am happy to state that the valuable work of Drs. Guido and Fridolin Sandberger, to whom, as you have already heard, the Council have this year awarded the balance of the proceeds of the Wollaston Fund, has made considerable progress during the past year. Two additional fasciculi (Nos. 6 & 7) of this work, entitled "Systematic Description and Illustration of the Fossils of the Rhenish (Palæozoic) Formation in Nassau," have appeared since our last meeting, and I understand that one more will complete it. To all students of the Devonian formation on the Continent this publication will be invaluable. Nothing can exceed the beauty and correctness of the illustrations, or the judgment and talent shown by the authors in identifying the several strata by their respective fossils. The literature of the different genera and species is carefully worked out, and great care and acumen have been shown in comparing fossil families with their living analogues. I might particularly instance the remarks on the genus *Scholiostoma*, several species of which show in their last whorl the peculiar turned-up character of *Strophostoma* amongst the tertiary Cyclostomacea and of *Anostoma* amongst living Helices. In the form of the mouth, too, some of these species have a remarkable resemblance with several species of Cyclostoma from the West Indies, and particularly from Jamaica. May not this genus, after all, be that of a terrestrial mollusk, thus indicating the propinquity of dry land, and the existence, during the deposition of the Stringocephalus limestone in which they are found, of a terrestrial flora, on which they must have lived? The authors of the work before us, while still referring the genus to the marine fauna, and placing it near *Scalaria* or *Rissoa*, allude to the remarkable resemblance between *Schol. crassilabrum* and *Tomigerus*, particularly *T. turbinatus* (Pfr.).

At the last meeting of German Naturalists and Physicians at Göttingen, Prof. Ferd. Roemer of Bonn made an interesting communication respecting the comparison between the Devonian formations in Belgium and in the Eifel. After describing the Belgian series as the most perfect and the best worked out, he gave the following ascending series of its principal formations:—1. Unfossiliferous lower quartz rocks. 2. Lower grauwacke beds of the Rhine near Coblenz. 3. Limestone. 4. Clay-slates with *Bryozoa* and *Calceolina* (called also Calceola-schists). 5. Dolomitic limestone resembling that of Paffrath. 6. Marl beds, also called Tentaculite-marl. 7. Clay slates easily decomposing, full of *Goniatites* and *Cardita retrostriata*. 8. Dark marly slates, remarkable for containing *Spirifer disjunctus* = *S. Verneuillii*. In Belgium and at Aachen these beds are everywhere immediately overlaid by the Coal-measures containing *Productus* in great abundance. In Prof. Beyrich's work on the Eifel, he has noticed the existence of only two members of this series, the same as are observed by Murchison and Sedgwick. At a subsequent period, however, a third corresponding bed or horizon had been discovered near Gerolstein, viz. Goniatite-beds near Rüdesheim, where a bed of marl-slate occurs with *Cardiola retrostriata* and *Goniatites*.

Other localities have been since found containing the fauna of the Paffrath Limestone. Since then, Prof. Roemer has found *Spirifer Verneuillii* in the Eifel, and marls associated with dolomitic limestone. The result at which Prof. Roemer has arrived is, that, with the exception of the Tentaculite-marls, all the Belgian subdivisions mentioned above have now been clearly made out in the Eifel.

We are indebted to the same author for an excellent work on the first period of the Palæozoic rocks, published in the third edition of Bronn's 'Lethæa Geognostica.' Whether the title Kohlen-Gebirge (Coal formation) is the most appropriate that could have been chosen, I will not now stop to inquire. The work professes to give a general account of the distribution of the Palæozoic rocks throughout the world, with their various subdivisions, and the general character of the organic remains of their faunæ and floræ. The author adopts the general divisions of Silurian, Devonian, Carboniferous, and Permian, and has inserted some valuable tables showing the parallelism of various formations in different countries.

In communicating to this Society a new geological map of the country about Christiania in Norway, by M. Kjerulf, Sir R. Murchison has given us some additional information respecting the Silurian and Devonian rocks in that district, confirming the views he had already stated in a former communication (see Quarterly Journal of the Geological Society, vol. viii. p. 182), and pointing out how completely the whole sequence of the Upper and Lower Silurians of Great Britain is represented in this thinner development of the Norwegian district. Even the great Russian empire, he observes, does not exhibit so perfect and clear a succession of the Palæozoic formations as this Norwegian trough in the parallel of Christiania.

Since this communication was read, I find that M. Kjerulf's views have been fully published at Christiania by Adolph Strecker in a work entitled 'Das Christiania-Silur-Becken' (the Silurian Basin of Christiania) chemically and geologically examined, by Theodor Kjerulf. The map communicated by Sir R. Murchison belongs to this work, the greater portion of which is occupied with chemical analyses of the different rocks in the district. The results of these inquiries, instead of clashing with the geognostic observations, as some persons might perhaps have feared, have not only confirmed them, but have established the universality of the law respecting the formation of volcanic rocks already laid down by Prof. Bunsen *, who has divided all igneous rocks into two classes, the trachytic and the augitic or pyroxenic.

Amongst the many valuable additions to palæontographical geology, I must mention the memoir of MM. de Koninck and Le Hon, "On the Crinoidea of the Carboniferous Formation of Belgium," originally published in the Collection of Memoirs of the Royal Academy of Belgium. So rapid has been the progress of discovery in this branch of our science, that whereas in 1842 one of the authors of this paper could only procure from these beds fifteen species of Crinoidea, they have now been able, partly by their own exertions and partly by the aid of numerous friends, to bring together fifty-three species. These belong to eleven genera, four of which are entirely new. They are derived partly from the Carboniferous limestone, which forms the basis of the formation in Belgium, and partly from the overlying beds of limestone and its associated clays. The perfect state of preservation in which most of them were found, has enabled the authors to correct and modify the opinions which have hitherto prevailed respecting the organization and habits of these singular animals.

The authors commence their work with a most imposing list in chronological order, commencing with 1558, of authors who have written on the Crinoidea. No less than 346 works are quoted, containing more or less reference to the subject. A mass of literature so overwhelming was probably never before quoted in reference to one single subject. This is then followed by a special historical account of the progress of knowledge on the subject of the Crinoidea in general, in which the authors confess that, notwithstanding all that has been written, the question is still involved in obscurity on many points, the removal of which they leave to those who may have more materials at their disposal.

* "Ueber die Processe der vulkanischen Gesteins-bildungen Islands." Pogg. Ann. vol. 83. p. 1.

This history of the progress of the discovery of the true character of these singular forms,—how, from being first looked at in an inverted position, and being considered as marine plants, they came to be regarded as corals,—and how the illustrious Blumenbach first assigned to them their true position in the scale of organic life,—is one of the most remarkable and most interesting in the range of palæontographical literature. But I must refer you to the memoir itself for the details.

Before describing the different species, the authors enter into general considerations respecting the structure, habits, and movements of these animals, derived partly from a careful examination of the numerous fossil remains, partly by analogy from the investigation of their two living congeners, pointing out the different families and genera, and the special arrangement, forms, and number of the different plates of the cup, by which they are respectively characterized. One of the authors promises in a future work to apply the terminology here adopted to all the Crinoidean genera, and to distribute them into natural families. The eleven genera described in this memoir are,—*Cyathocrinus, Poteriocrinus, Rhodocrinus, Mespilocrinus, Graphiocrinus, Forbesiocrinus, Actinocrinus, Dichocrinus, Platycrinus, Lageniocrinus*, and *Pentremites*.

This is followed by a short descriptive notice by M. De Koninck of a new genus of Crinoidea from the carboniferous beds of England, to which he has given the name of *Woodocrinus macrodactylus*.

Prof. Hans Bruno Geinitz has added to the stock of information on fossil botany for which we are already indebted to him, by the recent publication of his work, entitled "Darstellung der Flora des Hainichen-Ebersdorfer und des Flohaer Kohlenbassins," 4to, with a folio atlas of fourteen plates, as also by a larger work on the fossils of the Carboniferous formation in Saxony, illustrated by thirty-six large engravings of the well-preserved fossil plants of that region. His examination of this palæozoic flora has confirmed the observations already made by Prof. C. F. Naumann on geological evidence alone, that the Coal formation of Hainich-Ebersdorf is older than the Coal basin of Floha-Glückelsberg. The former belongs to what the Germans still persist in calling upper Grauwacké, the equivalent of the Carboniferous or Mountain Limestone. The investigations of Prof. Geinitz have shown that the carboniferous deposits of Zwickau, to which the work in question principally refers, are of the same age as the younger Coal-beds of Floha-Glückelsberg.

The author has endeavoured to exhibit the result of his investigations by the establishment of four distinct zones of vegetable life (Vegetation's Gürteln*), each of which is characterized by a different flora.

1st Zone.—Hainich-Ebersdorf; characterized by a preponderance of *Sagenaria*, particularly *S. Veltheimiana*: he calls it the Sagenaria-coal.

2nd Zone.—Planitz and Zwickau; chiefly characterized by *Sigillaria*,—therefore called the Sigillaria-coal.

* There is something quaint in this use of the word 'gürtel,' from which our synonymous word 'girdle' is derived, to express a 'zone.'

3rd Zone.—Russ-coal beds, peculiarly characterized by an abundance of *Calamites*,—therefore called Calamite-coal.

4th Zone.—Oberholmdorf and Ilmenau, the peculiar feature of which is the great abundance of Ferns,—therefore called Fern-coal.

M. Rössler of Hanau, Director of the Wetterau Society of Natural History, who has for many years directed his attention to the subject, has given a short notice on the organic remains of the Zechstein, or Magnesian Limestone, in the Wetterau, in the last Annual Report of that Society; and Prof. Reuss of Prague has, in the same volume, described the Entomostraca and Foraminifera which occur in the same formation.

On the Position of the Fossiliferous beds of San Casciano.—Much has been done, during the past year, to remove the great uncertainty which has long prevailed as to the precise position to be assigned to the fossils found in the San Casciano beds. This difficulty has arisen partly from the fossils themselves, many of which are peculiar to these beds, and partly from the singular intermixture of forms which has been found amongst them. In consequence of these anomalies, the geologists who visited the district (and amongst them are many of the most distinguished, both of our own countrymen and of foreigners) have come to various conclusions as to their true position in the somewhat complicated series of Alpine stratification. While some wished to place them in one or other of the formations of the Triassic system, others referred them as unhesitatingly to the overlying Lias, and not even to the lowest beds of this system, some even going so far as to refer beds now ascertained to belong to this San Casciano series to the Brown Jura*.

The exertions of Sir R. Murchison went far to disperse the mists which hung over this subject. In his paper "On the Geological Structure of the Alps, Apennines, and Carpathians," read before this Society in 1848, he states that this obscurity has been principally cleared away by the memoir of M. Emmerich, who, working out the details of a district rendered classical twenty-five years before by the researches of Leopold v. Buch, has clearly exposed the order of the strata; thus leaving little or no doubt that the chief and peculiar group of fossils of those Alps (Southern Tyrol) belongs to the Trias.

The researches of other geologists, and particularly of some of the Austrians attached to the Imperial Geological Institute of Vienna, amongst whom I may mention MM. v. Hauer and Süss, have established the existence, in the Salzburg Alps, of fossils identical with those which occur in South Tyrol; thus establishing, as Sir R. Murchison observes in the paper already quoted, the existence of true Muschelkalk types in the northern zone, where they had not before been recognized.

In a memoir on the Triassic, Liassic, and Jurassic formations

* The "Brown Jura" of the Germans is represented in England by the Middle and Lower Oolites,—from the Oxford Clay to the Inferior Oolite, inclusive.—See Fraas on the Jurassic Series, Quart. Journ. Geol. Soc. vol. viii. 2nd Part, Miscell. pp. 42 *et seq.*

in the N.E. Alps, read by M. v. Hauer before the Imperial Geological Institute of Vienna, at the close of 1853, he has gone into great detail on these formations, some portions of which, as referring to this question, I will here briefly allude to. The author commences by dividing the Triassic group of the N.E. Alps into two formations: 1. The Werfen, and 2. the Hallstadt. The first or lowest of them he again divides into—*a.* the Werfen slates or variegated sandstones, and *b.* the Guttenstein limestone, which he considers as probably equivalent to the Muschelkalk. He considers the Hallstadt strata as upper Muschelkalk. I may here remark that the author has excluded from this Triassic group the Dachstein limestone, which he had formerly considered as lower Muschelkalk, and has placed it as the lowest member of the overlying Liassic group. As far as the order of superposition is concerned, this correction appears, from the subsequent investigations of others, to be perfectly correct. But it is not equally certain that he is correct in placing the Dachstein limestone in the Lias. With regard to the Werfen slates, the author states that all recent inquiries have confirmed the correctness of the position originally assigned to them, viz. that they immediately overlie the Grauwacke beds, and underlie the whole of the Alpine limestone. The principal fossils found in them are, *Ammonites Cassianus* (Quenst.), *Turbo recticostatus* (Hauer), *Naticella costata* (Münst.), *Myacites Tasserensis* (Wissm.), very common, *Myophoria*, sp. unc., *Posidonomya Claræ* (v. Buch), *Posidonomya aurita* (Hauer), *Avicula striato-punctata* (Hauer), *Av. Venetiana* (Hauer). The *Ammonites Cassianus* is of rare occurrence, and it may be a question whether it has not been derived from the overlying Dachstein; for it is a remarkable fact, that one of the causes of the apparent intermixture of fossils in some of these Alpine collections, particularly those of S. Casciano, has arisen from the fact of their having been obtained from rivulets which descend through Jurassic as well as Triassic deposits. These Werfen slates are constantly overlaid by dark grey limestones, called by the author Guttenstein limestone or Muschelkalk, and frequently assume the form and character of Rauchwacke limestone. Fossils are almost unknown in them, with the exception of *Ammonites* (or *Ceratites*) *Cassianus* (Quenst.) and *Monotis Salinaria*. The upper portion of this limestone is occasionally dolomitic, and passes into the second or upper subdivision of the Triassic group.

The Hallstadt Limestone or upper Muschelkalk is remarkable for its beautiful and curious Cephalopods. The author here explains that his recent investigations have led to the conviction that his former statements respecting the position of the Dachstein limestone, which he had placed below the Hallstadt limestone, required correction: the sections found by M. Süss and himself in various parts of the Alps showed that the Dachstein Limestone should be placed above that of Hallstadt. With regard to the Cephalopods, which constitute the greater portion of the fossils found in this formation, the author refers to a distinct memoir in which they are described; the new forms discovered since the publication of that work will be published in the 2nd vol. of the Transactions of the Imperial Geological Institute. He observes, however, that five of the most characteristic forms, viz. *Ammonites Aon* (Münst.), *A. Rüppelli* (Klipst.), *A. Gaytani* (Klipst.), *A. Johannis-Austriæ* (Klipst.), and *A. Iarbas* (Münst.), all occur in the S. Casciano strata, which consequently, notwithstanding great lithological differences, may be safely paralleled with the Hallstadt beds.

The author then proceeds to state that the true position of the Hallstadt limestone is now clearly made out to be between the lowest Liassic group (to which he supposes the Dachstein limestone to belong) and the Trias,—and that the fossils contained in it do not afford sufficient evidence to place it with either of these groups, as no species peculiar to it has yet been found beyond the region of the Alps; nevertheless its intimate connexion with the Guttenstein limestone is a fair indication that it should be grouped with the Trias. He considers it, however, to be a still more difficult question to decide whether the dolomites which occur extensively beneath the Dachstein limestone are Triassic or Liassic. Before leaving the Triassic group, the author states that his present object has been to establish the correct parallelism between the formations of the Northern and those of the Southern Alps belonging to the Trias. Without going into detail on the subject, he briefly proceeds to disprove the arguments of M. Klipstein on the one hand, who wishes to place the San Casciano beds in the Middle Jura, and, on the other hand, those of M. Eichwald, who claims for them a much more ancient position, referring the Neptunian formation of Southern Tyrol to the Mountain Limestone. He observes, in reference to this question, that the San Casciano and Hallstadt beds are not to be considered as exact equivalents of the true Muschelkalk, but as a more recent portion of the Triassic group deposited above it.

The author next proceeds to describe the Liassic group, the lowest member of which he considers to be the Dachstein Limestone, so called from its constituting the principal portion of the Dachstein Mountains. With these are associated the Stahrenberg strata. Above these are the Kössen beds, the Gresten beds, and then, constituting the Upper Lias formation, the Adneth and Hierlatz beds. The only one of these formations to which I shall here allude is the Dachstein Limestone. This is described as frequently immediately overlying the Werfen or Guttenstein beds; sometimes it is deposited on dolomite, or united with it above the Hallstadt beds; and sometimes it rests on the Hallstadt beds themselves.

Amongst the fossils found in the Dachstein Limestone, *Megalodon triqueter* of Wulfen, also called *M. scutatus*, is by far the most abundant. It is found throughout the whole bed, and has been called the Dachstein bivalve, and is so peculiar to this bed as to throw some doubt on M. von Hauer's generalization that the Kössen beds which immediately overlie the Dachstein, and contain a large proportion of genuine Liassic fossils, are to be considered as forming with it only one formation, notwithstanding their obvious petrographical differences. This *Megalodon triqueter*, which occurs universally throughout the Dachstein Limestone, has only been found sparingly in one locality out of thirty-seven in which the Kössen fossils are found.

M. Süss has also communicated a paper on the Brachiopods of the Kössen beds, read before the Imperial Geological Institute so far back as the 23rd June, 1853. One of his objects is to show that these beds belong to the inferior Lias, both by palæontological comparison and by geographical extension. He considers them to be the same as the Gervillia beds of Emmerich and Schaffhäutl, and the Upper S. Casciano of Escher and Merian. This author then proceeds to state that the fauna of the Stahrenberg and Dachstein Limestone is identical with that of the Kössen beds, and adds that the whole mass of these beds lies on the Hallstadt beds, containing the fossils of San Casciano, and belonging to the Upper Muschelkalk. After describing other beds connected with these formations, M. Süss concludes by discussing "the reasons given by some geologists for identifying some members of them with the formations of San Casciano. The whole series of Kössen fossils gives us but three species identical with those of San Casciano, viz. *Cardita crenata*, the so-called *Spondylus obliquus* (the identity of which seems doubtful even to M. Emmerich), and *Actæonina alpina*, quoted by Prof. Merian, but without giving its locality. The *Avicula gryphæata* is found in the Lias of England, as well as in the San Casciano beds; and according to Mr. Peters, one of our species may probably prove identical with *A. contorta* (Portl.).

"The stratigraphical relations, at least as far as they exist in the Vorarlberg, do not appear to warrant a separation of the Kössen strata from the Lias. What has been already stated is enough to show that M. Escher's No. 13. Limestone with *Megalodon triqueter* (the equivalent of the Dachstein Limestone), and his No. 14. San Casciano formation (identical with our Kössen strata), cannot conveniently be considered as members of different formations. Since the investigations respecting the Cephalopods of the Salzkammergut have been made, there can no longer be any doubt that the Hallstadt beds are the equivalent of the S. Casciano formation, nor is there any reason for considering the former as only representing a portion of the S. Casciano group."

A further step towards clearing up the difficulties which prevented the satisfactory explanation of the position of the S. Casciano beds has been made by Prof. Merian of Bâle, who has lately visited some of the localities of the Vorarlberg Alps, and has communicated the results of his inquiries, first, in a letter addressed to Sir R. Murchison, and, secondly, in a paper read before the Geological Section of the Meeting of German Naturalists held last year at Göttingen. In the former communication Prof. Merian states that, having visited the Vorarlberg with his friend M. Escher, they found immediately under the Lias beds which are well developed, the Dachstein Limestone, characterized by numerous corals and the *Megalodon scutatus* of Schäffhautl. Below this Dachstein Limestone they found the Gervillia beds, lately called Kössen beds by M. v. Hauer. These they at once referred to the S. Casciano formation, in consequence of their containing *Cardita crenata* (Goldf.), *Aviculæ* of the family of the Gryphæatæ, and small turreted shells. Below these are thick masses of dolomite, which are again underlaid by sandstones with impressions of Keuper plants. The Gervillia-beds also occur in the vicinity of the Lake of Como, forming a good geological horizon below the Lias. The author states that they have given the name of San Casciano formation to the whole series of beds situated between the Keuper and the Lias. It is a marine formation which appears to be wanting in the North of Europe, and is only developed in the Alpine chain and in Eastern Europe. In a palæontological point of view it is distinguished from the overlying Lias by the absence of Belemnites, and from the Trias on which it reposes by the occurrence of Ammonites *à cloisons persillées*.

After alluding to the previous erroneous opinions entertained by various geologists respecting the position of the Dachstein Limestone and the Gervillia beds, Prof. Merian observes that the Austrian geologists are now of the same opinion as himself and his friend respecting the order of superposition of these beds. The only difference is that the former wish to refer these two groups to the lower Lias, whilst he and M. Escher refer the beds with *Ammonites globosus* and the beds of S. Casciano to a separate formation, which they call Upper Muschelkalk. In the communication read at Göttingen the Professor repeated these arguments, adding that the S. Casciano beds below the Dolomite alternate in some spots with some of the Keuper beds, and particularly with the Letten coal beds; and that he considers that the whole formation, which is essentially marine, should be looked on as a marine Keuper in the East and South of Europe, corresponding with or equivalent to the land or terrestrial Keuper of the West,—that they are in fact the marine representatives of the Keuper*.

It is perhaps one of the most interesting features in the consideration of this question, and one which has added greatly to the difficulty of unravelling the true relations of this part of Alpine geology, that we here find a regular unbroken sequence of beds lying conformably one over the other, from the lowest member of the Triassic group into the Liassic and the Jurassic formations. Not only do the different beds of sandstone, shales, limestones, and dolomites pass into and sometimes even alternate with each other, thereby producing what may be almost called an inosculation of the strata, but we also find a gradual passage of organic forms from one formation to another. If each new successive stratum as we ascend presents us with new groups and new associations of organic life, we still find them accompanied by some of the forms which characterized the beds below. Thus, while on geognostical and mineralogical grounds we are prevented from drawing very exact lines of demarcation between one formation and another, we are equally debarred, on palæontological grounds also, from defining with absolute accuracy or correctness the respective limits of the different groups. The Keu-

* For further details see also a Memoir by M. A. Escher von der Linth on the Geology of the Vorarlberg, published in the thirteenth volume of the Mémoires de la Société Helvétique des Sciences Naturelles, 1853.

per sandstones alternate with the lower San Casciano beds, according to Prof. Merian. Ammonites occur in the Hallstadt limestone, sometimes called Upper Muschelkalk, and considered the equivalent of the San Casciano beds, thereby connecting these truly Triassic beds with those Liassic beds above the Dachstein, in which numerous species of Ammonites abound. In the intermediate dolomites no fossils have yet been found. Nor have Ammonites yet been discovered in the Dachstein limestone, yet they abound in the overlying Kössen strata, which are considered to be the equivalents of the lower Lias by M. Süss, and to be upper San Casciano by Prof. Merian and his friend M. Escher. Thus, wherever we find the strata conformable, we have a confirmation of the well-known saying, "Natura non facit saltum." In fact, all natural changes are gradual under these circumstances. The conditions of life gradually change, and the organic forms are modified to meet these changes; certain species disappear, while others, adapted to the altered circumstances, are called into existence, and continue to flourish side by side with some of the preexisting forms; thus confirming the view already stated, that where the strata are conformable, no line can be drawn between successive formations,—the gradual change is not marked by sudden breaks in the series of animal life. In fact, we must not forget that our nomenclatures are for the most part only relative. Nature ever acts on one long unbroken plan, and knows as little of sharp limits between Trias, Lias and Jurassic, as between the families and genera of existing organic life. These terms are at best but temporary shifts to assist our memories, and to enable us to register our facts and our knowledge; and we must be careful not to give too much importance to nomenclatures which deserve at the best but a secondary consideration. I may have occasion to allude to this question again when referring to the progress of tertiary geology. I will only here observe, that I think M. Merian has exercised a wise judgment in making the San Casciano beds for the present a separate group, intermediate between the Trias and the Lias.

I cannot conclude these remarks without alluding to what I am sure every British geologist will consider an oversight on the part of the two Austrian geologists I have mentioned, in having omitted all allusion to the exertions on two separate occasions of Sir R. Murchison, and to the credit he deserves for having been the first to point out the true relations of these great Alpine formations. In the Geological Map of the Eastern Alps, the first ever constructed, and published in the third volume of our Transactions (2 Ser.), Sir R. Murchison and Prof. Sedgwick clearly laid down on the northern flank of the Alps a distinct series of rocks between the older slaty rocks (Verrucano) and the Liassic and Oolitic groups. To these they gave the name of Keuper, Muschelkalk, Bunter Sandstein, and Rauchwacké. This zone is also laid down on their map on the south flank of the Alps, passing through San Casciano, thereby showing that at that early period they had recognized the identity of the beds on the north flank with those of San Casciano and its vicinity, although San Casciano itself was not then alluded to. Again, in his paper "on the Geological Structure of the Alps, Apennines, and Carpathians," Sir R. Murchison fully explained the triassic character of the San Casciano beds,—an explanation which is now confirmed by the more recent discoveries of Merian and others on the northern flanks.

To M. E. Rénévier of Lausanne we are indebted for a geological memoir on the Perte du Rhone and its vicinity. The author was induced to undertake this work by the reflection, that, however often this curious phænomenon had been visited and quoted by geologists, no special description of it had yet been given, nor any geological map of it published on a scale sufficiently large to understand the details. After referring to De Saussure for an account of the scene, the author describes the different formations which are visible at this locality resting regularly and conformably on each other in an almost horizontal position. These formations are, Diluvium, Molasse, Upper Chalk, Gault, and the Aptian and Trigonian formations below the Gault, the two latter belonging to the Neocomian system. The lowest bed, in which is cut the narrow passage where the Rhone is almost lost to sight in dry weather, is the Caprotina limestone. The vertical and horizontal distances are given in the sections in their natural proportions.

Two memoirs by M. Bosquet of Maestricht, published in the second volume of the "Memoirs of the Committee for the Geological Map and Description of the Netherlands," are deserving of notice in connexion with secondary geology. The first is an account of some new Brachiopods from the Maestricht beds. The fossils described are, two new *Craniæ, C. comosa* and *C. Bredai*; the former is extremely rare, and only the lower valve has been as yet discovered; *Argiope Davidsoni, Rhyncora plicata* and *R. Konincki*. The second memoir is of far greater extent, and is entitled "The Fossil Crustacea of the Cretaceous Formation of Limburg." With the exception of a few species of Cirripedes and some few Decapods, the work is devoted to a description of the numerous Entomostraca abounding in this formation. Some of these, like *Bairdia subdeltoidea*, are so universally distributed throughout formations of different ages, that their geological value as a means of distinguishing strata is subservient to their importance in a natural-history point of view; several of the other cretaceous forms also are still found living in the Mediterranean and other seas. With regard to the genus *Cythere*, the most abundant of all, M. Bosquet in this work describes thirty-four new species from the cretaceous formation of Limburg, in addition to thirteen already described by him in 1847 from the Maestricht beds. He adds that he is also acquainted with about 114 species in the different beds of the tertiary formation. The species described are all beautifully figured, and some of the forms represented are of a curious and unusual character. Many are identical with those already figured and described by Mr. R. Jones in his "Monograph on the Entomostraca of the Cretaceous Formation of England," published in 1849 by the Palæontographical Society.

Prof. Bornemann, in his "Account of the Lias Formation in the neighbourhood of Göttingen and its organic contents," has also published some plates of the Foraminifera found in that formation. I am indebted to Mr. R. Jones for the observation, that, although the general *facies* of these German Lias forms as compared with the Foraminifera of the English Lias is very similar, the specific identities are but few. Out of fifty species from the Ilminster series, he can only find seven which can with certainty be considered as identical with any of the thirty-three species from the Göttingen Lias.

An interesting memoir by Prof. Reuss appears in the seventh volume of the 'Denkschriften der Kaiserlichen Akademie der Wissenschaften' of Vienna, "On the characteristic features of the Cretaceous Formations in the Eastern Alps, particularly in the Valley of Gosau and on the Wolfgang Lake." In the first place the author shows that the whole of the Gosau beds belong to the Upper Cretaceous period;—they belong neither to the Lower Greensand, where they have been placed by some writers, nor to the Flysch or Eocene, to which others have been disposed to refer them. He points out a remarkable connexion between the beds of conglomerate and the Hippurite limestone: wherever these latter occur in abundance, and as it were in their natural position, the conglomerates form the bottom bed, and the Hippurite banks appear to have settled themselves on the solid conglomerate and gravel beds. These Hippurite and Coral limestones form such an important member of the Gosau formation, that the author goes into great detail respecting them, pointing out the errors respecting their relative positions committed by former geologists. The Hippurite limestone alternates with the more marly beds at various levels throughout the whole formation; but the beds with *Actæonella* and *Nerinæa* also occur throughout the same portion of the deposit, sometimes lying below, sometimes alternating with the Hippurite limestone. Another remarkable feature of the Gosau beds is the almost entire want of coal, whereas it occurs abundantly in other parts of the Cretaceous deposit.

In concluding these general remarks, the author observes that the Gosau beds, which belong without exception to the Cretaceous formation, represent one connected inseparable whole, and form a system of marly-conglomerate, limestone, and sandstone beds, irregularly alternating with each other, and which it is impossible to subdivide into separate independent formations. The study of the fossil remains contained in it shows that such a separation cannot be justified on palæontological any more than on geognostic grounds. This, however, only refers to the lower fossiliferous beds; the upper portion contains no organic remains, but the petrographical characters oppose the possibility of their being referred to a different system.

The next question raised by the author is with which of the various cretaceous beds of other countries the Gosau beds should be compared. An accurate knowledge of the fossils is necessary to answer this question. The author is of opinion that it is more correct to refer them to the Chalk above the Gault,—the upper chalk, but in comparing the Gosau fossils with those of other districts, the author only takes such as are common to other Chalk formations. The whole number of Gosau fossils is 443, amongst which are 34 Foraminifera, 140 Anthozoa, 14 Bryozoa, and 15 Entomostraca. The Gasteropods have 135, and the Conchifera 80 species. The remaining number is made up of Radiaria, Brachiopods, Cephalopods, Annelides, and Rudista.

After showing that the Gosau beds have the greatest affinity with D'Orbigny's *Système Turonien*, the author describes the geological features of the beds near the Wolfgang Lake, which, although their organic contents are not so abundant as in the Gosau Valley, evidently belong to the same system. In the second part of his memoir, viz. palæontological observations on the Gosau beds, the author principally directs his attention to the Foraminifera, Anthozoa, Bryozoa, and Entomostraca, with the study of some of which he had been occupied for many years. These are fully described, and the figures by which they are illustrated, particularly the Corals, are admirably executed.

But time would not permit me to give, nor would you have patience to listen to, the long list of recent papers and publications on different branches of geological investigation to be found in the various scientific periodicals of Germany. The Journal of the Imperial Geological Institute of Vienna, the Journal of the German Geological Society, as well as the Jahrbuch of Leonhard and Bronn, and the Palæontographica of Dünker and Herman v. Meyer, are full of new and valuable information. I must, however, specially allude to the last two numbers of the last-mentioned work, which have appeared during the last year. The memoir by Dr. Jordan and Herman v. Meyer on the Crustacea of the Coal Formation of Saarbrück, and particularly the account of the fossil insects of the same formation by Dr. Goldenberg, are most interesting; the latter especially, as it is only very recently that organic remains of this class have been found in these beds, the oldest in which they have hitherto been met with.

Tertiary Geology.

M. Hébert, so well known for his numerous and valuable communications on the tertiary formations of the continent, has, in conjunction with M. E. Rénévier of Lausanne, published in the Bulletin of the Statistical Society of the Department of the Isère, an interesting "Memoir on the Fossils of the Upper Nummulitic Formation in the neighbourhood of Gap, the Diablerets, and other localities in Savoy." The fossils with which the Nummulites are associated in these localities, which M. Rénévier has himself explored, are such as are generally considered to belong to a more recent period than that to which the Nummulites have been hitherto referred. The beds in general show a remarkable identity and analogy as to their fauna with that of Ronca, already described by M. Brongniart in his "Memoir on the Vicentin;" on the other hand, it shows great discrepances with the nummulitic beds of Nice, Corbières, and Biaritz.

The authors do not consider the subject as yet sufficiently exhausted to explain the many difficulties with which it is associated, but they observe that these nummulitic beds contain a certain number of species more recent than those of other localities which are generally considered as the type of the Nummulitic formation, and that these more recent species are the most abundant. This has led them to consider these beds as the upper portion of the Nummulitic formation, and to call them the Upper Nummulitic formation; and they think that it will turn out eventually that the nummulitic beds here described are more recent than any hitherto known.

"Perhaps," they say in conclusion, "it may be supposed that some data are given in this memoir to determine the age of these upper nummulitic beds, and that they should be placed between the sands of Beauchamp and those of Fontainebleau. We consider such a conclusion would be too hasty, and that our work, however conscientiously carried out, is not of sufficient importance to lead to such a conclusion." The object of the authors was to call attention to new facts, desirous only to be of use in solving the difficulties which they had pointed out.

In the second volume of the "Memoirs of the Commission for the Geological Map and Description of the Netherlands," is published a list of the fossils found in the tertiary deposits of Guelderland. They have been principally found in variegated marls along the frontiers of Guelderland and Oberyssel, between Münsterland and Bentheim. The bottom of these marls has not been reached, but they are supposed to rest on the chalk which crops out near Bentheim and Münsterland. They have been penetrated by borings to a depth of seventy yards, and are overlaid by a thick deposit of diluvium, consisting of sand and gravel containing fragments of granite and other plutonic rocks, together with others belonging to the primary and secondary periods.

After giving the list of fossils from these clays, in some of which septaria, gypsum, and iron pyrites are found, the Commissioners conclude with the following remarks:—"From the geographical position, the mineral composition, and particularly from the fossils, we must conclude that the tertiary formations of Guelderland belong to the Miocene division of North Germany, according to the nomenclature of Beyrich. When the work of Prof. Beyrich shall be more advanced, we shall see with which of the North German localities the Netherland beds have the greatest connexion; but it will probably be with those of the marls of Bersenbrück, north of Osnabrück. A great number of the fossils are identical with those of Dumont's Tongrian and Rupelian systems of Belgium (Upper Eocene of Lyell, =Miocene of Beyrich, Hébert, and others); but it is remarkable that about a twentieth of them are the same as those of the Scaldisian system of Dumont (the Antwerp crag of Lyell), and these belong to the *Pliocene* period, a remark which has also been made by Beyrich respecting the fossils found at Bersenbrück."

It is impossible to overlook the importance of this discovery as affording fresh evidence of the close connexion between the formations of Belgium and North Germany. The occurrence, too, of a certain proportion of Antwerp crag fossils, supposing them, as is here stated, to be really intermixed with the others, would also tend to prove the correctness of the views of those geologists who have been disposed to consider the fossils of North Germany to belong to a system extending upwards into beds of a newer period, rather than to one which should be classed with the Eocene beds below;—nor would this view be invalidated, even should it be found, on closer examination, that these Antwerp crag fossils belong to a more recent formation than the other North German fossils. They all belong evidently to a series of beds the sequence of which is uninterrupted, and would thus equally prove the existence of a gradual passage upwards rather than a connexion with Eocene beds below.

This same volume of memoirs also contains much interesting matter respecting the overlying drift beds and diluvium, some of which are referred to the action of the Rhine, while others are considered as of Scandinavian origin. Here, then, we have a wide field open for inquiry, as the two beds appear to be easily distinguishable.

In reference to the geology of the Netherlands, the 'Bulletin de la Soc. Géol. de France,' vol. xi. p. 21, Nov. 7, 1853, contains an interesting notice, "Sur la Constitution géologique des environs d'Amsterdam, &c., par M. P. Harting." The author gives the particulars of seven artesian wells at Amsterdam, one of which was carried to the depth of 174 metres, or 172 metres beneath the mean sea-level. All these wells gave approximatively the same result. They showed that the surface-bed was composed of a peat $1\frac{1}{2}$ to $5\frac{1}{2}$ metres thick, formed of freshwater plants and fallen trees. Beneath this is a series of marly clays, with subordinate sands. In mineral structure these beds were found to agree with the silt now brought down by the Rhine and Meuse, whilst their organic remains show them to have been deposited in the sea. The mineral debris are examined with great care and skill, as are also the organic remains. Of the latter the author determines nine species of Gasteropods, thirteen species of Lamellibranchiates, several Zoophytes, nine species of Foraminifera, and one Annelid, mostly of recent species. One bed is composed in great part of the siliceous carapaces of Diatomaceæ, of which M. Harting enumerates thirty-three species, whilst dispersed in the other beds are nine additional species. Only a few remains of plants are found—fragments of *Pinus sylvestris, Zostera marina*, &c.

Beneath this argillaceous series is an immense mass of sand, through which none of the borings have penetrated, and consequently its thickness exceeds 117 metres. This deposit shows traces of stratification; but no traces of organic remains, with the exception of a few fragments of plants, have been found in it. It is composed chiefly of fine sands, but contains also pebbles of quartz, sandstone, syenite, limestones, flints, &c., mostly minerals not found in the upper beds.

Another well at Gorinchem reached a depth of 182 metres; here organic remains were found all through. To the depth of 121 metres they are land and freshwater remains, including bones of three species of mammals, one fish, nine land and freshwater shells (which, although so fragile, are preserved entire), and traces of plants. Beneath this the beds contain marine remains, amongst which are ten recent species of shells. With these are associated a considerable number belonging to the Campinian, Tongrian, and Bruxellian Systems of M. Dumont, the Crag of England, and the Calcaire grossier. The author arrives at the conclusion that this great mass of sand and clays, as well as the lower sands of Amsterdam, belong to the Campinian system of Belgium (or our Crag), and that the upper beds belong to the Lehm period of the Rhine. Further examination is necessary before we can conclude that this opinion is correct.

In the island of Urk in the Zuyderzee, M. Harting discovered a low hill of diluvial clay full of fragments and boulders of the older rocks, some two metres in diameter—all rolled. Many of them belong to the rock-masses of Scandinavia, and others to those of England and Scotland. The author contrasts this with the deposits from the south of Amsterdam and Gorinchem, the debris of which he considers solely derived from the hills of the Rhine and the Ardennes. He also touches upon the subject of the gradual subsidence of the land in Holland, and considers the fact of the base of the peat being two to three metres beneath the present mean sea-level, a strong probability in favour of this view. There are indications of this subsidence being at the rate of two inches in the century. At his suggestion a Commission has been appointed to inquire into and determine this question.

M. Hébert has also communicated (Bulletin, p. 419) a notice on the "Plastic Clay" of Paris, and its relations to the beds in the north of the Paris basin. The puddingstones of Nemours, which attain a thickness of thirty or forty feet, he now agrees with M. de Roys (p. 453) in placing at the base of the Tertiary series, and he considers them to result from an extensive denudation of the chalk and *calcaire pisolitique* which took place *after* the deposition of the Rilly beds. The mottled and pure plastic clays which next succeed, form, according to this author, a distinct and separate zone, always underlying the *fausses glaises* and the lignites of the Soissonnais; and in this respect these mottled clays would differ from those in this country, which Mr. Prestwich has shown to be intercalated with the lignites and fossiliferous sands. The upper sands of the Soissonnais are, as it is well known, wanting in the neighbourhood of Paris. He then proceeds to show what were the conditions under which this series of beds were deposited, and remarks that probably large brackish water lagoons extended from Paris to Reading and Brussels, among which were here and there freshwater lakes of greater or less extent. He offers no positive theory to account for the origin of the pure plastic clay, but suggests that it may possibly have been ejected in the same way as the gypsum beds. On this, however, he does not insist.

M. d'Archiac and M. de Roys differ on this subject from M. Hébert.

M. Hébert has also given (p. 647) some further development to his views respecting that curious deposit of Rilly, with its large *Physa* and numerous land and freshwater shells. This travertine with the underlying white sands M. Hébert, in a previous memoir, had placed at the base of all the tertiary beds, considering it a lake deposit of which the greater part had been swept away prior to the deposition of the marine sands of Rheims, which latter underlie in this district the lignite and plastic clay series. In a paper communicated to the Geological Society of France, Mr. Prestwich contested these views, and endeavoured to show that the white sands of Rilly were merely an altered and local condition of the marine sands of Rheims, that the Rilly travertine was consequently newer than these, and that it belonged to the base of the lignite and plastic clay series. As the group of organic remains belonging to these beds is one *per se*, the solution of this question depends upon stratigraphical evidence. M. Hébert now adduces further arguments in support of his opinion, and shows that this travertine has a far wider range than before known, having found it at Dormans, and extending to the confines of the department of the Oise.

M. Ami Boué gives (Bulletin, vol. xi. p. 61) the result of some curious researches on which he has been engaged respecting the depth of former seas and the height of former mountains, and concludes that, taking the mean depth of the present seas to be from 12,000 to 18,000 metres, there is a gradual decrease from that depth to the seas of the older geological periods—the Tertiary seas having averaged 10,000 to 16,000 metres, the Cretaceous 8000 metres, and finally the Permian and older seas 3500 to 9000 metres. At the same time he estimates that the mountain chains of the earth have now attained their greatest elevation, or a mean which he makes exactly equal to the depth of the present seas given above: in the same proportion he fixes the height of the older mountains, making those of the Permian and Silurian period 3500 up to 9000 metres in height. He also estimates the mean elevation of the present general surface of the land (mountains excepted) to be 300 metres, gradually decreasing to 100 and even 60 metres during the Permian and older periods.

My predecessor in this chair alluded in his address at our last anniversary to the "Treatise on the Tertiaries of the Mayence Basin," by Dr. F. Sandberger of Wiesbaden, but delayed entering on the consideration of its contents, as well as of those of the works of other German writers, especially of Beyrich and Dünker, until the paper by myself on the same Mayence tertiaries, and which was then announced, should have been read before the Society. This paper having now been read, as well as another paper on the Tertiaries of Hesse Cassel, I shall endeavour to fill up the hiatus left by our late lamented President by putting together, as well as I can, the information already obtained respecting the Tertiary formations of Germany. Our late President would have done full justice to this interesting subject; I can only attempt to follow his footsteps at a distance.

The formations described by Dr. Sandberger, Prof. Beyrich, and myself belong to the oldest marine tertiaries yet observed in Germany. Dr. Sandberger refers solely to those of the Mayence basin, the district to which the observations in my first paper are chiefly confined. The work of Prof. Beyrich treats of the tertiaries of North Germany, extending from Silesia, the mountains of the Hartz and the Teutoberger Wald, to the shores of the Baltic; my second paper refers mainly to the tertiaries in the neighbourhood of Hesse Cassel. I will endeavour to point out the principal geological features of these three districts, and to explain some of the points on which differences of opinion still exist. I will take Dr. Sandberger's "Memoir of the Mayence Basin" as my text for that formation. The lowest member of the tertiary series in this district is the marine sand of Weinheim, near Alzey. These sands repose on hard red sandstone belonging to the Carboniferous formation of the Donnersberg, and lie in the hollows between several spurs of red sandstone extending in a W.N.W. direction from that mountain. Near the edge of the basin they are unfossiliferous, but at the distance of one or two miles organic remains are found in great abundance. Here the sands become mixed with innumerable fragments of comminuted shells, and bands of hard calcareous rock alternate with the shelly sand. The organic remains are purely marine. The sands are overlaid by blue marls of considerable thickness, which, while preserving to a certain extent their marine character, show, by the great preponderance of *Cerithia* of several species, together with *Cyrena*, the first indications of a brackish-water formation. Traces of brown coal have been found in some portions of this lower blue marl. Above this is a vast accumulation of limestone beds, divided by the German geologists into three groups—1st, Freshwater limestone; 2nd, Cerithium limestone; and 3rd, Littorinella limestone; both of which latter are characterized by the abundance of these respective forms. The lower portion of the Cerithium limestone contains, in particular localities, a great variety of *Helices* of several species, besides other land shells, which have led Dr. Sandberger to give it the name of freshwater limestone. I cannot agree to this denomination; the brackish-water shells still pervade the whole formation, and the land and other freshwater shells have evidently been drifted in by rivers pouring their waters into this probably vast æstuary basin. In the same way the mammalian bones found in these formations have been washed in.

These limestone beds, which abound more and more in freshwater shells as we ascend, are again overlaid by a second blue clay formation, containing in some districts, and particularly in the Wetterau, thick deposits of brown coal, which are extensively worked. These are supposed by Dr. Sandberger to be of the same age as the brown-coal beds of the Wester Wald. The blue marls still contain in places a few brackish-water forms, as *Cyrena Faujasii* and a small *Cerithium*.

In the neighbourhood of Hesse Cassel the most remarkable feature is, that the blue marls and sands containing the remains of a marine fauna overlie the extensive brown-coal deposits there worked.

This marine fauna is supposed by Dr. Philippi and Dr. Sandberger to be newer than that of Weinheim. Again, in the neighbourhood of Magdeburg marine formations occur in two localities:—1st, the Westeregeln sands, which also overlie the brown coal; and 2nd, the Magdeburg beds, which are considered identical with the Septaria clay of Brandenburg and Berlin. Of these the Westeregeln sands are considered the oldest. Septaria also occur in the blue clays in the neighbourhood of Hesse Cassel underlying the bed of shelly sand, evidently belonging to the same system. In my second paper I have stated the reasons why I consider it not improbable that, notwithstanding certain slight differences in the organic contents, these three deposits of Magdeburg, Cassel, and Weinheim belong to one formation, corresponding as nearly as possible with the Middle Limburg beds of Belgium. They appear to mark the commencement of a tertiary marine fauna in the North of Germany, and being thus evidently the commencement of a system, I have been inclined to look upon them as older Miocene rather than younger Eocene. Our late President, in describing the youngest tertiary deposits in the Isle of Wight, mentioned two facts, viz. that they rested conformably on the older Eocene deposits, and must therefore be taken as a part of that formation; and secondly, that some of the beds contained the same organic remains as were found in the Weinheim sands and marls. He consequently concluded that these Weinheim beds must also be Eocene. Now it must be observed that the species on which he founded this opinion are not strictly speaking marine, but brackish-water species, principally *Cyrena subarata* and certain forms of *Cerithia*. I hardly think that such evidence alone justifies this conclusion. The species have a very considerable vertical range, and hence it would perhaps be rash to argue on any contemporaneity from them alone; and, moreover, being brackish-water forms, it is impossible to show any connexion between the æstuarine or brackish-water areas at such a distance. A similarity in the condition of life may have led to the appearance of these forms in different places at different epochs; and it is therefore possible, notwithstanding the identity of species, that the two brackish-water deposits of the Isle of Wight and Weinheim may not be contemporaneous. But even if they were so, we have every day brought before us additional evidence to show that we must not look for those breaks or interruptions in the regular succession of strata, which are considered as marking the transition from one formation to another, everywhere at the same point. While local convulsions were causing an interruption in one district, the regular sequence of deposits was being continued unbroken in another; and thus the Eocene deposits may have continued in the Isle of Wight for some time after those changes in the relative level of land and sea had taken place, which in the North of Germany marked the commencement of the Miocene epoch. We may therefore have here one of those anomalous deposits between two hitherto supposed distinct formations, combining some of the characteristic features of each, and which must be considered as marking the transition from the one to the other.

But besides these Magdeburg and Westeregeln sands, other tertiary deposits occur in the North of Germany which belong to a younger period. They occur along the shores of the Baltic, and through the N.E. portions of Holland, and have been by some identified with the crag of Antwerp. Their exact extent and superposition to the Miocene beds does not appear to have been yet fully made out.

Turning our attention now to the more Eastern and Southern parts of Germany, it may be observed that some of the tertiary deposits of the Vienna basin which have been long known for the abundance of their fossil contents, are probably of an older age than the Antwerp crags. My lamented predecessor in this chair alluded last year to the valuable work by Dr. Hörnes, describing the fossil mollusca of the Vienna basin. This is generally subdivided into three groups, the Lower Tegel, the Upper Tegel, and the Leitha Limestone; and although no marked distinction or break can be pointed out, the lower beds are generally described as Miocene, and the upper as Pliocene. The difficulty of marking any separation has led some German geologists to describe the whole under the new name of "Neogene." The fact, however, appears to be, that we have here the undisturbed passage from the Miocene to the Pliocene formation, thus filling up the gap between the Septaria clay of Brandenburg and the Crag of Antwerp.

Of late years the progress of geological inquiry, and perhaps also the extension of railway cuttings, have pointed out many localities in North and East Germany where tertiary deposits have been discovered containing fossils which bear a remarkable identity with those of Vienna. A short time ago Prince Schönaich Carolath communicated to Professor Beyrich the discovery of numerous tertiary fossils in Upper Silesia, in the neighbourhood of Königshütte and Gleiwitz, near the village of Mikultschütz. Their appearance at once suggested an identity with those of the Vienna basin. Prof. Reuss of Prague has since published in the 'Journal of the Geological Society of Germany*,' an account of a critical examination of the specimens forwarded to him for that purpose. His attention was principally directed to the Foraminifera, the Bryozoa, and Entomostraca, and the result has been to show a remarkable identity with those of the Vienna basin. The spot where they have been found is on the direct road from Breslau to Cracow, and about sixty miles north of the Carpathian chain. After describing the species, Prof. Reuss observes, that out of 139 species sent to him, there are only thirteen which were not already known from the Vienna basin. The Silesian fossils are referred to two principal localities, Miechowitz and Mikultschütz. With regard to the former, Prof. Reuss observes, that "the calcareous marl of Miechowitz cannot well be paralleled with any particular group of the Vienna basin, but may rather be looked upon as representing the whole three groups together. At the same time it must be observed, that the fossil remains rather seem to point

* Vol. iii. p. 149.

to a connexion with the uppermost group, the Leitha limestone;" he adds, that this opinion is solely founded on an examination of the forms of *Foraminifera, Bryozoa,* and *Entomostraca.* With regard to the other formation, that of Mikultschütz, which is not so rich in organic remains, he observes, that, considering the total absence of the *Bryozoa,* so characteristic of the Leitha limestone, the probability is that the clay beds of Mikultschütz are the equivalent of the Vienna Tegel, with a somewhat greater tendency to the upper rather than the lower group.

With regard to the further extension of this formation north of the Carpathian hills, I may observe, that Prof. Kuh has ascertained, by the discovery of fossils, that the gypsum deposits of Upper Silesia, in the neighbourhood of Ratibor and Troppau, also belong to the Tegel of the Vienna basin. Amongst the fossils which occur at Schreibersdorf, between Troppau and Ratibor, Prof. Kuh mentions, besides several species of *Foraminifera, Natica glaucinoides,* Sow., and *Corbula rugosa,* Lam., both abundant in the Vienna basin. Prof. Labecki of Warsaw, in describing the Brown-coal and Salt deposits of Poland, observes, that the Brown-coal beds, which Leopold v. Buch had already identified with the Brown-coal of Upper Silesia, and considered as a Middle Tertiary formation, extend into the kingdom of Poland, thus showing a connexion between the Miocene deposits along the foot of the Sudetes (the Erzgebirge and the Riesengebirge), and those in Poland at the foot of the Carpathian Mountains, and that they are generally connected with the Salt deposits, such as those of Wieliczka, &c. It does not appear that the Miocene fossils have yet been found in Poland; but in the neighbouring province of Gallicia, on the N.E. slope of the Carpathian chains, the Brown-coals and Saliferous clays are overlaid by a bed 12 feet thick, containing in abundance the fossils of the Leitha limestone and the Tegel of Vienna*.

I must, however, observe, that the statement of Prof. Labecki, confirming the remark of L. v. Buch, that there is only one Brown-coal formation in Europe, appears to me to require some modification. In one respect indeed it may be correct, viz. that they all belong to the Miocene period. But the Brown-coal formation which extends from Brandenburg through Silesia into Poland, must not be confounded with that which occurs so extensively in the neighbourhood of Magdeburg and Westeregeln. The latter underlies the fossiliferous sands of Westeregeln and of Magdeburg, which belong to the oldest tertiaries of Northern Germany, whereas it appears from the statements of Herr Plettner of Berlin, that the Brown-coal of Mark Brandenburg overlies the Septaria clay of Magdeburg and Berlin, which again overlies the sands of Westeregeln. Plettner, however, considers the Septaria clay as forming the lowest member of the whole Brown-coal formation of Brandenburg.

We have thus the following sequence in ascending order:—

1. Brown-coal of Magdeburg, resting on blue clay.
2. Westeregeln sands.

* L. v. Buch, Archiv, v. Karsten u. v. Dechen, vol. xxv. p. 164.

3. Septaria clay of Magdeburg, Berlin, Stettin, &c.
4. Brown-coal of Brandenburg, Silesia, Poland, &c.
5. Tertiary beds of Gallicia,—the equivalents of the Vienna basin.

The recent investigations of the Austrian geologists, encouraged by the establishment of the Imperial Geological Institute of Vienna, and the admirable publication of the fossils of the Vienna basin by Hörnes, have led to the more perfect examination of other beds containing an identical fossil fauna in other portions of the Austrian empire, and especially in Hungary and Transylvania.

In the 5th vol. of the 'Journal of the German Geological Society' is an interesting account by Prof. Neugeboren of the fossil remains found at Ober Lapugy in Transylvania, in the valley of the Marosch, not far from the Banatic frontier. Prof. Neugeboren describes this locality as one of unusual interest. A bed of clay upwards of 300 feet in thickness, occupying the small extent of 1000 square toises, about 40,000 square feet, represents the whole of the tertiary deposits of the Vienna basin. In the formation of these deposits there has been no interruption or break whatever. The whole has been formed in one long period of continued repose; almost every species from the different groups of the Vienna basin has been found here in the most perfect state of preservation, together with many others not yet found near Vienna, viz. *Conus nocturnus*, Lam.; *Cypræa rugosa*, Grat.; *Cypræa Hörnesi*, Neugeb.; *Marginella Deshayesii*, Michelotti; *Mitra striato-plicata*, Bellardi; *Columbella Dujardini*, Hörnes, &c. Thus we have here a gradual passage from the Miocene to the Pliocene formation without any break, the upper beds of the Vienna basin being considered the equivalents of the Subapennine formation in Italy. This opinion is confirmed by Prof. Reuss, who, in his examination of the Foraminifera, &c. of Upper Silesia, found many forms identical with those of the Subapennine formation of Castell'arquato, besides others still living in the Adriatic.

We also learn from the reports of the meeting of the Imperial Geological Institute of Vienna, that Dr. Hörnes visited Hungary and Transylvania last summer, principally for the purpose of ascertaining how far the tertiary deposits in those countries coincided with those of the Vienna basin. He has reported that the mineralogical and palæontological points of resemblance between these two widely separated regions are so complete, that there can be little doubt, if any, of their perfect identity. The sea, which, during the period of their deposit, occupied the Vienna basin, seems, as Dr. Hörnes reports, to have been the connecting link between two large contemporaneous oceans, the one covering the upper Danubian basin, the other the plains of Central Hungary, as in the present day the Sea of Marmora forms the connexion between the Black Sea and the Ægean. The tertiary deposits of Korod and Lapugy in Transylvania, of Remesert in Banat, of Baden, Steinabrunn and Oltnanz in Austria, together with those of Vilshofen in Bavaria, of S. Gallen in Switzerland, and of Montpellier, Bordeaux, and Touraine in France, whose faunas (with the exception of local modifications) have all the same character, may serve to point out the extent of the ocean which, during a portion of the Tertiary period, covered a considerable portion of Middle and Southern Europe from east to west. Dr. Hörnes confirms the statement of Prof. Neugeboren respecting the remarkable abundance of fossils in the tertiary beds of Lapugy, where some of the shells still retain traces of colour. In another report he mentions that the Vienna basin has now produced 1300 species of animal remains, of which 600 are mollusca. He has also stated, that on comparing a collection of sixty-five species of tertiary fossils from Girgenti in Sicily, no less than forty-five are identical with those of Vienna.

On this subject I will only further add, in reference to the remark of Prof. Hörnes respecting the former extent of the Miocene-Pliocene ocean, that Prof. Bianconi of Bologna, in his Latin essay "De Mari olim occupante planities et colles Italiæ, Græciæ, Asiæ Minoris, &c., et de Ætate terreni quod geologi appellant 'Marnes bleues,'" has some interesting details on the subject; and for this reason, although not exactly relating to the progress of geology during the past year, I venture briefly to allude to it on this occasion. After describing the extent of the marine tertiaries of Italy, and along the shores of Greece and of the Archipelago, in which he observes, that the usual characteristics of the formation are blue clays beneath, overlaid by yellow sands, the latter abundantly rich in fossils, chiefly the equivalents of those now living in the neighbouring sea, he proceeds to describe the valley of the Danube, and shows, that as Vienna is only 480 feet above the level of the sea, a very slight depression (less indeed than that required in many parts of Italy) would bring the whole valley of the Danube in connexion with the Mediterranean waters, thus forming a vast bay in the ancient Pliocenic ocean. He then shows, chiefly on the authority of A. Boué, that this vast Pliocene sea extended over Gallicia, Podolia, Bukowina, and even over parts of Southern Russia, where it is now covered by a younger formation, through the Crimea and to the very confines of the Caspian Sea, referring to the works of De Verneuil on the geology of the Crimea, published in the 'Mémoires de la Société Géol. de France,' t. iii. 1 sér. 1838, p. 12.

But I must not pursue this subject any further. The further examination of these Miocene formations throughout the North of Germany may perhaps enable us to have a better idea of the former limits of the Miocene sea, and of the connexion between different portions of it, than was entertained by those who looked only to the Bosphorus as the means of communication between the Mediterranean and the Danubian Miocene-Pliocene deposits. Every year now adds rapidly to our knowledge, and I trust we may look forward to more complete details from the efforts and zealous cooperation of the geologists of Germany at no very distant period.

Prof. Kaup of Darmstadt has taken advantage of the recent discoveries of photography to illustrate his last publication on the Fossil Mammalia. The organic remains thus illustrated are those of several species of Rhinoceros, a family to which Prof. Kaup has for many years devoted his attention. It is well known that the

Museum of Darmstadt holds high rank for its valuable collection of fossil bones, a very large proportion of which have been collected by Prof. Kaup himself. The photographic illustrations are, I believe, the first instance of the application of this process to such a purpose, at least on such a scale as is here given; the result is highly satisfactory as far as correctness of delineation and general effect are concerned, though it might be a question how far it would answer to produce the necessary number of copies required for a large sale.

From Italy we have also received interesting contributions to tertiary geology, in a memoir describing the fossils of Monte Mario, near Rome, collected by the Count de Rayneval, M. Van den Hecke, and Prof. Ponzi. The section of Monte Mario given by the authors consists in descending order of—1. a bed of volcanic tuff, which forms the capping of the hill; 2. sands and concretions; 3. fossiliferous sand; 4. fine sand; 5. blue marl, probably Subapennine. The beds dip slightly to the N.W. The authors insist on the care with which they have confined their remarks exclusively to the fossils of the sandy beds, excluding altogether those of the Subapennine marls, which are the marls of the Vatican, and form the basis of the hill. The great feature of the whole deposit is the preponderance of Lamellibranchiate bivalves. The general arrangement is described as follows:—The lowest bed contains *Panopæa*, *Terebratula*, and *Clavagella* in its natural position. Above these is a compact zone of *Ostrea*, *Pecten*, &c. This is followed by a bed in which *Pectunculus* is most abundant ("en quantité prodigieuse"). Above them, in a fine sand, are *Cardium*, *Tellina*, *Venus*, *Syndosmya*, *Lucina*, with myriads of *Venus ovata*, *Mactra triangula*, *Leda minuta*, *Corbula striata*, with *Lutraria* and *Arca mytiloides* in the upper portion. Above these is another Oyster-bank (*Ostrea foliosa*), with a few species of *Pecten*; after which all trace of organic remains disappears. The authors then proceed to point out the relations which exist between the *ensemble* of these fossil remains and the existing fauna of the Mediterranean, 210 species out of 270 collected being still found in the neighbouring sea. However correct the conclusion may be to which the authors have come, that the sea in which this fauna lived must have been differently constituted from the present, some of the data on which that conclusion is founded will require modification in their future publication, inasmuch as they place *Psammobia ferroensis*, *Venus ovata*, and others, amongst the shells which are rare in the living state; and in arguing on the absence of other forms, now abundant in the Mediterranean, they overlook the fact that such forms as *Mitra*, *Columbella*, *Murex*, *Buccinum*, *Purpura*, &c., are generally only found on rocks and a rocky coast, and do not abound on soft and sandy bottoms.

With regard to the age of this formation, the authors consider it to be intermediate between the plutonic action which caused the elevation of the Apennines, and the volcanic action which formed the chain of volcanos of Italy and Sicily parallel to the axis of the central chain.

According to the section which they have published, these fossiliferous sands overlie conformably the blue Subapennine marls, but it may still be doubted whether they belong absolutely to the same formation. They appear to correspond, to a remarkable degree, with a formation which I have described in an account of the geology of some parts of Tuscany*, where it forms the capping of the hill on which the town of Volterra is built, and has received from Savi the name of *Panchina*; the only difference being that some of the Panchina beds have a more calcareous composition, which, however, is only local, and I have also described these calcareous beds as alternating with others of an arenaceous character. Bivalves also greatly preponderate in the Panchina, particularly *Ostrea* and *Pecten*; I also found the upper bed of shelly limestone equally full of *Cardium*, *Pecten*, and *Ostrea*, but in a comminuted state. I think it would be desirable, that the authors, in publishing a more detailed account of the fossils which they promise for this year, should revise their list of extinct species, for I find amongst them several which are given by different authorities as still living; amongst these I may mention *Syndosmya Renieri*, a living Sicilian species, *Tapes virginea*, *Ostrea edulis*, *Nassa musiva*, *N. semistriata*, and *Dentalium coarctatum*.

In the 'Giornale dell' I. R. Istituto Lombardo di Scienze, Lettere ed Arti' for 1854, is an interesting account of the fossil flora of Sinigaglia, by Prof. Massalongo of Verona. The formation is described as Miocene; the general geological features of the country are Subapennine. I will only observe, that the memoir is illustrated by four plates, of vegetable remains, executed in coloured lithography with a degree of perfection and effect which is beyond all praise. The same journal also contains an account of the *Pachypleura Edwardsii*, Cor., a new species of Acrodont Saurian from the triassic strata of Lombardy, by Emilio Cornalia. Parts of several individuals of this species have been found, chiefly in the schists of Besano. The work is accompanied by two illustrations, showing the broken fragments of the organic remains as found, together with a representation of the animal restored.

The observations by M. de Verneuil and M. de Lorière on the geology and physical geography of Spain (Bull. Fr. p. 661) form an important contribution to our knowledge of a country of which so little on these points is known. They record above 400 barometrical and thermometrical observations, and establish generally the altitude of the extensive table-lands and mountain-chains which constitute so large a portion of that country.

Asia.

M. Pierre de Tchihatcheff has published in the 'Bulletin de la Société Géologique de France' some interesting additions to our knowledge of the geology of Asia Minor. His memoir embraces three subjects:—1st. The tertiary deposits of a portion of Cilicia Trachæa, Cilicia Campestris, and Cappadocia. 2nd. The tertiary deposits of the south of Caria and of a portion of the north of Pisidia.

* See Quart. Journ. Geol. Soc. vol. i. p. 278.

3rd. The Palæozoic deposits of Cappadocia and of the Bosphorus. Having myself had an opportunity of exploring the geology of some parts of Asia Minor, I am the more anxious to lay before you a short notice of the results of M. de Tchihatcheff's inquiries, which may be considered as supplementary to his paper published in 1850.

In the first portion of his memoir, M. de Tchihatcheff, starting from Karaman, a large town of Lycaonia, sixty miles S.E. of Iconium, describes an interesting and extensive tertiary deposit abounding in fossils, and which he attributes to the Miocene period. This formation commences within six or eight miles south of Karaman, and has been traced, more or less developed, to the coast of the Mediterranean. In fact, commencing on the northern flank of the Taurus, it is found in thin horizontal beds amongst the highest peaks of the mountain chain, capping with its perfectly level deposits the highly inclined limestones, marls, and schists of the cretaceous rocks, whilst on the southern flanks of the Taurus it constitutes to an enormous thickness the broken and rugged country which intervenes between it and the sea. In an easterly direction he has traced it for upwards of seventy leagues, occupying almost the whole country between the southern crest of the Taurus and the Mediterranean. In the rich diluvial plain of Tarsus and Adana it is found in river-sections under the diluvium, whilst nearer the mountains it is itself occasionally underlaid by tertiaries of an older epoch, viz. the nummulitic limestone of the Eocene period. The occurrence of this extensive Miocene deposit on the shores of the Mediterranean is a fact of considerable interest, agreeing as it does with the observations made by Prof. Forbes on the shores of Lycia, who, in the 2nd vol. of his 'Travels in Asia Minor,' describes the marine tertiaries met with at four localities. The principal of these is at Saaret, near Antiphellus, where he and his companions collected thirty-four species of Mollusca in good preservation. From a careful examination of these species, our late President had already come to the conclusion that these Lycian tertiaries belonged to the Miocene age, and were contemporaneous with the formations of Bordeaux and of Touraine, and with the Miocene tertiaries of Italy. There is, however, one very remarkable difference between the fossils found by Prof. Forbes and those of M. de Tchihatcheff, in the different proportions of univalves and bivalves. Out of the thirty-four species of Prof. Forbes, five only are bivalves and twenty-nine univalves. M. de Tchihatcheff, on the other hand, out of forty-one species found in the valley of Kudéne, gives only twelve univalves, the remainder, with the exception of one Echinoderm, being bivalves.

It is well known that highly fossiliferous beds of the Pliocene age occur in the islands of the Ægean, on the shores of the Morea, and at Lixouri in the island of Cephalonia, besides other places on the shores of the Mediterranean. It is therefore to be hoped that with the assistance of these Miocene formations in the Eastern Mediterranean, some future geologist may be enabled to make out the exact relations between the Pliocene and Miocene and earlier tertiary deposits.

The second portion of M. de Tchihatcheff's memoir refers to the tertiary deposits in the south of Caria and in a portion of the north of Pisidia. In the first place he describes an interesting section from Melassa to Geramo, situated on the northern shore of the Gulf of Cos. The nucleus of the country, as in most of the other mountain-chains which I have seen in that part of Asia Minor, consists of clay-slates and crystalline limestone, capped on its northern flanks by tertiary lacustrine deposits resembling those formed in other parts of Asia Minor. On the southern slope, however, close to the sea-shore near Geramo, M. de Tchihatcheff describes the existence of marine tertiaries, which he refers to the same Miocene formation already mentioned as occurring in Cilicia; they extend some way along the coast eastward from Geramo. But the most remarkable instance of their occurrence is the steep and isolated hill of Davas or Daous, situated some fifty miles inland from the Gulf of Cos, to the N.E. Here M. de Tchihatcheff found an isolated hill consisting of almost vertical beds of indurated marls and sandstones, capped by horizontal beds of tertiary formation abounding in fossils; from the collection he made, M. de Tchihatcheff ascertained that they also belonged to the Miocene series. Thus it appears that the Miocene seas here extended considerably inland, and to the north of the present coast. From Daous eastward to the Lake of Buldur, M. de Tchihatcheff found no further trace of tertiary marine remains.

The third portion of the memoir refers to the Palæozoic rocks of Cappadocia and of the Bosphorus. M. de Tchihatcheff had already briefly alluded to his discovery of Devonian rocks in the range of the Anti-Taurus south-eastward of Cæsarea in a letter addressed to Sir R. I. Murchison, and read before the Society in 1849. M. de Tchihatcheff again visited these regions in 1853, and not only ascertained the very extensive development of the Devonian formation, but also the existence of the carboniferous or mountain limestone, as proved by the fossils submitted to the inspection of M. de Verneuil. Ascending the banks of the rapid Sihun, after quitting the district of the mountain limestone abounding in true Carboniferous *Productus*, the author found that it was replaced by a blue unfossiliferous limestone associated with clay-slates, mica-schist, and quartzites. The nature of the country and its excessive vegetation did not enable him to detect the exact relative position of the two beds, but at no great distance he again came upon a blue crystalline limestone abounding in Devonian fossils. This formation extends for more than ten leagues up the valley, gradually becoming less rich in fossils as the valley is ascended; at length all organic traces disappear, and the blue limestone passes into a white marble, still preserving the fetid odour which characterizes all the fossiliferous limestones above mentioned. This rock is frequently associated with clay-slate and mica-schist, and is penetrated occasionally by *melaphyre*. M. de Tchihatcheff concludes this portion of his memoir with a general sketch of the palæozoic rocks of Asia Minor, and particularly of the Bosphorus. The localities where they have been observed are the following:—the Bosphorus, the northern shore of the Gulf of Nicomedia, the southern shore of Cilicia between Seleucia and Alaya, and the Anti-Taurus, and he refers them to the three following systems,—Silurian, Devonian, upper and lower, and Mountain Limestone. With regard to the Silurian rocks, however, it must be observed that M. de Tchihatcheff only admits their existence on the Giant's Mountain near Constantinople, on the authority of the notice published by Mr. Strickland and myself in the Transactions of this Society. He himself considers them to be Devonian. Now on this point I have only to observe, that I am far from wishing to insist on the fact of these beds being Silurian. The fossils are, I believe, still under the consideration of M. de Verneuil; but it must be remembered that at the time when Mr. Strickland published his paper describing the numerous fossils we had collected on the Giant's Mountain, the limits between Silurian and Devonian were not then so sharply defined as at present, and that the term Silurian was generally used to express the greater portion of the lower fossiliferous grauwacké beds below the Old Red Sandstone.

The paper by Mr. W. K. Loftus, "On the Geology of the Turco-Persian Frontier, and of the district adjoining," of which an abstract has been already published in our Journal, derives additional interest from the fact of its confirming the existence of the nummulitic and other formations from the western shores of Europe through the Alps, Bulgaria, and Asia Minor, to the very heart of India and the mountains of Scinde. Mr. Loftus was attached to the joint commission of the English, Russian, Turkish, and Persian Governments appointed for the purpose of fixing the boundaries of the respective territories of the Sultan and the Shah. In this capacity he had numerous opportunities of making repeated traverses across the mountain range of Zagros and through the districts which form the boundary of these two powers. Beneath the more recent deposits of sand, gravel, and fluviatile clay, partly freshwater and partly of marine character, Mr. Loftus describes the real tertiary deposits, which he subdivides into two groups, the uppermost being the gypsiferous, and below that, the nummulitic group. In both of these, characteristic fossils occur, and both series of rocks are greatly disturbed. These again are succeeded by the secondary rocks, the upper beds of which contain cretaceous fossils. Masses of highly crystalline fetid blue limestone which are found beneath the cretaceous rocks are referred by Mr. Loftus to the Lower Secondary Series. From what I have seen of the fetid blue limestones in Asia Minor, I should have been disposed to refer them to an older period. We then have in continued descending order, Palæozoic rocks, metamorphic schists, granite, and trap rocks.

Our knowledge of the geology of India has made some progress during the past season, although, I must confess, not equal to what it might have been; I had hoped that the introduction of railways into the three Presidencies of India would long ere this have produced more fruit than it has yet done. We have received no information from these sources. But, on the other hand, one of our own members, who has never visited India, has greatly contributed to our means of making ourselves acquainted with the general geology of Hindostan. The Geological Map of India by Mr. Greenough is a worthy counterpart of his Geological Map of England. We all know the careful and systematic manner in which Mr. Greenough has for a long series of years collected and arranged information respecting the geography, geology, and other kindred branches of knowledge from every portion of the globe; and many have been the regrets which I have heard uttered, that with such a mass of systematically-arranged information as he possesses, greater than that of any other individual, he should not already have enabled us to benefit by its publication in some form or other. Mr. Greenough has at length come forward, and the geological map of India is a splendid proof of the value of his materials, and of his power of making use of them.

In exhibiting this map before the Geological Section at Liverpool, Mr. Greenough accompanied it with remarks on the different formations which have been observed in various parts of India. All the principal formations as known in Europe appear to have been met with in that vast country, from the tertiaries of the Punjaub and the Siwalik Hills, whose interesting fossils were described by Col. Cautley and Dr. Falconer, to the Silurian formation of the Himalaya, which affords many forms of Trilobites, Mollusca, and Zoophytes characteristic of the Silurian period, and very similar to those of Europe, though none are probably specifically identical.

I must also mention some interesting communications received from the Rev. Messrs. Hislop and Hunter, respecting the geology of the neighbourhood of Nagpoor. Communications on this subject had already reached us, partly from Mr. Malcolmson many years ago, and lately from Lieut. Sankey, but the details now furnished are more complete and satisfactory. The basis of the country is gneiss, quartz-rock, mica-schist, and granite, on which reposes a sandstone observed over a great extent of country; with this are associated in some districts shales and argillaceous sandstones, rich in vegetable remains, the age of which is not yet satisfactorily made out. These are overlaid by trappean rocks, separated into two divisions by an intermediate layer of a cherty and argillaceous character, abounding in some places with land and freshwater fossils, amongst which, however, the latter greatly preponderate. This bed is chiefly seen along the escarpments of the trap hills, and has a very extensive range. It has been traced more or less uninterruptedly to a distance of 1050 miles in a direct line from Rajmahal to Bombay, and 660 miles from N. to S. to the neighbourhood of Padpangali, near the mouth of the Godavery. It is apparently a lacustrine deposit, but its age has not yet been made out with any degree of certainty, though the flora is supposed to have some resemblance to that of the London Clay. It is almost superfluous to say, how cautious we must be in attempting to assign comparative ages to such distant localities; a caution which is all the more necessary when it refers to lacustrine deposits, which, being naturally isolated, cannot be expected to afford the same terms of comparison with similar formations at a distance, as we might naturally look for in marine, or even subaërial deposits, with respect to marine or terrestrial forms. It may, I think, also be doubted how far we should adopt the conclusion at which the authors of this memoir have arrived, that both the trap-formations, the one below as well as the one above the freshwater deposit, are of more recent date than the freshwater formation itself, and that the lower trap has been protruded from below, and forced in between the freshwater bed and the underlying sandstone. Prof. Owen has described the cranium of a reptile obtained from these underlying sandstones by MM. Hislop and Hunter; of this fossil he observes that the characters of the skull, as far as he could judge from its condition, leave no reasonable doubt of its nature and affinities as allied to the labyrinthodont batrachians, and he has given it the name of *Brachyops breviceps*.

A paper in the 'Bull. de la Soc. Géol. de France,' 1854, p. 500, on the Geology of the provinces of Oran and Algiers, is important on account of the careful comparison which has been made by M. Bayle of a large collection of the fossils brought by M. Ville from that part of Africa with their European analogues. Several jurassic forms belonging to the middle oolitic series are identified, but a still greater number of lower cretaceous fossils have been recognized in the next overlying series. Amongst these fossils, however, are found several which have a close analogy with oolitic forms, and *two oolitic Ammonites* are especially mentioned. The nummulitic series is of considerable extent, and is characterized by the *Nummulites lævigatus*. In the tertiary beds which follow next, almost all the fossils are identified with Molasse species, and are referred therefore to the Middle Tertiaries. These are overlaid by some upper tertiary beds, which, in the province of Algiers, are very rich in organic remains. A long and important list (p. 511) of these fossils is given, most of which belong to the Sub-apennine period. The beds of the drift period are also of considerable importance, both from their extent, thickness, and the fossils they contain. The upper beds are characterized by land and freshwater shells, whilst along the sea-board the lower beds containe marine shells. All these appear identical with living species.

To Dr. Foetterle of Vienna, acting under the suggestions and with the assistance of M. Haidinger, the Director of the Imperial Geological Institute of Vienna, we are indebted for the first attempt to construct a Geological Map of Central, and of by far the greater part of Southern America, extending from lat. 5° north to lat. 35° south. We have thus an opportunity of judging of the general *ensemble* of the numerous rocks of which that vast continent is composed. For the last three years the desire for such a map has been prevalent in Vienna, and its want has been long acknowledged. The first impetus to its construction was given by the Brazilian Consul, M. Sturz, who, while the subject was under deliberation, offered a prize for the best geological map of Brazil. At the same time M. von Martius was preparing a map for his 'Flora Brasiliensis.' We have therefore now two maps ready for colouring. That of Dr. Foetterle is $\frac{1}{15,000,000}$ proportion, and is accompanied by a slight notice of the different formations found in this portion of South America. This notice is highly interesting, though in some respects the work of Dr. Foetterle must be considered as a compilation, since he has not himself visited this country. The formations which he describes are as follows:— 1. Granite and gneiss granite, very extensively developed. 2. Gneiss with mica-slate, very abundant on the east shore of Brazil. 3. Itacolumite, partly clay-slate and partly sand. 4. Talc slate, remarkable for the occurrence of diamonds. It forms some of the most extensive mountains in Brazil. 5. Grauwacke formation. 6. Transition limestone. 7. In Bolivia D'Orbigny has found slaty sandstones, with remains of *Cruciana, Orthis, Lingula, Calymene, Asaphus,* and *Graptolites*; these belong to the Silurian system. 8. Devonian formation, consisting chiefly of quartzose sandstones, with remains of *Spirifer, Orthis,* and *Terebratula.* 9. Coal formations, with several peculiar European fossils, as *Spirifer Pentlandi, Sp. Roissyi,* and *Productus Villiersi.* 10. Trias, consisting of variegated clays and sandstones. 11. Chalk, the most extensive formation in South America, extending from Venezuela to Tierra del Fuego. 12. A red sandstone, the position of which is uncertain. 13. Volcanic formations. 14. Tertiary formations: fossils do not appear to be abundant in this formation, and hence the difficulty of assigning it to its proper period. 15. Diluvium.

General Works.

Amongst the many works of a more general character bearing on the progress of geology which have appeared during the past year, I must not omit to mention the magnificent publication of Prof. Ehrenberg entitled 'Mikrogeologie.' The microscopical discoveries of infusorial remains made by the author of this work during the last fifteen or twenty years are too well known to require any special notice on this occasion. In his present work the author professes to describe the infusorial results of the microscopical examination and analysis of 836 different formations derived from every quarter of the globe, from almost every region between the poles and the equator, and comprising the rocks of every geological formation from the earliest periods down to the present day. The author states as one of the most important geological results of his inquiries, that the arrangement of these microscopic forms does not confirm the laws which have been recognized with regard to the larger fossil organisms, which regularly become more and more peculiar and divergent from existing forms in proportion as we descend lower in the series. On the contrary, he finds the same genera and sometimes the same species extending downwards to the Carboniferous period, and possibly even to the Lower Silurian and the so-called unfossiliferous sands of St. Petersburgh.

Amongst the general conclusions which have resulted from this investigation, the author states that all these microscopic forms may be divided into two groups. 1. Forms of fresh water and dry land. 2. Forms of salt water and its products. Sometimes the mixture of these two groups indicates the existence of ancient æstuaries and river mouths. Another result is that in all the formations of the world, in the air, on land, and in or under the water, only six great classes of microscopic forms are to be found. These are, 1. Siliceous, of which there are four classes, viz. Polygastrica, Polycystiniæ, Phytolithariæ, and Geolithiæ, and 2. Calcareous, of which there are two classes, viz. Polythalamiæ and Zoolithariæ. But I must refer you to the work itself for the further distribution of these classes, where each preponderates, and how certain forms serve in many cases to designate one formation or another. The work is illustrated by forty-one plates, executed with great ability. I will only mention that the separate results of the analytical examinations of the 836 substances are given in this work, and that in most cases the author appears to have made from five to ten analyses of each. These are generally arranged geographically in the first instance, and the results of the general examination of each district are separately given.

I may also mention that a second edition of Bernhard Cotta's agreeable and instructive work entitled 'Geologische Bilder,' Geological Pictures, has appeared during the last year.

The French 'Bulletin' for the last year contains several interesting papers bearing on the application of Chemistry to Geology. A paper by M. Delesse (Bull. p. 127), entitled, "On the action of alkalies on rocks," points to the fact that as silica in a soluble state is now found in a great number of sedimentary rocks, and as, equally, the alkalies or the alkaline salts exist in small quantities in almost all spring waters, the action of the latter on the former, "although feeble, having been continued throughout all geological time, has necessarily contributed powerfully to the formation of pseudomorphisms" (p. 141). Granite and quartzose porphyry are but slightly attacked by alkaline solutions. Lava, basalt, melaphyre lose under 20 per cent. by their action. Trachyte, retinite, perlite, and obsidian are the rocks which are the most readily attacked, losing sometimes to the extent of 40 per cent. Further, decomposed rocks are much more readily acted upon than the same rock when undecomposed. "*Cæteris paribus*, the action of alkalies on rocks is the greater according as the rocks are richer in silica, less crystalline in structure, or contain less hyaline quartz" (p. 140). As bearing on this same subject, some observations by M. Saemann (p. 143) are also interesting.

M. Delanoüe (p. 562) suggests several very necessary cautions in the application of the theory of metamorphism. He is willing to admit to their full extent the important influence of heat and gaseous emanations in rocks, but not the intrusion throughout entire masses of substances entirely foreign to the composition of those rocks. He contests the possibility of dolomitization by metamorphic action, also the introduction of felspar into rock-masses by the same action, contending in either case that the chemical elements necessary for the change pre-existed in the rocks, and that they have only been modified by heat. M. Delanoüe contests (p. 569) also some explanations that had been brought before the Society by MM. Delesse, Deville, and Durocher, accounting for the presence of sulphur in thermal waters, and passes in review the various changes brought about by the percolation of rain-water through the earth.

Conclusion.

It only remains for me, in conclusion, to make one or two observations on a subject which, in the present condition of our science, appears to me too important to be lost sight of, and which, if neglected, may lead to many useless discussions and unfortunate misconceptions. However paradoxical it may sound, I believe that, as our knowledge of geological formations advances, some of our difficulties increase. We have found during late years that, in proportion as we extended our knowledge of different formations, we have been compelled not only to introduce a greater number of principal formations, but to subdivide these again into groups, and again to subdivide the groups into distinct beds. This process has long continued. We are no longer satisfied with primary, secondary, and tertiary epochs; it is not enough that we have introduced the Permian, the Neocomian, and similar terms to designate different periods, or that we have subdivided the Secondary rocks into Triassic, Liassic, Jurassic, and Cretaceous; all these divisions are again subdivided, I might almost say, "*ad infinitum*." As the investigation of geologists has extended itself over distant countries, and has brought fresh continents under our notice, new and at first sight anomalous combinations have been brought to light. The limits and breaks already assigned to different formations in the countries where first observed, have not been found always to hold good. The marked unconformability of stratification and the distinct differences of palæontological evidence, on which the limits of formations were first grounded, have in other countries either disappeared altogether, or have required to be greatly modified. It has been found that between these respective limits, as at first laid down, certain fossils of the lower beds extend higher up into those above, while some of those hitherto supposed to be characteristic of the overlying formation are found extending downwards into beds of an older age. On the other hand, that unconformability of strata which was supposed to mark the limits of epochs, and to point out the breaks occasioned in the successive deposition of strata by great natural convulsions, is often found to disappear when the investigation is extended and the strata are traced into other countries. In this dilemma the first step has been to intercalate new beds as intermediate between the different formations, connecting them as it were by a certain community of animal life, marking the passage from one condition of existence to another; as, for instance, the S. Casciano beds are now introduced between the Triassic and the Liassic, the Carboniferous shales between the Old Red Sandstone and the true Carboniferous beds, and others which will readily occur to you. But the difficulty does not cease here. As we extend our inquiries, we find that the gradual passages from one formation to another become more frequent, and that the breaks in the conformability of strata, instead of being the normal condition of the passage from one formation to another, are mere local phænomena, and we are thus almost forced to the conclusion that such marked separations between the different formations as we have been fondly trusting to, do not really exist in nature. I believe the time will come, when, having brought before us a greater amount of sections all over the world (if indeed it is not possible to do so already), we shall find that there exists a gradual passage from the very oldest to the newest strata; that from the earliest fossiliferous rocks to the most recent post-pliocene formations there has been one unbroken sequence of deposits, modified only by local disturbances, showing the gradual change of organic life according to the different conditions of existence; that in every case a certain number of species existing in the beds below have been continued upwards, mingled with new forms specially created to suit the new state of things; and that this progress has ever been going on in some part of the earth's surface, undisturbed by other local changes and convulsions. We know that as the conditions of life varied, new forms were called into existence, while former ones were gradually disappearing; but we shall, I think, be more and more forced to give up that view which led us to subdivide the countless myriads of ages of geologic time into epochs, formations, groups, and subdivisions, and to look upon the whole series as one grand group modified in time by a slow and imperceptible progress, and affording breaks and interruptions of conformability of strata only as local phænomena. This difficulty, as I said before, is gradually increasing, and to guard against it we require not only caution with regard to ourselves, but toleration towards others who are disposed to place the local limits of those formations, to the nomenclature of which we must still adhere for the sake of convenience and description, otherwise than where we are inclined to place them ourselves.

Again, although it may sound to some like a geological heresy, I would add one observation more, in the shape of a caution against our allowing ourselves to be led to trust too implicitly to mere palæontological evidence. The errors which may proceed from this cause are twofold; either we conclude on the contemporaneity of strata at a distance from each other on the sole ground of real or supposed identity of species, or *vice versâ*, we maintain that they are not contemporaneous, because they contain a certain proportion of different species. The conclusion may possibly be correct in both cases, but the grounds on which it rests are not necessarily sufficient. We have only to examine the existing faunas round the coasts of Europe and in the Arctic Seas to be struck with the remarkable difference in their contents. Even the shores of our own island at no great distance from each other present very great divergences of typical forms, dependent no doubt on numerous extraneous agencies, many of which we can ourselves detect, but of which many have as yet escaped our notice, and will probably continue to do so for ages to come. Why then should we not admit the same phænomena in former ages? why must we necessarily jump at the conclusion that, because different strata contain different species, they *must* belong to different periods; or *vice versâ*, that because they contain the same species, they belong to the same period? Local features and local phænomena may account for this difference or identity. Nor can we depend with safety on petrographical characters alone. Identity of structure does not prove identity of age. I do not mean to say that such palæontological or petrographical evidences are not available to the geologist. They are often all that he can find, and it is impossible to rate too highly the assistance which palæontology has rendered to geology. But what I would venture to observe is, that without the aid of stratigraphical evidence they cannot be implicitly relied on. This, after all, will be found to be the master-key to enable us to unlock the mysteries of ages, and to explore the secret and long-hidden paths of geological progression.

Gentlemen, my task is finished. I have only to entreat your indulgence for the many imperfections contained in this Address. I am aware that much has been omitted which might fairly have been expected in it, and probably much has been inserted which a more experienced geologist than myself would have deemed superfluous. I trust you will receive it as an earnest of my best wishes for the prosperity of our Society, and of my interest in that science which in common with yourselves I have cultivated for so many years. If I have been in any way successful in meeting with your approbation of what I have done, and of the manner in which I have endeavoured to discharge my duties as your President, I am bound to say that that success is mainly owing to the able assistance I have received from every Member of the Council, and from your partiality in overlooking many deficiencies.

THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

NOVEMBER 1, 1854.

John William Dawson, Esq., William Cunnington, Esq., William Henry Mortimer, Esq., and John Henry Murchison, Esq., were elected Fellows.

The following communications were read:—

1. *On the Occurrence of* GOLD *in the* TRAP DYKES *intersecting the* DICYNODON STRATA *of* SOUTH AFRICA. By R. N. RUBIDGE, Esq., M.B.

[In a letter to Sir R. I. Murchison, V.P.G.S.]

IN the early part of this year some rumours arose of the discovery of gold near Smithfield, a newly established town in the Orange River Sovereignty. It was stated, that some persons, riding over a flat, had seen some fine specimens of quartz, turned up by a jackal in scratching a hole in the earth. The quartz brought in as a curiosity was recognized by a person who had been in Australia as similar to that found in the gold regions of that country. This induced search, which was at length rewarded by the finding of gold in several spots; and, a portion of the quartz first found being broken, a piece of gold was obtained from it. A pit was sunk in the centre of a large shallow valley, and some gold was found at a depth of 15 feet in the gravel.

These accounts excited great interest in the colony. Mr. Bain happened to be on the frontier at the time, and a deputation waited on the Governor in Graham's Town and suggested the propriety of sending him to the spot, to report on the alleged discovery. His Excellency, however, appears to have doubted the truth of the report, and declined detaining Mr. Bain from his duties; he accordingly returned to his post in the western districts.

Gold in small quantities continued to be found; and some nuggets reaching this place, with greatly exaggerated accounts of the success of the diggers, caused great excitement, particularly among the younger and more unstable part of the community. Several clerks gave up their situations to repair to the "diggings," and many rash speculations were entered into. Merchants and tradesmen raised the price of their goods. An affidavit from a person in Smithfield who has some local reputation as a chemist, to the effect that he had examined some mineral containing 20 per cent. of copper and 10 per cent. of gold, occasioned still more interest, for it was stated that the mineral in question was to be obtained in waggon-loads quite near the surface.

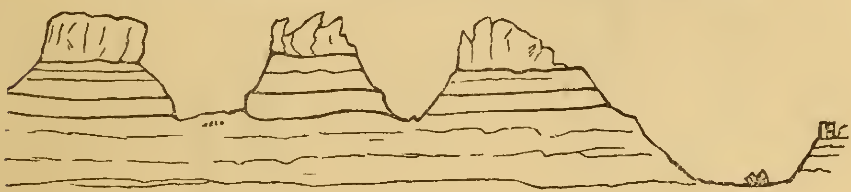
Under these circumstances the desire for more accurate information gained ground, and a subscription was set on foot, by the merchants and others in this place, for raising the means of sending some person or persons, possessed of some geological and mineralogical knowledge, to the spot, to report on the truth of the accounts received, and to discover, if possible, what probability there might be of gold or other metals being found in such quantities as to make mining profitable. The choice fell on myself, a medical practitioner known to have made geological collections, &c., and Mr. Paterson, the editor of one of the local papers, not a geologist, but a man of general intelligence. We left this on the 27th of March last and arrived in Smithfield eight days after.

I presume that the writings and map of my friend Mr. Bain* have made you familiar with the geology of this country, more especially with that interesting formation the "Dicynodon strata," which will ever be associated in the minds of geologists with his name. This singular series of strata of enormous extent, probably exceeding three times the area of Great Britain and Ireland, and perhaps thousands of feet in depth, yet apparently presenting evidence of lacustrine origin, is penetrated everywhere by dykes of igneous rock, varying from less than a foot to some hundreds of yards in breadth; sometimes of a compact basalt-like character, at other times (in the larger dykes) like coarse granite, or composed of hornblende and quartz with felspar (syenite) or zeolite. Yet, excepting near the western border of the Zeurbergen Range, the strata are rarely disturbed more than ten degrees from the horizontal plane, and even such disturbances

* Forming a part of the 7th vol. of the Geological Transactions now in the press.—Ed.

are rare and of extremely limited extent. The only alteration I have observed in the structure and chemical composition of the strata adjacent to a dyke is a little increase of hardness, and numerous vertical fissures, giving the rock an appearance of being cut up into cubical masses. The dykes cut each other in all directions, so that we have been unable to refer them to any system or systems as to age or direction. They form the central masses of the mountain-ranges, which are crowned with precipitous escarpments of the igneous rocks; the sloping sides of the mountains being due to the unequal wearing of the horizontal strata (see fig. 1). With the exception of

Fig. 1.—*Diagram of the Structure of the Mountains of Stratified Rock capped with Basalt, &c. in Southern Africa.*



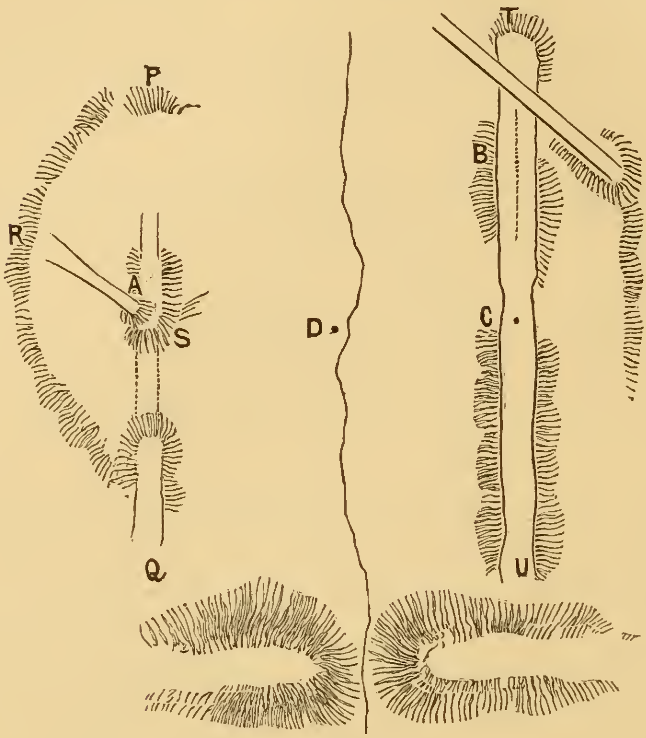
iron, which is abundant in both the igneous and aqueous rocks, and manganese, we have not yet found in the Colony any metal in this formation.

On my arrival at Smithfield, I found the formation to be the "Dicynodon strata" just spoken of, still horizontally disposed, and with no traces of metamorphic action; fossils, both animal and vegetable, being found quite uninjured at 3 or 4 feet distance from even the larger dykes. The stratified rocks were a hard, greenish-white, compact sandstone (becoming brown on exposure), forming good building-stone, and in layers 10 or 15 feet thick, alternating with other layers of nearly the same thickness, of a bluish-brown and much more perishable sandstone, which is common in the whole extent of the formation. Where concretions of hard blue limestone are found in this rock, it is generally fossiliferous; these concretions or nodules seeming to be connected in some way with the fossil bones of the *Dicynodon*, which are often imbedded in them. I did not see any fossils in the harder sandstone on this spot, though some very like it contained vegetable impressions in other places.

The plain, or rather the broad shallow valley, in which the gold was found was bounded on either side by a low range of hills; the small brook escaping to the south by a gorge in hills of 1000 or 1200 feet in height. (See fig. 2, p. 4.)

The first spot I examined was the hole where the gold was first found in the quartz turned up by a jackal, (A) in the sketch-plan. There were a number of the usual rounded masses of igneous rock lying about in apparent confusion, which, on close examination, I found to result from the disintegration of two dykes which formed a junction just at the spot selected by the jackal for his domicile, at A in the sketch. One of these dykes (P Q) ran nearly due magnetic north and south, the other (R S) crossed it at an angle of about 50°.

Fig. 2.—*Sketch-plan of the Valley in which Gold was found in Southern Africa.*



Stream.

P, Q. } R, S. } Dykes of trap-rock. T, U. }

A. Place of the jackal's hole where auriferous quartz was first found.
B, C. Pits sunk in one of the dykes.
D. Hole sunk in the gravel of the valley.

Several parties had been engaged in digging on this spot; and, on turning up the masses of igneous rock, some fine specimens of crystalline quartz were found, several of which, when broken, were found to contain small nuggets of gold in their cavities. These masses of quartz were peculiar in appearance*, consisting of a plate of opake white quartz with masses of crystals growing from one side over that which lies undermost in the earth. The gold was in the cavities of the plates. It appeared to me that the plates were veinstones, which had been detached in the decomposition of the dyke with its contained vein, for, although I could not detect a regular vein, such as I shall have to describe presently, yet I believe there was one, but the partial decomposition of the surface prevented me tracing it. Just at the junction (A), a mass of blue rock was found, some of which had been

* I have never seen anything like them in the Colony, though quartz abounds everywhere.

hammered to pieces by a party from Burgher's Dorp, and a small piece of gold had been found imbedded in the mass. On examination I found it to be a mass of hard calcareous sandstone imbedded in the igneous rock. The stratified rocks adjacent to the dyke were the brownish-blue perishable sandstone described above, without any lime. Was this lump a mass of the nodules altered by heat? Small veins of calcareous spar intersected it, as usual in the nodules.

I rode across the valley, about a mile and a half broad, to examine the other dyke (T U). I found its direction to be 4° west of magnetic north. Like the former, it was cut through by a more recent E. and W. dyke, not quite so broad, the N. and S. dyke being about 12 feet broad, the other 8 feet. About 60 feet from the junction two Englishmen had sunk a pit (B) which gave one a good view of the structure of the dyke. It was composed of the usual compact blue syenite of the narrow dykes of this formation. The first 5 or 6 feet of the rock was somewhat decomposed, but lower down it was but little altered. A vein of quartz, varying from 2 inches to 2 feet, traversed the dyke longitudinally nearly in the middle. This quartz was opaque, and had numerous small cavities in which little masses of gold were occasionally found; but so poor was the vein, that a large sackful, part of which was knocked out with a hammer by myself, yielded only two little bits of gold, not weighing together 10 grains. At about 300 yards to the south was another pit (C), sunk by a party from Burgher's Dorp, on the same vein. They too had found several nuggets, but the quantity gained was so small that the pit was abandoned after reaching the depth of 15 feet.

The stratified rocks were the same as those at the other dyke, unaltered in position, and with little or no traces of the action of heat. They were visible only by digging away the soil, as the dyke projected merely a few feet above the level of the plain, so that only a narrow ridge of igneous rock formed the margin of the valley.

It appears to me quite certain that the gold must be *in situ* in the quartz vein; for, beside the fact that no other than "Dicynodon rocks" are found within 200 miles, at least, of the spot, I cannot conceive that the metal could get into the vein by mechanical means, especially as the dyke is in some parts the most elevated land in the neighbourhood; and the valley is separated from the Caledon River, the only source of convection from a distance (at present existing), by a high range of hills, at least 1500 feet high. Besides, in all the spots pointed out to me as sources of gold *in situ*, I found the dykes meridian-directed. The sketch shows this to be the case at Smithfield; it was so at the Kraai river near Aliwal, and at the Kroomberg. It was only in northern-directed dykes that I found quartz in regular veins. At the Kraai river the gold was found in quartz surrounding a mass of the calcareous sandstone, like that at the junction of the two dykes at the jackal's hole (A). There was no vein.

Near the centre of the valley (D), a hole had been sunk through the alluvial soil to the depth of 15 feet, when a layer of coarse gravel was found, resting on clay. This layer yielded several nuggets. Another hole was in progress of digging near the former, the water having proved troublesome, and I have heard since I left that five nuggets, weighing 96 grains, have been obtained.

I cannot anticipate any great success for the diggers, as the only primary sources of gold in the valley appeared to be the two dykes above described. The result of my inquiries is the conviction that the gold may be found in small veins over a large extent of country, that no large or rich veins have yet been seen, nor do I think that such exist. I cannot agree with my friend Mr. Bain in thinking that the gold has been conveyed from a distance, for the reasons above given. I believe too that gold in masses of 50 grains' weight is never transported by water so far as 100 miles from its source.

It has been mentioned, that, though the ranges of mountains in the Dicynodon-strata of the Colony take a north-easterly direction, yet no distinct lines of igneous action can be referred to different dates. In the Sovereignty, on the contrary, it appeared that the meridian-dykes were decidedly the more ancient, as, wherever I had an opportunity of examining them, they were distinctly cut through by the north-easterly ones; and, though there were some dykes which seemed to take directions which were difficult to refer to either of these systems, I thought that most of the igneous rocks in the country might be referred to two sets. 1st. A northerly or meridian-directed set, which form the centres of many ranges of hills and mountains extending from the Stormberg westward for some hundreds of miles, running in their northerly course to Horrismith at least, and, according to some accounts, to Megalies-Berg. The Wittebergen and Koesbergen belong to this system.

2nd. A north-easterly set, crossing the others, and in the Sovereignty giving ranges subordinate in size to the last, but to the eastward greatly larger, so as to give their direction to the Quathlambo or Draakenberg. I find great confusion in the different maps of this region, some making the main range of the Quathlambo to take a north-easterly course, though others make it take a bend northward about the lower third of its course; some of the names too (such as the Wittebergen) are applied to two or three ranges in different places, and taking different directions. Mr. Bain tells me that the geology of the Draakenberg is the same as that of the Sovereignty, viz. horizontal Dicynodon-strata, pierced by syenitic dykes. This I know to be the case in the Wittebergen and Stormbergen, which are in reality its southern terminus. But the Orange, Caledon, and Kraai rivers have in their beds pebbles which can belong to no such rocks as they pass in the lower part of their course. A trader told me that he had seen them in the river 200 miles above Aliwal, but had never seen the rocks they came from. They are masses of amygdaloid, with a red or brown-red coloured felspar basis, with crystals of a circular zeolite (stilbite, I presume). There are no such rocks in the Cape Colony. Whether with this change of igneous rock might exist greater metallic deposits in these regions, can, I imagine, only be determined by inspection.

The Umyinvost or St. John's River would, I think, be a good point of departure for an expedition to explore the Quathlambo. I found the difficulties of reaching the eastern part of the range from the westward so great, owing to the uncivilized state of the country, that I was obliged to abandon all thought of the undertaking in the limited time I had at my disposal. Indeed, I fear it will be a long time before anything effectual will be done without assistance from home. South Africa is a poor country; there are few or none who have the means of spending their time in such researches.

As I could not find any other probable source of native gold than the veins of the meridian-directed dykes, in which, for reasons before given, I believe that the gold is found *in situ,* and as they appeared to be poor in quality and remote from each other, though extending through a wide range of country, I gave it as my opinion, that though small quantities of gold might be found occasionally in all that region, yet it seemed improbable that it could ever be a source of profit for mining operations. If I could have traced a tendency to convergence of the northerly ranges in any point, I should have thought that a more extensive igneous action there might have occasioned larger gold deposits, but all my inquiries led to the belief that the ranges continue to run parallel for several hundreds of miles.

From the eastern ranges of the Stormbergen to some distance beyond Aliwal, there occurs through that country a layer of anthracite, which is incombustible, although it deflagrates with nitre. There are some fine vegetable impressions in the sandstone covering it. I regret to say I could not get any specimens sufficiently portable to enable me to bring them away. Where the dykes pass through this coal-like substance, it is converted into an inferior plumbago.

Throughout that country also there are numbers of agates and cornelians, some of them of good quality. They do not appear to be the produce of the spot where they are found, and are generally met with in the lower grounds near the course of the large rivers, and associated with the amygdaloid pebbles above referred to. Some agates are found on the eastern coast also, near the mouth of the Sunday river. These too appear to be associated with the amygdaloid of the Zeurbergen.

I thought of sending specimens of the rocks and minerals alluded to in this letter, but have deferred doing so until I hear that they will be acceptable.

Mr. Bain has gone to the western copper-field, near Walvisch Bay, to examine the new metallic discoveries there. I have seen specimens from thence which appear to me to promise great benefit to the country.

Port Elizabeth, South Africa, May 11, 1854.

2. *On the* Occurrence *of* Copper *in* Tennessee, U.S. By W. Bray, Esq.

[Communicated by the President.]

[Abstract.]

The gneiss and mica-schist of Eastern Tennessee strike south-west and north-east (about 47° E. of N.), and dip to the south-east (at angles of about 25°), running parallel to and forming an outer range of the Alleghany Mountains. Veins of copper and iron ores, with occasional quartz veins, lie in the schists, dipping parallel with them, and consisting of porous oxide of iron at top, with iron pyrites and carbonate and sulphuret of copper lower down. The veins are described as being sometimes 45 feet wide, and traceable for upwards of 70 miles; but they are worked chiefly in the extreme south-east corner of Tennessee, in the township of Duckton, in the county of Polk, a district ceded by the Indians to the States about four years ago.

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3. *Notice of the* Discovery *of a* Reptilian Skull *in the* Coal *of* Pictou. By J. W. Dawson, Esq., F.G.S.

The reptilian specimen described by Prof. Owen (Quart. Journ. Geol. Soc. No. 38. p. 207. pl. 9) is the upper part of a head found by me in 1851, at the Albion Mines, in a heap of rubbish extracted from a band of carbonaceous clay iron-stone and coarse coal, occurring in the main coal-seam, about 5 feet below its roof, and known to the miners as the "*holeing-stone*." This band is marked No. 5 in the detailed section of the Albion main coal given by Mr. Poole and myself in the Geological Society's Journal, vol. x. p. 47. It varies in thickness in different parts of the mine, from 2 inches to about 18 inches; and it contains much coprolitic matter, and a few scales, teeth, and spines of fishes, as well as minute Spirorbis-like shells, similar to those found in the Joggins coal-measures attached to plants*. None of these fossils, however, are by any means abundant; and the vegetable remains contained in the "holeing-stone" have in general been reduced to the state of homogeneous coal, or of mineral charcoal. There can be little doubt that this remarkable band indicates a somewhat protracted submergence of the area of coal then accumulating under the waters of a lake or lagoon.

As stated in a note which accompanied the specimen, when forwarded to the Geological Society in 1852, the matrix split in such a manner as to leave the upper part of the skull adhering to the larger portion of the block, while the palate bones and teeth came away in fragments. Believing at the time that the fossil had belonged to a fish allied to *Holoptychius*, and that it was interesting chiefly as an illustration of the exceptional fact of the occurrence of

* Quart. Journ. Geol. Soc. vol. x. p. 39.

remains of large fishes in a coal-seam, I forwarded to the Geological Society only the upper and more entire part of the specimen, retaining the remainder in my own cabinet. Since, however, the specimen has proved to be of so much greater interest than I had anticipated, I now beg leave to present to the Society the remaining portions, in the hope that they may enable Prof. Owen more fully to make out the character and affinities of the animal to which they belonged.

I shall also take the earliest opportunity to examine such portions of the "holeing-stone" as may now be exposed at the mines, in the hope that I may be rewarded by further discoveries. I may remark, however, that I have at various times examined considerable quantities of this material, without finding any fossils except the remains of small fishes already mentioned; nor am I aware that other remains of large animals have been discovered in it, with the exception of a smooth and nearly cylindrical hollow bone, apparently a part of a large spine*, now, I believe, in the collection of Henry Poole, Esq.†

Additional Remarks on the SKULL *of the* BAPHETES PLANICEPS, OW. By Professor OWEN, F.R.S., F.G.S.

Since the communication of the notice of the portion of cranium of the Labyrinthodont Reptile above-named (Quarterly Journal of the Geol. Soc. May 1854), I have been favoured with the view of some other fragments of the same cranium, including parts of the interior or under-surface, with several teeth buried in the coal-matrix, and exposed at the fractured surfaces.

In the ordinary Labyrinthodont Reptiles of the European Trias, one or two teeth at the fore-part of the jaws have the form and proportions of large canines, the rest are smaller and more slender pointed teeth.

One of the present fragments includes the fore-part of the right maxillary and premaxillary bones, and shows a single large laniariform tooth descending from the fore-part of the maxillary into the substance of the subjacent matrix: in front of the tooth is one of the smaller, pointed, serial teeth: of which teeth other fragments show other examples, the base of the teeth being anchylosed to shallow sockets in the bone.

So much, therefore, of the dental system of the *Baphetes*, as is here exhibited, accords in the general characters of shape and relative size, of disposition and mode of fixation to the jaw, with the dentition of the Labyrinthodonts.

* This bone was exhibited at the Meeting of the British Association at Liverpool, when it was regarded as probably belonging to a very large fish. Since the reading of this paper Mr. Dawson has sent word that on further search he has met with a fragment of a spine like that found by Mr. Poole, and numerous scales of apparently large ganoid fishes in the rubbish-heap of the coal-seam referred to. —ED. Q. J. G. S.

† Late of the Albion Mines; now of Alvaston, Derbyshire.

A transverse section was taken from about the middle of the large tooth, and exhibited the usual labyrinthic structure: rather less complex than in the *Labyrinthodon Salamandroides.*

The character of the exterior surface of the cranium was indicated in the specimen originally submitted to me by the impression it had left on the coal, when that substance was plastic: some of the present fragments show the surface itself, and demonstrate the pitted reticulate character which is so common in the Labyrinthodonts.

All the additional evidence thus derived corroborates the inference from the first portion of the present fossil skull, that it belonged to a Labyrinthodont Reptile.

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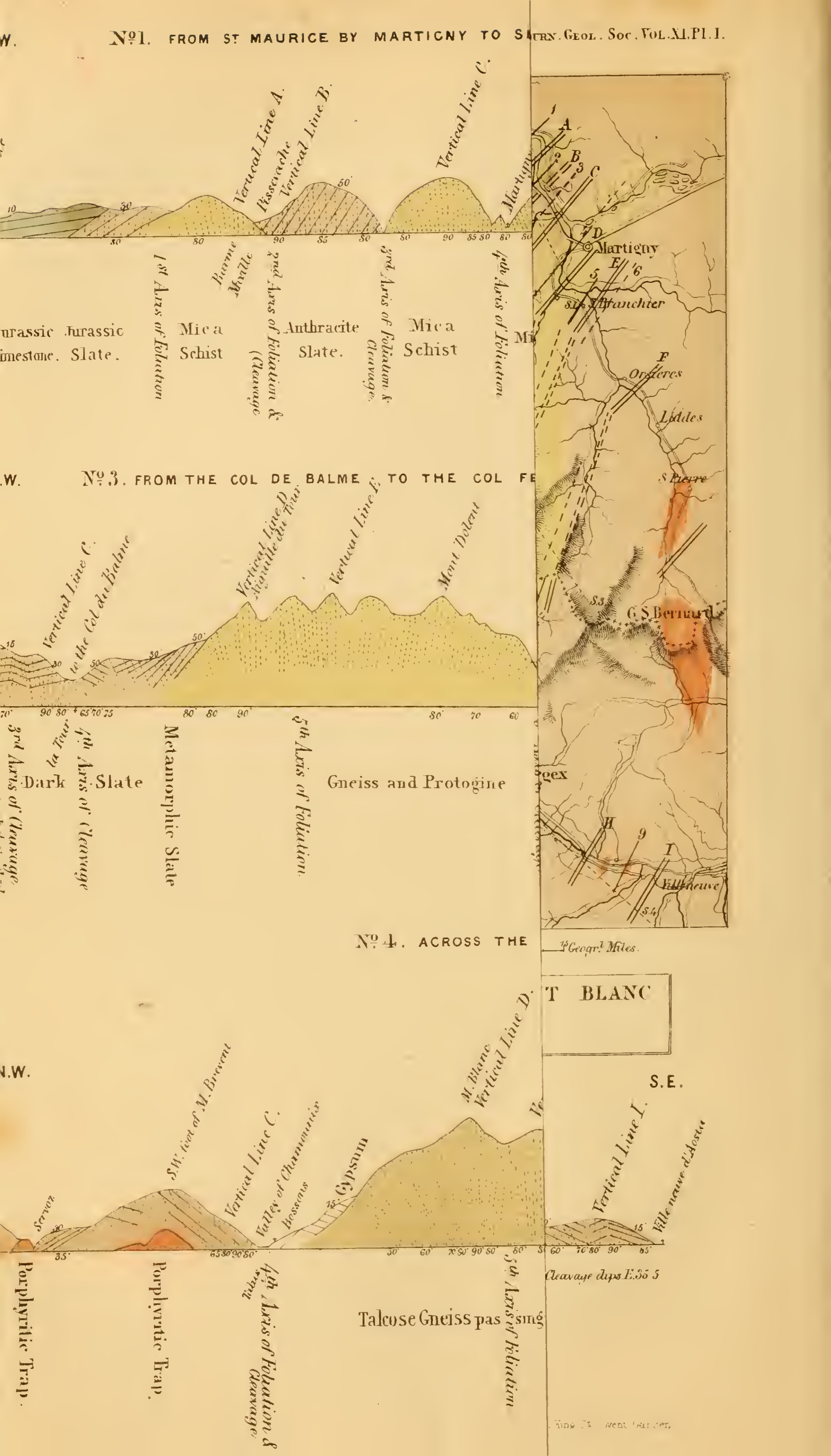
4. *On a Specimen of* Nummulitic Rock *from the neighbourhood of* Varna. By W. J. Hamilton, Esq., Pres. G.S.

In offering to the Society the accompanying specimen of Nummulitic Limestone from Buyuk Aladyn in the neighbourhood of Varna, I am desirous of making one or two observations respecting its occurrence. The specimen was forwarded to me by my brother, Col. F. W. Hamilton, Grenadier Guards, who, in a first communication (since published in the Literary Gazette, July 29, 1854, p. 690), expressed an opinion that the hollow depressions which occur abundantly on the surface of these limestone hills were the result of artificial excavations, and that the columnar-looking rocks which remain standing in the middle, were the pillars by which the roof was originally supported. In a subsequent letter he observes that the hollow depressions occur in so many parts of the country on the limestone plateau, that he believes he must give up his former opinion that they are artificial, and look upon them as natural depressions.

On referring to Boué's 'Esquisse Géologique de la Turquie d'Europe' (Paris 1840), I find that, after mentioning the fact of the vast development of the cretaceous formations in Turkey (p. 17), he alludes to the occurrence in Bulgaria of enormous masses of *Orbitolites,* constituting a portion of the nummulitic group. Further on (p. 21), he observes that the upper beds of these cretaceous rocks are full of *Orbitolites,* to which he has given the name of *O. Bulgarica.*

He also alludes to the great prevalence of caverns and grottos in some portions of the cretaceous beds of Turkey in Europe, many of which have assumed the form and appearance of a funnel (*entonnoir*). He believes them to be all natural, and to be owing to the different degrees of hardness of the different beds of rock. Some are described as occurring on the surface of the plateau, probably resembling, though on a smaller scale, those seen in the Carst near Trieste.

I have placed on the table for the purpose of comparison, a specimen of Nummulitic Rock from the centre of Asia Minor. I obtained



Quart. Geol. Soc. Vol. XI. Pl. I.
W.
Nº 1. FROM ST MAURICE BY MARTIGNY TO S
Vertical Line A.
Pissevache
Vertical Line B.
Vertical Line C.
1st Axis of Foliation
Barme
Mieville
2nd Axis of Foliation & (Cleavage
3rd Axis of Foliation & Cleavage.
4th Axis of Foliation
urassic Limestone.
Jurassic Slate.
Mica Schist
Anthracite Slate.
Mica Schist
W.
Nº 3. FROM THE COL DE BALME TO THE COL FE
Vertical Line C.
to the Col de Balme
Vertical Line D.
Vertical Line E.
Mont Dolent
3rd Axis of Cleavage
4th Axis of Cleavage
Dark Slate
Metamorphic Slate
5th Axis of Foliation.
Gneiss and Protogine
Nº 4. ACROSS THE
T BLANC
N.W.
S.E.
Servoz
S.W. foot of M. Brevent
Vertical Line C.
Valley of Chamounix
Bossons
Gypsum
M. Blanc
Vertical Line D.
Vertical Line I.
Villeneuve d'Aoste
Porphyritic Trap.
Porphyritic Trap.
4th Axis of Foliation & Cleavage
Talcose Gneiss passing
5th Axis of Foliation
Cleavage dips E.35 S
A
B
C
D
Martigny
E
S. Branchier
F
Orsieres
Liddes
S. Pierre
G. S. Bernard
H
I
Villeneuve
Geogrl. Miles.

it from a spot near the sources of the Mæander, where that river bursts forth in the market-place or *agora* of Celænæ, as described by Strabo, evidently after a subterranean course under the mountains, the river having previously disappeared at the foot of the hills in a more elevated plain on the N.E. side of the mountains.

The two specimens show both in lithological appearances and organic character a very remarkable resemblance. Even the species of Nummulite appears to be the same, thus affording another link in that vast chain of nummulitic formations which extend almost from the west of Europe to the northern provinces of India. In the Varna specimen Mr. T. R. Jones has made out an *Orbitoides* (*Orbitolites* of some authors), which is probably identical in species with the *Orbitoides dispansus* of Persia and Scinde.

November 15, 1854.

Francis Galton, Esq. was elected a Fellow.

The following communications were read:—

1. *On the* Structure *of* Mont Blanc *and its* Environs. By Daniel Sharpe, Esq., F.R.S., F.G.S.

[Pl. I.]

Mont Blanc has been represented by Professor James Forbes, in his admirable work on the Alps, as consisting of a mass of stratified granite, in which the strata are arranged in the form of a fan with one vertical axis running through the whole chain: on both sides the granite is stated to overlie a great formation of limestone, its beds dipping under the granite in perfect conformity with the strata of the granite itself, and a similar conformable superposition of granite upon limestone is stated to occur in the Montagne de la Saxe on the east of Mont Blanc*.

The section given by Professor Studer adopts the above views with the following modifications: instead of granite, the chain is stated to consist of protogine flanked by gneiss and metamorphic slates, the beds dipping under these are described as black limestone and slate, and the Montagne de la Saxe as felspar-slate†.

There are two apparent anomalies in these statements which stand in contradiction to the general experience of geologists elsewhere: 1st, the alleged conformity of stratification between the crystalline and the secondary rocks; 2nd, the superposition of the granite or protogine upon the latter. It is of such vital importance to the progress of geology that we should have correct views upon these points, that no apology is needed for a re-examination of the evidence on

* J. Forbes, Travels through the Alps of Savoy, chap. xi., and Topographical sketch, No. 3.

† Studer, Geologie der Schweiz, vol. i. p. 168 to 176, and Section, p. 175.

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which they rest; since the higher the authority on which an error is promulgated, the more pernicious is it to the progress of science.

On a recent visit to the Alps I devoted ten days to the environs of Mont Blanc, to examine the accuracy of the views above stated, and to observe the relations of the foliation of the crystalline rocks to the cleavage of the surrounding stratified slates. The time at my disposal only allowed me to take a hasty view of the principal phænomena; but here, as throughout Switzerland, the higher mountains have long been especial objects of study, and require little re-examination, and it is in the valleys and on the lower flanks of the hills that observations are wanted to classify and work out the position of the secondary rocks. The following pages contain the results of my observations, which, though very incomplete, will help to bring the geology of this interesting district into harmony with our general experience.

The structure of the great chain of Mont Blanc is well seen from the Mer de Glace; by ascending as far as the Jardin we obtain a section of more than three-fourths of the chain, which may be completed by visiting its eastern flank in the Val Ferret; the direction and dip of the rocks which form the intervening ridge being distinctly visible from both sides. Saussure has given minute descriptions of many parts of the chain; Forbes, Studer, and others describe other portions, so that very little remains unknown.

The mineral character of the rocks has been well described*; they consist for the most part of a talcose gneiss, usually containing both mica and talc, which towards the centre of the chain is so slightly foliated as to resemble granite, while on its flanks the more marked foliation brings it to the condition of talc-schist or mica-schist. The less foliated portions have been called *Granit veiné*, *Alpine granite*, and *Protogine*; but there is no natural line to be drawn between these and the more schistose varieties, and a passage may be traced by insensible gradations from the schist to the more massive and granitic rock of the centre†.

Instead of the simple fan-shaped arrangement of the foliation, with one vertical axis, which has previously been attributed to the gneiss of Mont Blanc, I found two nearly parallel lines of vertical foliation running through the whole chain, separated by a narrow, steep anticlinal axis; on the Mer de Glace these lines are about a mile and a half apart, but they diverge a little in their course both to the north and south. Ascending the Montanvert from the valley of Chamounix, the foliation when first seen dips E. 50°, becomes gradually steeper as we ascend till it reaches E. 80° above the little inn; on the Mer de Glace, between the Montanvert and Trélaporte‡, the direc-

* Saussure, § 677; Studer, vol. i. p. 168; Bakewell, Tarentaise, vol. ii. p. 22.

† There is an exception at the angle on the Mer de Glace, where a projecting mass of granite is distinctly separated from the surrounding gneiss.

‡ These points will be found in Professor J. Forbes's Map of the Mer de Glace accompanying his "Travels through the Alps of Savoy." It is necessary to warn the reader that the engraver of that map has laid the line of *True North* to the west instead of the east of the magnetic north.

tion of the foliation changes to N. 15° E., N. 25° E. and N. 30° E., its inclination rising from a dip of E. 25° S. 75° to the perpendicular at Trélaporte, where it strikes N. 30° E.; to the eastward of this spot it dips W. 30° N. 85°, then 80°, again changes to E. 30° S. 80°, thus forming an anticlinal: it again reaches the perpendicular at the Couvercle, with the strike of N. 30° E.: from this point to the eastward the dip is W. 30° N., the inclination gradually diminishing till it reaches 60° on the west side of the Val Ferret. In the intervening ridge which separates the Mer de Glace from the Val Ferret, including the Géant, the Col de Géant, the two Jorasses and the Aiguille de Léchaud, the foliation dips between 75° and 80° (see Pl. I. Sections, Nos. 3 and 4). There is therefore a narrow anticlinal axis in the centre of the chain, with half an arch on each side of it; and the other parts of these arches must be looked for on the other sides of the Val Ferret and Allée Blanche, and of the valley of Chamounix.

Let us now follow the direction of the two lines of vertical foliation just mentioned. The western line, which is seen at Trélaporte on the Mer de Glace, runs S. 30° W. through the Aiguille des Charmoz; if continued in the same direction it would pass through the highest point of Mont Blanc; on the side towards Chamounix the summit is entirely covered with snow, but on the eastern side the rock is less concealed, and it appears, when seen from the Val Ferret, to be composed of vertical masses: we carry the same line through the Aiguilles de Blaitière, du Plan, and du Midi, in all of which Saussure informs us (chap. xviii.) that the foliation is vertical with a strike of S. 35° W. For a short distance further south my information fails me, but on nearly the same line we find the Jurassic rocks of the Col du Bonhomme intersected by a vertical cleavage striking S. 25° W.

The same line of vertical foliation may be traced in the same manner northward from the Mer de Glace; it runs N. 30° E. through the Aiguille du Dru, and N. 35° E. on the western side of the Aiguille du Tour; from that point I can only carry it on conjecturally to meet a line of vertical cleavage striking N. 30° E. through the slate a little west of Sembranchier in the valley of the Drance.

I have not followed the eastern line of vertical foliation to the northward, but I can point out its course for some distance southward; from the Mer de Glace we can see that it runs S. 30° W. from the Aiguille du Moine to the Couvercle; from the southern point of the Tacul it passes S. 25° W. through La Tour Ronde and the second Flambeau to the Vierge: Saussure describes Mont Broglia behind the Glacier de Miage, as composed of vertical mica-schist, striking N.E. and N.N.E. (§ 891), and farther on I found a slaty limestone in the Allée Blanche, above the Lac de Combal, intersected by a vertical cleavage striking S. 35° W., with plates of mica on the planes of cleavage (see Pl. I. Sect. 7), and the Jurassic rocks of the Col de la Seigne are vertically cleaved in the same direction on the continuation of the same line.

The information relating to the parallel chain of Mont Brevent and the Aiguilles Rouges is less complete; but I have reason to believe that, like Mont Blanc, it has a narrow anticlinal axis bounded by two lines, along which the planes of foliation and cleavage are vertical, and outside of which these planes dip towards the central axis: the chain consists of gneiss or protogine, overlaid and flanked by a metamorphic semi-crystalline slate, so that it contains foliated and laminated rocks in contact. But the regularity of its structure has been disturbed by intrusive rocks of more modern date. The following are the details which I collected regarding it. On the west of Martigny the high ridge of mica-schist which intervenes between the Drance and the Trient has an axis of vertical foliation striking N. 30° E.; this axis may be traced on the west side of the ravine leading from Martigny le Bourg to the Forclaz on the road to Chamounix, and it is seen well exposed close to the village of Trient: the river Trient here runs nearly west, and separates the mica-schist just mentioned from the slate of the Col de Balme; on the south side of the valley we find the cleavage of these slates vertical, with a strike of N. 15° E., which changes on the Piedmontese side of the Col de Balme to N. 45° E., and continues with this latter direction till it meets the vertical foliation of the crystalline rocks of the Aiguilles Rouges. Saussure (§ 642 and 646) informs us that the foliation of Mont Brevent is vertical, with a strike to the magnetic north, or N. 19° W., and a little south-west of Chamounix vertical gneiss forming part of the flank of Mont Brevent is seen to strike due N. on the side of the valley; some miles to the S.W., near Bionnay, a metamorphic slate has a vertical cleavage striking N. 30° E., but the rocks in the interval between this point and the foot of Mont Brevent are in great confusion.

M. Studer, p. 162 and 163, states that the structure of the middle of the group of the Aiguilles Rouges is anticlinal; and Saussure, § 552, mentions the vertical foliation of Mont Loguia, and at § 598 and 689, vertical cleavage near Valorsine striking W.N.W.; combining these observations, there is little doubt that the general structure of the chain is that stated above, and that its foliation corresponds to the foliation and cleavages of the hills west of Martigny, which is shown in Section 1, Pl. I.

The Arve, after running S.S.W. through the valley of Chamounix, turns round the foot of Mont Brevent to the N.W., and lays open in a deep ravine a large mass of hard dark felspathic rock*, massive in the centre of the mass, but irregularly slaty towards its exterior, which has thrown the neighbouring rocks into great disorder, giving both to the beds and cleavage a strike of about N.W. The foliation of the intrusive rock itself is obscure, but appears to be in concentric curves corresponding to the external form of the mass, a common arrangement in rocks of this class: this rock is seen on both sides of the Arve, and is crossed by the road at the highest point of Les Montées, a little west of the village of Ouches. A smaller mass of a similar rock is seen a little east of Servoz, equally disturbing the

* Saussure, § 503, describes it as consisting of pierre de corne, quartz, and felspar, with very little mica.

regularity both of the bedding and cleavage in that neighbourhood*. These rocks, and others of similar character occurring in the same chain near Valorsine, are treated by M. Studer, p. 161 and 162, as parts of the crystalline axis of the chain; but their disturbing the regularity of the cleavage planes proves their eruption to be after the lamination had been completed. Now the foliation of the Aiguilles Rouges corresponds so exactly to that of Mont Blanc, as to leave no doubt of these two chains having been formed contemporaneously; and we thus learn that Mont Brevent and the Aiguilles Rouges have been subjected to disturbing influences at a later period than Mont Blanc; an observation of which the full importance will be seen in reference to the beds in the intervening valley of Chamounix, to which we will next proceed.

The section No. 3, Pl. I. shows roughly the position of the beds at the head of the valley of Chamounix on the southern side of the Col de Balme: the rock which rests on the gneiss of the chain of Mont Blanc, at the foot of the Aiguille de Tour, is a metamorphic slate, containing nodules of quartz set in a semi-crystalline mass. These nodules appear not to be true pebbles, but to owe their form, in some degree at least, to metamorphic action; but this is a point of great difficulty. The rock reminded me of the slaty crystalline grits of Cumberland. The bedding is distinct, dipping N.W. 40° to 50°, and the cleavage, equally distinct, dips E. 35°, S. 70° to 80°, in conformity with the foliation of the gneiss on which it rests†.

Upon the metamorphic slate rests a great series of black and dark brown slates dipping 30° to the westward; but on the east side of the Col de Balme the same slates dip 50° to the E.N.E., and on the west side of the Col they dip 30° to the W.S.W., and further on they are thrown into some confusion. The cleavage of the slates forms a regular anticlinal axis at the Col de Balme, and a synclinal axis a little east of the Col; further east it forms another anticlinal, which must be the continuation of the anticlinal axis of the Aiguilles Rouges, mentioned above. At this line the cleavage is thrown into great confusion, which may be seen in some of the little ravines on the descent from the Col de Balme towards La Tour: here again we see proofs of the disturbance caused by a more recent elevation of the Aiguilles Rouges, by which the rocks on the western side of the valley are more affected than those on the eastern side. One of the beds seen near the village of La Tour deserves especial notice; it is a purple slate slightly micaceous, brecciated, with pebbles or masses

* The rocks at the Hospice of the Great St. Bernard and of the Val d'Entremont, near St. Pierre, and also the intrusive rocks in the Val d'Aosta, east and west of Livrogne, appeared to me to be of a similar character to the above: they also strike a little W. of N., and disturb both the bedding and cleavage of their respective neighbourhoods: see Studer, vol. i. p. 205.

† Saussure, § 552, describes a rock near Valorsine as "une espèce de granit veiné, parsemé de nœuds de quartz lenticulaires, posés de plat entre les feuillets de la pierre et parallèlement à eux." This is probably similar to the metamorphic slate on the flank of the Aiguille de Tour. Similar rocks occur in many parts of this district in contact with the gneiss, and their resemblance to gneiss has often proved a source of confusion.

of slate of different colours and consistency, all of which are flattened between the planes of cleavage, showing the pressure to which the rock has been subjected in a direction perpendicular to the cleavage planes*.

Owing to the great accumulation of fragments which have fallen from the mountains and form a steep talus on both sides of the valley, the secondary rocks of the valley of Chamounix are difficult of examination; indeed in many parts there are no secondary beds visible, the detritus of the valley extending up to the base of the crystalline rocks. I had not time to ascend the various ravines which offer a chance of detecting the secondary formations exposed; but in the localities which I examined, I saw nothing to justify the idea that the gneiss really overlies the secondary beds; nor do the descriptions published by preceding observers justify any such conclusion. I am persuaded that the notion has arisen from an approach to conformity in the dip of the foliation of the gneiss of Mont Blanc, along the side of the valley, with that of the beds of stratified rocks, which for the most part dip at various angles towards the chain of Mont Blanc. But this apparent conformity is accidental: the folia of the gneiss owe their position to a deep-seated agency of the nature of which we are ignorant, which produced an arrangement of wonderful symmetry, extending on a uniform plan over a vast area, before the more modern of the beds at Chamounix were formed: the easterly and south-easterly dip of the beds in the valley is due to the circumstance already alluded to, that the chain of Mont Brevent and the Aiguilles Rouges has received a movement of elevation at a later period than Mont Blanc; and in consequence the beds lying between the two chains are higher on the western side of the valley and dip towards Mont Blanc.

The interest attaching to the question, whether the crystalline rocks overlie the secondary formations of Chamounix, makes it necessary to examine the statements on the subject in some detail.

Saussure devotes Chap. 22 to the secondary rocks of Chamounix: he mentions beds of slate, limestone, and gypsum dipping to the S.W. at angles of 28°, 30°, and 45°, and sums up at the end that they are all more modern than the crystalline rocks, adding, "celle du Biolay, § 708, dont les couches sont engagées sous celles de la montagne primitive, semblerait pourtant faire une exception à celle règle." Yet the previous description of the quarry at Biolay here referred to by no means justifies this exception; it is "les couches sont situées précisément comme celles de la montagne primitive à laquelle elles sont adossées."

Mr. James Forbes calls attention to two masses of dark grey lime-

* Saussure in several parts of his Travels, § 841, 848, 850, &c., describes with great minuteness, brecciated slates with amygdaloidal pebbles arranged with their flat sides parallel to the *plans des feuillets*, and in every instance concludes that the *feuillets* indicate the original stratification, and that the rock has been raised from a horizontal to its present vertical position. In the bed at the Col de Balme the bedding cannot be mistaken, as this bed is interposed between others of a totally different character.

stone mentioned by Saussure, § 709 and 710, one of which rests on the flank of the Aiguilles Rouges below the Croix de la Flegère, dipping S.E. 70°; the other, of similar character, is opposite to it on the east side of the valley, forming a little hillock, called the *Côte du Piget*, between the present and the ancient moraines of the Glacier du Bois: the beds dip S.E. 30°, from which he infers that this limestone dips under the gneiss of Mont Blanc (Travels, p. 63). But as the contact of the limestone and gneiss is not seen, the mass being, as stated by Saussure, "entièrement isolée dans le bas de la vallée," the conclusion is evidently not drawn from observation. The assertion that limestone dips under the granite in the valley of Chamounix, is several times repeated by Professor Forbes, but the only points especially mentioned, at pp. 63 and 66, do not justify this conclusion.

M. Necker had previously asserted in general terms that the talc-schists cover the secondary rocks along the whole valley of Chamounix*, but without indicating any precise spots where such superposition was to be seen.

Considerable information relative to the secondary rocks will be found in a very interesting memoir by M. Favre on the Environs of Chamounix, in the Bibliothèque Universelle de Genève for April 1848, in which the author announced his discovery of Jurassic and Anthraxiferous beds resting on the summit of the Aiguilles Rouges. He states that on the west side of the valley of Chamounix a band of anthraxiferous beds rests on the base of the Aiguilles Rouges, overlaid by jurassic beds which are seen on the other side of the valley dipping S.E. 30°, adding, "les schistes cristallins paraissent plonger sous les roches de cristallisation et reposer sur les calcaires dont les couches présentent la même inclinaison." He concludes with great justice, "Il me semble donc que c'est la chaîne des Aiguilles Rouges qui a déterminé le redressement des roches sédimentaires placées dans la vallée de Chamounix. Cette opinion me paraissait d'abord assez extraordinaire, car c'était annuller jusqu'à un certain point l'importance géognostique de l'énorme chaîne protogineuse du Mont Blanc."

It is evident from these passages that M. Favre has nowhere seen the crystalline schists of Mont Blanc lying upon the sedimentary beds in the manner represented in the section which accompanies his memoir. From seeing the jurassic beds at the base of the hill dip towards the schists which form its side, at angles occasionally coinciding with those of the dip of the foliation of the schists, the inference has been drawn that the jurassic beds dip under the schists.

In my Section No. 4, Pl. I., I have shown the position of a mass of gypsum alternating with steatitic clay, which I visited in the Ravine between the Montagne de Taconnay and the Montagne des Forts, near the spot mentioned by Saussure, § 706: the beds dip S. 15°, and are entirely free from cleavage. Another quarry of gypsum, a little south of the foot of the Glacier de Taconnay, offered some

* Études Géologiques dans les Alpes, vol. i. p. 138.

peculiarities of interest; it exhibits the junction of two beds of gypsum of very different characters, separated by an irregular waving line, which is on the whole vertical, striking E. The southern portion is traversed by well-marked planes of cleavage, dipping S. 70°, along which are small folia of talc, giving the mass a grey colour. The northern bed is a pure white gypsum, quite free from cleavage; the annexed woodcut, fig. 1, will give a rough idea of this arrangement.

Fig. 1.

Talcose Gypsum. Pure white Gypsum.

It appears from these sections that there are two deposits of gypsum of very different ages in the valley of Chamounix; the earlier one laminated, the later deposited after the lamination of the rocks was completed. In both these cases the detritus concealed the base of the gypsum.

The lower part of the valley of Chamounix is so much filled up by detritus that I despaired of finding anywhere the central axis of the valley exposed; but since my return I observe that Saussure mentions at § 656, that at Blaitière, to the east of the village of Chamounix, the foliation of the crystalline schists is nearly horizontal, striking N.E., from which spot the inclination gradually increased as he ascended towards Mont Blanc. This observation bears out what I had inferred, that the foliation of Mont Blanc and the Aiguilles Rouges forms together a complete arch, the crown of which runs down the valley of Chamounix.

In Section No. 5, Pl. I., I have given a rough sketch of the position of the bedding and cleavage of the rocks seen in crossing the Col du Bonhomme from Nant Bourant to Chapieux. The Bonhomme is exactly on the southern prolongation of the western line of vertical foliation of Mont Blanc. The section is a most interesting one, and worthy of more time than I devoted to it; but as M. Favre is engaged on the examination of the wild region to the south of Mont Blanc, we may soon hope to see it properly described. The ascent from the West is principally over dark slates of the anthraxiferous series, which form a very irregular and disturbed anticlinal; they are traversed by cleavage dipping usually E. 25° to 30° S., at angles increasing as we ascend the hill from Nant Bourant. These are surmounted by a great series of jurassic beds, in which I noted the following descending series, which, however, was taken down too hastily to be given as more than a rough approximation.

Hard slate, seen at Chapieux ; cleavage well-marked.

Slaty limestone ; cleavage distinct.

Hard quartzose grit, without cleavage.

Black slate of great thickness, with quartz veins along the planes of cleavage, which are wavy, and somewhat irregular.

Quartzose grit, without cleavage.

Grey siliceous limestone, without cleavage.

Rotten black slate, with marked cleavage; on which the Second Cross stands.

Hard grit, free from cleavage.

Soft black shale.

Sandstone and calcareous conglomerate alternating with beds of hard blue limestone, the whole free from cleavage.

Sandstone, with distinct cleavage.

Hard grit, without cleavage.

Hard metamorphic grit, with marked cleavage running up to the *Bonhomme*.

Hard siliceous limestone, without cleavage, probably the base of the jurassic series.

Indurated sandstone passing into quartz rock, with innumerable joints; cleavage obscure; probably the commencement of the anthraxiferous series.

Hard siliceous limestone, free from cleavage, on which stands the First Cross.

Hard quartzose grit, without cleavage.

Black slates.

The jurassic beds all dip either S.E. or E.S.E. from 20° to 30°; their cleavage is vertical on the top of the Pass, and dips N. 30° W. at regularly decreasing angles from the top to the Second Cross, where it forms an anticlinal. The strike of the cleavage varies from N. 25° E. to N. 60° E.

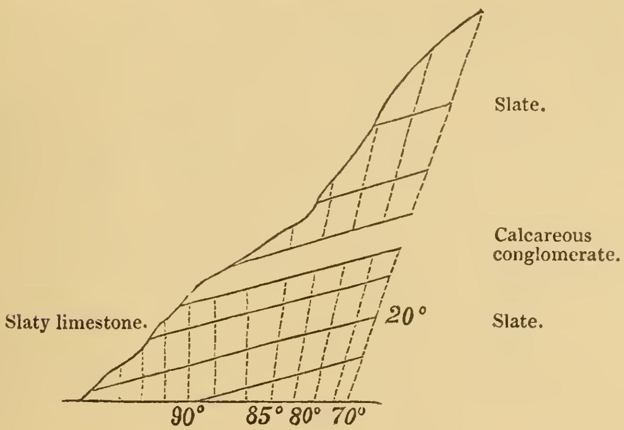
I should not have offered a section so hastily drawn up, but for the interest attaching to the arrangement of the cleavage planes. In the first place it is to be observed, that many of the hardest beds, best able to resist pressure, are quite free from cleavage; while other beds, both above and below them, are so thoroughly cleaved as to be quite slaty. And the intercalation of the compact beds has very little altered the direction of the planes of cleavage in the other beds, which are nearly conformable; though perhaps rather less regularly so than appears in my section. I observed a similar alternation of slaty and compact beds, in many other parts of the Alps, in the uppermost series of beds which exhibit a slaty structure; but nowhere can it be better studied than in the Col du Bonhomme; the force which produced the cleavage acting from below has laminated all the older rocks, but towards the upper limit of its action has only affected those beds whose materials yielded most readily to its influence.

The rocks of the Col du Bonhomme are coloured in M. Studer's Map of Switzerland as jurassic deposits of unascertained age; perhaps attention to the above-described peculiarities of cleavage may enable us to fix their age more nearly. In the passes of the Saanitsch and the Gemmi, and in the neighbourhoods of Meyringen, Grindelwald, and Lauterbrunnen, I observed that all the Lower Jurassic Rocks, and the lower portions of M. Studer's Middle Jurassic Series, were thoroughly intersected by slaty cleavage; that in the middle portion of the Middle Jurassic Division only the softer beds were slaty, the harder beds alternating with them being free from cleavage, and that in all beds above these there was no trace of cleavage. Now it is more than probable that in each district the cleavage took place at one period, and ceased at the same time throughout the district; and that the formation in which only certain beds are slaty is in each case the uppermost subject to the cleavage action. Therefore we may infer that the beds of the Col du Bonhomme are of the same age as those of the Saanitsch, &c., which exhibit similar phænomena of partial cleavage, and which M. Studer has ascertained to belong to the middle part of the jurassic series. Thus geologists will find that the study of slaty cleavage may sometimes give them new and unexpected assistance in determining the relative age of deposits; and this assistance will be found where it is much wanted, in rocks of which the study is rendered difficult from the destruction of other evidence by metamorphic action.

The next point to which I wish to call attention is the conformity between the arrangement of the cleavage planes at the Col du Bonhomme, and that of the folia of the gneiss of Mont Blanc; the section of the cleavage planes gives the same fan-shaped figure as that of the gneiss, and this on exactly the same line of strike; for the plane of vertical foliation which cuts the summit of Mont Blanc, produced along its strike, coincides with that of the vertical cleavage of the Bonhomme; and in the Col de la Seigne, a little east of my section, another plane of vertical cleavage corresponds to the eastern plane of vertical foliation of the Mont Blanc chain. Or, if instead of fixing our attention on the fan-shaped structure, which has too exclusively occupied all Swiss geologists from Saussure downwards, we look to the arches or anticlinal axes, we find that the anticlinal of cleavage planes of Nant Bourant on the west of the Bonhomme corresponds to that of the valley of Chamounix; and the anticlinal on the east between the Bonhomme and Chapieux to the central anticlinal axis of Mont Blanc. This not mere conformity of direction and position of the planes of cleavage and foliation, but actual continuation of the same divisional planes along arches or anticlinals having the same axis, appears to me conclusive proof that the cleavage of the slate and foliation of the gneiss and schists are portions of one great operation, of which we must carefully study the effects, before we can hope to learn its causes or nature.

Let us now turn to the line of valleys, which, under the names of the Allée Blanche and the Val Ferret, bounds the eastern side of the Mont Blanc range. The western side of the Allée Blanche is in a great measure masked by the enormous moraines of the great glaciers which descend from Mont Blanc, and the various interesting phænomena connected with these somewhat distracted my attention from the geology of the valley; but I sketched the section shown in fig. 2, on the west or Mont Blanc side of the valley, a little above

Fig. 2.



the Lac de Combal. Slates of various characters rest conformably on a bed of calcareous conglomerate, in which the cleavage is very obscure; this rests on a thick formation of slaty limestone, with mica lying on the planes of cleavage. The beds all dip conformably to the S.E. at about the angle of 20°, and are consequently resting upon the gneiss of Mont Blanc. The cleavage strikes N. 25° E., dipping near the mountain towards the E. 25° S. at high angles, but is vertical in the limestone at the side of the valley; this is on the line of the western axis of vertical foliation of the gneiss of Mont Blanc, and connects that line with the vertical cleavage of the Col de la Seigne*. These beds doubtless belong to the jurassic series of the Col du Bonhomme, and may owe their more metamorphic character to their proximity to the gneiss; they cross the valley near the chapel; they are probably separated from the gneiss by a metamorphic siliceous slate, which is seen on the west side of the valley below the Glacier de l'Allée Blanche.

I examined the Piedmontese Val Ferret rather more in detail; the position of the rocks on the north side of the Col Ferret is shown in Sect. 3, Pl. I. A thick bed of quartz rock rests upon the gneiss at

* Saussure, § 845, mentions two pyramidal hills of a similar micaceous limestone near the head of the Allée Blanche with highly inclined beds; he doubtless mistook the cleavage planes for the stratification.

an angle of 60° or 70°; it is irregularly jointed, but neither bedding nor cleavage can be distinguished in it. On this rests a series of slightly twisted beds of dark slates, some of them calcareous, others of a more siliceous nature and with some subordinate beds of slaty sandstone, dipping E.N.E. 60°; at the Petit Ferret the beds form a synclinal axis, up which the footpath runs. From this point to the road up the Grand Ferret, the slates dip N.W. 40°, but on the south side of that pass they dip N.E. 50°*. The anticlinal seen at the Grand Ferret is the continuation of the anticlinal axis mentioned by Professor Forbes, *op. cit.* p. 211, which runs down the whole of this valley, and is continued for a short distance in the lower part of the Allée Blanche.

The cleavage planes are wavy, but on the whole vertical between the two passes; on the western side of the Petit Ferret they dip E. 75°, meeting the folia of the gneiss of Mont Dolent in a steep anticlinal, which is the continuation of the axis of cleavage which runs down the valley, a turn of the valley having here separated the axis of cleavage from that of the strata, which coincide lower down the valley. As the arrangement of the cleavage planes is here very nearly in harmony with that of the district, we may infer that the beds have been very little disturbed since their lamination.

For several miles down the valley there are no stratified rocks on the western side, which is bounded by a steep wall of gneiss, whose foliation dips towards the great chain about 60°; the strike at the head of the valley is N. or N. 10° E.; but lower down it follows the prevailing direction of this district, N. 30° E. On the east side of the valley the slates dip steadily about N.N.E. 50°.

In the lower part of the valley a considerable mass of slate rocks lies on the west side of the valley, forming a low shoulder to the great chain; the beds all dip towards the gneiss, forming an anticlinal axis with the slates on the opposite side of the valley. Their position is shown in Section 4. I climbed the ravine which bounds Mont Frety on the north side of the village of Entrèves far enough to satisfy myself that the slates rest against a steep wall of gneiss. Saussure tells us that he spent a day in the examination of the junction of the schists with the gneiss; he says, § 872, "Les couches s'appuyent contre la montagne;" § 874, "On voit toujours des schists appliqués contre la base des montagnes primitives."

I was glad to find on my return that my view of the relative positions of the gneiss and slates of Val Ferret was thus confirmed by the testimony of Saussure, since it is in direct contradiction to the account given by Prof. J. Forbes, who throughout his 11th chapter repeatedly asserts that the granite overlies the limestone on the west side of the Val Ferret, especially mentioning the limestone beds of Mont Frety as exhibiting this superposition, pp. 210, 212, 222, and 246†. I can only conclude that this dip of the beds of slate

* Prof. J. Forbes, *op. cit.* p. 246, calls all these beds, as well as all the secondary beds of the Val Ferret, limestone. They are principally clay-slates with some subordinate calcareous beds. Saussure describes them minutely, § 862 and 872.

† Professor A. Sismonda also asserts that the protogine covers the calcareous

towards the gneiss, coinciding in direction with the dip of the planes of foliation of the gneiss itself, has led our distinguished countryman to a belief in the actual superposition of the gneiss over the slates.

The same Section, No. 4, Pl. I., shows the position of the beds of the southern extremity of the Montagne de la Saxe, as they are seen on the road from Entrèves to Courmayeur. The upper beds consist of metamorphic semi-crystalline slate, dipping E.S.E. 50°, and resting conformably on a series of black slates with the same dip. The mineral waters of La Saxe rise at the junction of these two slate formations. Prof. J. Forbes describes these beds as granite resting upon limestone, p. 211, and his section, p. 210, shows a thick mass of granite overlying limestone at an angle of 50°. I did not observe any calcareous beds in the lower slates, nor are they mentioned by Saussure, who describes the beds in detail, § 881. But M. Studer has observed them to consist of black slate and limestone, vol. i. pp. 173 and 383, and Section, p. 175. The upper series, however, is undoubtedly a slate, with distinct bedding and cleavage, both conformable to those of the beds below. M. Studer terms it *Feldspath-Schiefer*; Saussure calls it *une roche feuilletée, quartz et mica*†.

The last-mentioned beds abut against a mass of rock of a more crystalline character, which must, I think, be considered gneiss; it forms a low hill, reaching from the village of La Saxe to Courmayeur. The foliation of this mass is vertical, but ill-defined; the cleavage of the slates between La Saxe and Val Ferret dips E. 40° S., at angles diminishing from 85° to 75°, as we recede from the gneiss. Thus the planes of cleavage and the beds both form an anticlinal with a common axis on the line of the Val Ferret, but with different degrees of inclination, and the foliation of the gneiss of the eastern side of the chain of Mont Blanc forms part of the same anticlinal arrangement, showing us that the elevation of the beds of Val Ferret to their present position was contemporary with the elevation of Mont Blanc; for any subsequent elevation of the beds would have disturbed the symmetry of the cleavage planes, as has been the case in the valley of Chamounix.

Instead of crossing the Col Ferret and thus keeping close round the chain of Mont Blanc, I turned down the valley of Aosta and returned to Martigny by the Great St. Bernard. Sect. 4, Pl. I., shows the position of the rocks as far as Aosta, but being drawn from the road, the western portion was taken on the north side of the valley, the eastern end beyond the bridge of Escutira on the south side.

beds at Pra Sec in the Val Ferret. Memoria sui Terreni stratificati delle Alpi, p. 12.

* Saussure adds below, § 881, "Voilà donc des roches regardées comme primitives, qui reposent sur un genre de pierre unanimement regardée comme secondaire. Ces dénominations de primitives et de secondaires sont-elles fautives, ou bien cette superposition monstrueuse des roches primitives sur les secondaires serait-elle l'effet d'un bouleversement? C'est ce que je n'oserais point encore décider." We escape from the horns of this dilemma by answering that the upper rock is not primitive but secondary.

The cleavage planes form a succession of arches or anticlinals, one of which is disturbed by eruptive felspathic rocks near Livrogne*, which also distort the slates and alter their mineral character in the neighbourhood. For almost twelve miles from Val Ferret, nearly to Livrogne, the beds all dip eastward, presenting an enormous succession of slates, which probably include the Anthraxiferous series, the Lias, and the lowest portion of the Jurassic beds. From the general resemblance of these slates, the rarity of organic remains in them, and their deceptive mineral characters, dependent on their degree of metamorphism, I fear that it will be long before our Swiss colleagues succeed in reducing them to intelligible arrangement.

Section 1, from St. Maurice to Sembranchier, following first the valley of the Rhone, then that of the Drance, in both of which the rocks are for the most part well exposed, shows us their relations a little north of the chain of Mont Blanc, and is most instructive with reference to the connexion between the cleavage of the slates and the foliation of the crystalline rocks. Commencing on the north-west, there is an anticlinal axis between St. Maurice and Miville, formed partly of the cleavage of the lower jurassic slates, partly of the folia of the mica-schist, bounded eastward by a line of vertical foliation near Miville, which is probably a continuation of the line of vertical cleavage of Mont Buat. A second anticlinal axis, very narrow and steep, occurs at the Pissevache, and a third at the valley of the Trient, both of which combine the planes of cleavage and foliation. A fourth anticlinal is seen in the foliation of the mica-schist at Martigny, which is the continuation of that of the valley of Chamounix. A fifth anticlinal occurs between Bovernier and Sembranchier, combining the foliation of the mica-schist with the cleavages of the slates; this is the continuation of the central anticlinal axis of Mont Blanc. This section ends here, but the Val d'Aosta section, No. 4, Pl. I., shows a continuation to the eastward of the same arrangement of the cleavage-planes in anticlinals or arches.

The various sections referred to as Nos. 1–5, Pl. I., are drawn on parallel lines across the chain of Mont Blanc, with the view to show the connexion between them; each anticlinal has the same number in every section; and each line of vertical cleavage, or, in the language of the Swiss geologists, each fan-shaped arrangement of the planes is marked by the same letter, commencing in each case on the western side.

In chapter 48, devoted to the valley of the Rhone from St. Maurice to Martigny, Saussure describes all the slate-rocks as vertical, or inclined only a few degrees from the perpendicular†; having taken the planes of cleavage for those of bedding, and regarded the bedding as a series of parallel joints; and this not from inadvertence, for after a careful description and comparison of the two sets of divisional planes, he decides that the more vertical ones are the *couches* or planes of bedding, the more horizontal ones *fentes* or joints; and that the whole mountains have been raised from a horizontal to their

* See Studer, vol. i. p. 205, and note, p. 15, *ante*.

† These slates are shown in my Section, No. 1, Pl. I.

present vertical position, § 1049, 1050, 1065. The same systematic error runs throughout the whole of Saussure's volumes; wherever slates occur, their cleavage is almost invariably represented as stratification. Had this error died with its author, it would not now be necessary to expose it, but unfortunately it has taken deep root in Switzerland, and is to be found in the most modern geological works, leading to accounts of perpendicular beds in many slightly-disturbed districts.

Saussure arrived at his conclusion by the following process, which shows the accuracy of his observations, which, even when his conclusions are erroneous, are always trustworthy and instructive. He starts with this axiom, frequently stated in different terms: "Les pierres feuilletées, de quelque nature qu'elles soient, ont constamment leurs couches parallèles à leurs feuillets." § 1287, also 2326. This, when applied to crystalline rocks, such as gneiss, mica-schist, &c., is perfectly true; their principal divisional planes are invariably parallel to the plates or *feuillets* of mica or talc; so that the direction of the foliation may be seen either in the arrangement of the mica in a hand specimen, or in the apparently parallel divisional planes which intersect whole ranges of mountains. But by the term *couches*, Saussure implies, as he expressly tells us, stratified beds formed of materials successively deposited from a fluid, § 1882, 2314, including in stratified rocks *Granits veinés*, gneiss, and schists primitive and secondary, and therein he confounded the stratification of sedimentary deposits with the foliation produced by crystalline agency.

The next step follows necessarily from these premises: finding in many slates that the cleavage-planes are lined with plates of mica or talc, Saussure concludes that these planes represent the true bedding of the rock; and thus he is led, by a remorseless adherence to his principles, to represent most of the slate-rocks visited as standing perpendicularly on end, until, as he himself tells us in § 1050, he was accused of seeing vertical beds in every mountain.

It is remarkable that Saussure was led into this error from observing the analogy between the foliation of the schists and the cleavage of the slates; this analogy was afterwards forgotten until Darwin convinced himself that gneiss and mica-schists were not stratified, by a process of reasoning similar to that of Saussure, but built on a correct foundation. Coupling the now well-ascertained fact that the planes of cleavage of slate are not due to stratification with his observation that those planes are analogous to the planes of foliation of gneiss and mica-schist, he drew the true conclusion that the foliation has no reference to stratification*. Saussure was at least consistent in his error, which he arrived at from building correct reasoning upon an unsound basis: but no such compliment can be paid to the English geologists, who, after correctly distinguishing cleavage planes from stratification, still continued to class the foliation of crystalline rocks with the latter instead of the former; thus proposing to unite two phænomena of totally different origin,

* Darwin, Geological Observations on South America, chap. vi.

while they separated those which are really analogous, and probably due to one and the same cause.

I have already alluded, p. 12, to one most remarkable feature in the structure of this district, that the crystalline rocks are most massive where their foliation is vertical, and become more and more schistose as its dip recedes from the perpendicular. This was well described by Saussure, § 677, &c., and has struck every observer who has followed him. This structure is the reverse of what occurs in the Highlands of Scotland, where I pointed out that the foliation is usually least marked where the angles of inclination are slight, and most complete where the gneiss is perpendicular or highly inclined*. Nor is this structure universal in Switzerland: it holds good in the chains of the Aiguilles Rouges, Mont Blanc, the Finsteraarhorn, the St. Gothard, Mont Combin, and the Dent Blanche; in which there is also a strong mineral resemblance, all partially consisting of protogine. But the contrary structure is found in the great range of crystalline rocks which extend from Monte Rosa through the canton of Ticino: there, as in Scotland, the centres of the arches of foliation consist of rock as compact as, and frequently more so than their flanks.

This difference of structure produces a corresponding difference in the physical features of the two great chains of the Alps: around Mont Blanc and the Bernese Alps the axes of foliation and cleavage run along deep and narrow valleys, and the harder rock, having its divisional planes vertical, or nearly so, stands out in sharp peaks or *Aiguilles*, often bounded by mural precipices; in the southern range from Monte Rosa to the Lago Maggiore, the central arches of foliation are broad and elevated, constituting a large part of the chain, which has no longitudinal valleys of importance on the line of the strike of the foliation, and the mountains are usually more striking from their massive grandeur than from the elegance of their outline. But I will not now pursue this subject further, as I hope to have opportunities of following it more effectually in future.

Should any geologists be disposed to test in the country here described the accuracy of the observations relating to cleavage and foliation contained in this memoir, or to follow out the same subject in other districts, let them recollect that there are everywhere minor local irregularities arising from various disturbing agencies, which must be overlooked, lest in overwhelming themselves with details, they lose the power of obtaining general views of phænomena which extend over many hundred miles: Saussure, who was a minute observer where minuteness was required, but who knew when to dispense with it, has left us the following warning, "ce n'est pas avec des microscopes qu'il faut observer les montagnes," § 1882.

* Philosophical Transactions, 1852, p. 447.

EXPLANATION OF PLATE I.

Map and Sections to illustrate MR. D. SHARPE'S *Paper on the neighbourhood of Mont Blanc.*

The object of the Map and Sections being to show the direction of the planes of foliation and cleavage, only the principal geological features are represented, and four colours employed.

The Yellow represents all the unstratified foliated rocks; including Gneiss, Protogine, Mica Schist, and Talc Schist.

The Purple represents the stratified Slates; including all the stratified deposits intersected by slaty cleavage.

The Blue represents the beds of Jurassic Limestone, which are free from cleavage.

The Crimson shows the intrusive igneous rocks of more modern date than the cleavage.

The Black lines on the Map indicate the strike or direction of the planes of foliation and cleavage; where they cross the rocks coloured yellow, they represent the foliation; where they cross the purple colour, they show the cleavage. These lines are double where the foliation or cleavage is vertical, single along the central axis of an arch or anticlinal of foliation or cleavage. The angles of inclination of the planes along the axes and between the axes and the vertical planes can be learned from the sections, as the scale of the Map is too small to admit of the intervening planes being laid down. The lines are dotted where they have not been actually observed, but their direction has been inferred either by continuing them from the localities observed, or by drawing them parallel to the strike of the intervening variously inclined planes which have been observed, but which have not been laid down on the Map from want of space.

The ground-plan of the Map is copied from the one-sheet map of the kingdom of Sardinia, reduced by Andriveau-Goujon of Paris from the larger official map.

The Sections Nos. 1 to 5 are drawn on parallel lines across the chain of Mont Blanc, No. 1 lying most to the North, No. 5 most to the South, and their directions are indicated by lines on the Map, marked § 1 to § 5. They are all nearly on the same scale, with the height somewhat exaggerated: the dotted lines represent the planes of foliation and cleavage. Each line of vertical planes of foliation and cleavage is marked by the same letter, and each anticlinal of those planes by the same number; thus all the points marked alike are on the same line of strike, and the lines on the Map are similarly marked.

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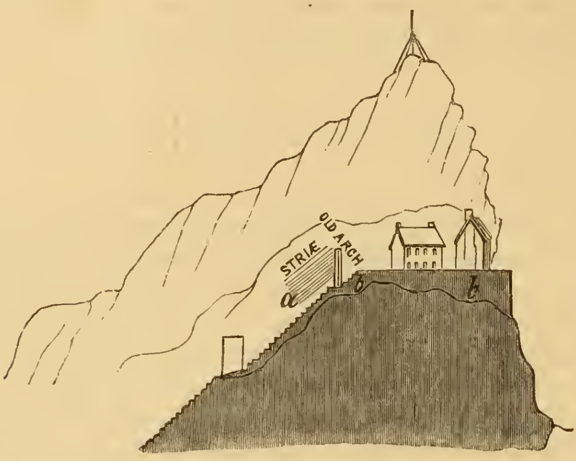
2. *On the Occurrence of* GLACIAL TRACES *on the* ROCK *of* DUMBARTON. By Capt. L. BRICKENDEN, F.G.S., of Dumbarton Castle.

As the very peculiar and remarkable positions in which glacial striæ and abrasions are sometimes observed on the surface of rocks in

Scotland may tend, if carefully examined, to explain the particular mode in which such phænomena have been produced, it is probable

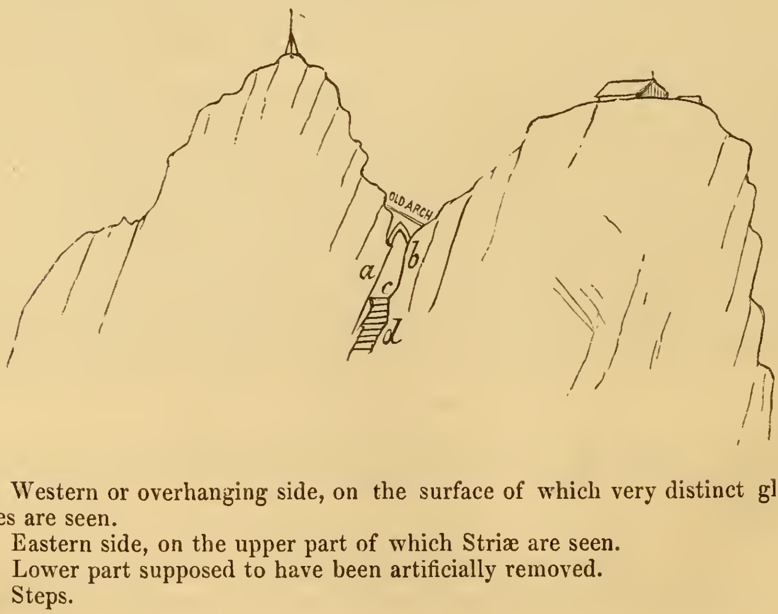
Figs. 1, 2, & 3.—*Sections and Plan of Dumbarton Rock, showing the position and direction of the Glacial Striæ.*

Fig. 1.—*Transverse Section of the Rock of Dumbarton, made in the direction of the Fissure which runs through its centre from North to South.*



a. Western side of fissure on which the Striæ are chiefly seen.
b. Line supposed to indicate the former depth of the fissure, now filled up to form the base of the buildings and barrack-yard.

Fig. 2.—*Longitudinal Section of the Rock, showing the inclination of the lines of fracture, and the corresponding inclination of the sides of the Fissure.*

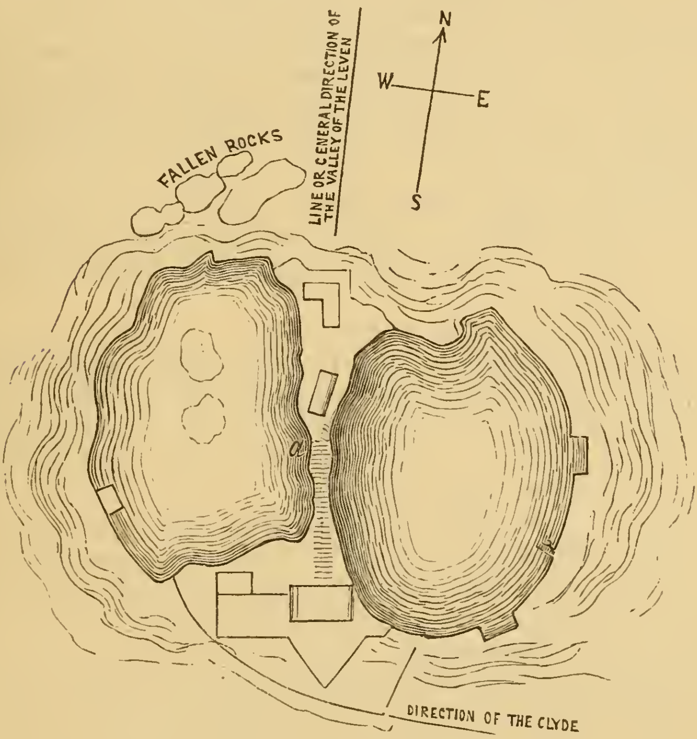


a. Western or overhanging side, on the surface of which very distinct glacial traces are seen.
b. Eastern side, on the upper part of which Striæ are seen.
c. Lower part supposed to have been artificially removed.
d. Steps.

that the occurrence of glacial traces beneath an overhanging rock bordering a fissure at Dumbarton Castle is, amongst others, worthy of being recorded.

The hard whinstone, which here rises up abruptly from the alluvial shores of the River Clyde, exhibits in a very interesting and beautiful manner the crystalline and prismatic structure peculiar to such trappean effusions, but the lines of fracture or divisional planes of the Rock of Dumbarton are observed to incline generally at an angle of about 70°, giving to the Rock on one of its sides a rather precipitous and overhanging appearance. The effect of denudation or abrasion has therefore been to wear or score it in certain parts into fissures, the sides of which have a parallel inclination; and across

Fig. 3.—*Plan of the Rock of Dumbarton Castle.*



a. Fissure.

the centre of the Dumbarton Rock there is one of considerable depth, dividing the hill into two parts or summits, as shown in fig. 2.

It is on the sides of this fissure, which now forms a passage, and the only mode of approach to the buildings on the Rock, that striæ and abrasions are observed, which constitute the subject of this notice.

The fissure intersects the Rock from south to north, pointing directly up the valley of the Leven, through which in the distance appears the lofty summit of Ben Lomond. The wall of rock on the left hand or western side of the fissure about midway up the ascent, inclines over the passage at an angle of about 70°, which is the prevailing inclination of the columnar divisions of the whinstone, and chiefly here on its very hard and durable surface are seen engraved, very distinctly, furrows and striæ; indicating the full force of the propelling agent and its instrumentality, whatever that may have been, in the most contracted and cavernous part of the fissure. On the opposite or eastern side it appears that the rock has been artificially removed at some time for the purpose of widening the passage, which even now does not exceed 10 feet in width; but on the upper part very well-defined scratches are seen to maintain a direction corresponding to those on the western side. The striæ are not horizontal, but run in lines nearly conformable to the declivity of the passage. As, however, these striæ are seen on an impending surface of rock, nothing can be learnt from them as to the precise point by compass, from which the abrading agent may have proceeded; and all that we can now perceive of its action is that which was confined within the narrow fissure, into the northern entrance of which it had intruded itself. That part of the Rock on which these abrasions are seen stands above the Clyde at an elevation of about 150 feet, and above this the Rock rises precipitously about an equal number of feet to its highest point.

In the accompanying sketches (figs. 1, 2, 3) are shown, by transverse and longitudinal sections, the form and dimensions of the fissure, both as it now is, and as it probably appeared previous to the period of human history.

The Rock of Dumbarton rears its bold front immediately in the central line of the valley of the Leven, through which the small river of the same name flows in its meandering and alluvial channel from Loch Lomond to the Clyde; and it must at all times have presented a direct barrier or obstruction to whatever has descended in that channel from its highland source.

At the foot of the Rock on its northern side a strong tenacious clay, evidently belonging to the boulder-formation, descends beneath the level of the tide; this is in a great measure obscured by a talus; and at a short distance from the Rock it is covered by the alluvial deposits of subsequent periods. But in this boulder clay we recognize the remains of that extensive glacial detritus which at the conclusion of the epoch of its accumulation very probably existed to a great depth in this part of the Leven Valley, and more particularly where its transport would be arrested by the abrupt escarpment of the Rock.

November 29, 1854.

The following communications were read:—

1. *On a* Pterichthys *from the* Old Red Sandstone *of* Moray. By Captain L. Brickenden, F.G.S.

(Abstract.)

This communication had reference to a species of *Pterichthys*, remarkable for its great size (estimated by the author at 25 inches [average] in length, and 6 inches in breadth), and its peculiarly ornamented and wrinkled surface. The paper was illustrated by drawings, in which the author had made a conjectural restoration of the external bony armour and the lateral appendages of the fish, from the numerous characteristic fragments that he had obtained in the upper division of the Devonian strata, chiefly from the Vale of Rothes.

The central dorsal plate of this species has some resemblance to, but is much larger than Agassiz's figure (Poiss. V. G. R. pl. 30[a]. figs. 17, 18) of the specimen referred by him to *Coccosteus*, but more lately by Sir P. Egerton and Hugh Miller to *Pterichthys* (Quart. Journ. Geol. Soc. vol. iv. p. 310, 311); and the jointed side-spines or "cephalic oars" resemble those referred by Agassiz to the *P. major*, but belong to a very much larger fish.

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2. *On the* Gold-bearing District *of* Coromandel Harbour, New Zealand. By Charles Heaphy, Esq., Commissioner of Gold Fields*.

[Forwarded by His Excellency Sir George Grey, and communicated by the President†.]

Physical Geography of the District.—The Peninsula of Coromandel stretches for about fifty miles in a general direction of N. 30° W. and S. 30° E., and is the northern extremity of a high range which extends from a mountainous centre near the Taupe Lake and Boiling Springs in the interior of the Northern Island of New Zealand. The peninsula forms the eastern shore of the Frith of the Thames, on the western coast of which, about forty miles distant, the Settlement of Auckland is situated.

The peninsula varies in breadth from four to twenty-two miles, and is mountainous in its whole extent; a main range, but very little deflected from a northerly and southerly direction, and of an average height of 1500 feet (the highest summits being about 3000 feet above the sea), runs along its centre, throwing off spurs of inferior heights

* See also a short notice of the gold diggings in this locality, Quart. Journ. Geol. Soc. No. 39, p. 322.

† This communication was accompanied by a large map and landscape sketches of the district; the former with frequent geological indications. A box of specimens was also sent, which are referred to in the memoir.

to the eastward and westward. Detached hills occasionally take the place of the spurs, and the direction of these is in one instance prolonged by a chain of islands extending in a line parallel with the main range.

In several places the continuity of the main range ceases, and detached hills of an equal height flank the gap. A second range, however, rises after the interval of a mile or more, and is prolonged in the general direction of the first.

On the western side of the peninsula the Harbours of Mauaia, Tekouma, and Coromandel are formed by the jutting out of spurs from the central range.

Geology of the District.—In a country covered with so dense a forest as that of the wooded districts of New Zealand, and where there are no artificial cuttings, sections showing the geological structure are but few; and anything farther than a slight sketch of the geology must be the result of more extensive observation than time and circumstances have yet enabled the writer to give to the subject. Judging from what has actually been observed, and without assuming the existence of any rock in a place in which it has not been seen, the following may be stated.

The predominating rock in the whole of the principal range and most of the subordinate hills appears to be a decomposing breccia (Specimens marked A.)*. This breccia, of which variously-coloured granites and red porphyry (Specimens A.*) are the chief components, mainly forms the sides of the range of the spurs, together with the detached hills and outlying islands. The highest points of the main range, generally precipitous crags, are of granite (Specimens B.). Where the water-courses have cut deep into the sides of the ridge, slate (Specimens C.) is exposed, of a blue or dark grey colour, and with a varying dip and strike. Trap and quartzose veins are very prevalent; and indications of copper (Specimens D.), iron (Specimens E.), and silver are common. Quartz veins, of a breadth from half an inch (Specimens J.) to that of 15 feet, traverse the slate and breccia, and generally run in a direction similar to the trend of the main range, of which in some cases they form the crest. Where the spurs from the range follow an easterly or westerly direction, the quartz veins intersect them, still in parallelism with the range.

On the western coast, at distances of 4 and 6 miles from the main range, a granite appears, of a character somewhat approaching to that of gneiss, together with clay-slate. The relation of these formations with the main ridge has not yet been traced.

On the eastern side of the peninsula is an extensive district composed of indurated pumice-sand, which from the rounded form of its grains, and the horizontal position of its layers, appears to have been deposited below the sea, and to have been subsequently elevated. The indentation of Mercury Bay, with its rivers, is the division between this formation and the crystalline rocks of the main range.

To the westward, at a distance of about 30 miles (across the Thames Frith), is the volcanic formation of Auckland; the clay-slates of

* The specimens referred to in the paper are in the Society's Collection.

the Islands of Waiheke and Ponui, however, intervening. In the Auckland district, in a space of about 20 miles square, may be counted thirty or more extinct or quiescent craters, the fires of which appear to have burst up through horizontal clays and sands, in which a scoriaceous ash, in thick beds, was already a component part.

The localities in which gold has been found.—Gold, either in considerable quantities, or in specks, only discernible on carefully washing the sand, exists in the beds of many of the streams of the peninsula. Rich deposits are also found in the clay on the slopes and spurs of the chief mountain range.

The Valley of the Kapanga, and the mode of working.—The gold was first found at the Kapanga stream, which, following a southerly course for about 4 miles, at the foot of the main range, flows into Coromandel Harbour on the western side of the peninsula.

The bed of the Kapanga is rocky; large boulders of quartz and fragments of trap occasionally forming "bars," and causing falls in the stream of 2 or more feet in height. Immediately below these "bars," and on the side where during freshets there is an eddy, is the spot where the deposit of gold is the richest. The diggers, in parties of four or six, with the aid of tackles and levers, haul out the larger fragments, and carefully sift and wash the gravel which lies below them. At a depth of from 5 to 7 feet from the surface the "bed-rock" is generally laid bare, and immediately on this the largest specimens of gold are found. The party excavate, in the manner described, for about twenty yards up the course of the stream, to the fall; then, having turned the water into the hollow so dug, they continue their work on the opposite side of the stream-bed. In this unscientific manner a party working steadily may obtain about a quarter of an ounce per day per man.

The banks of the stream are steep, and covered, as in the whole mountain range, with a thick growth of timber. When wooden troughs are made to conduct the water along at a higher level, and the stream-bed be so left dry, it is very probable that the yield of gold will be much increased.

The gold, however, is not confined to the bed of the stream; the soil on all the flats and banks of the stream, where the ravine is narrow, yields grains of gold on careful washing. In one place, on a slope of the hill about 150 yards from the stream, a deposit was found of such richness as to yield 400*l.* worth of auriferous quartz from the space of eighty square yards. There the gold was discovered in a small runnel of water, amongst the roots of the trees on the surface. Immediately below was a layer, about 10 inches deep, of quartz-grit (Specimens F.), lying on a mass of yellow and blue clay, which in its turn rested on porphyritic breccia (Specimens A.) at a depth of about 30 feet. Upon washing the quartz-grit (Specimens F.), it was found to contain much gold, although the clay around and below yielded scarcely any trace of the metal. The quartz layer dipped at a slight inclination in the direction of the stream below, and pursued its course for about thirty yards on a wavy plane, at a mean depth of 4 feet below the surface.

From the admixture of the quartz-grit (Specimens F.) with partly decayed vegetation, which did not extend into the adjacent clay, it might be inferred that the layer had been the detritus of the bed of a a small rill, the hollow of which had been filled by a subsequent slip of clay from the hill above. Although the fragments of auriferous quartz (Specimens G.) in the layer were perfectly sharp in their angles and presented no appearance of having been rolled, yet, on examining the rock above, scarcely a trace of gold was found. Eighty feet lower down on the hill-side traces of gold had also disappeared. The deposit was entirely local.

Around the spot where the gold lay, and imbedded in the clay, are large boulders of quartz (Specimens H.), the rounded shapes of which bear evidence to their having been much rolled. Specks only of gold are found about them. The crystallization of the quartz (Specimens H.) in these boulders is more perfect than in that containing gold. In the latter (Specimens G.) the quartz has a crumbling appearance, as if decomposing. It is possible that one of these boulders was originally a fragment from an auriferous quartz-vein on the mountain above. Its breaking up might have resulted from frosts, and from the action of the water of the hollow into which it had rolled on a stone rendered less adhesive by the crossing and recrossing of scales of gold through its substance.

The gold is most abundant in the upper part of the valley of the Kapanga, where the stream-bed is narrowed in to a breadth of about 25 feet by the steep sides of the ravine. Lower down, where the valley expands, the gold is so diffused over the soil of the flats as not to pay for working. In the mud-flat where the Kapanga flows into the harbour, specks, or what is termed the "colour," may be obtained by careful washing.

The Mataawai Stream.—The Waiau stream flows from immediately under the main range in a north-westerly direction to Coromandel Harbour. One of its tributaries, the Mataawai, intersects the range in its course at a low level, and reveals a dark grey slate-rock. Gold, ramified through rounded pebbles of quartz (Specimens I.), was found in considerable quantities during the last summer, in the crevices of the slate-rock, below the gravel of the stream-bed. Several specimens weighing about 4 oz. and $5\frac{1}{2}$ oz. were washed, and one was obtained of the weight of $7\frac{3}{4}$ oz. All the gold and auriferous quartz (Specimens I.) in this stream present a rounded surface, such as would be caused by long-continued attrition.

The Karaka.—The Karaka stream, midway between the Kapanga and the Mataawai, also partly intersects the main range, and, like the last-named stream, exposes the grey slate. In this stream only grains of gold have yet been found.

Other localities.—The places already mentioned, together with the granite coast at Otaki and the Manai Creek, where gold has also been "prospected," are on the western side of the main range. On the eastern it exists in the Arataonga and Makirau valleys, and at Kuatunu, under Mount Kenny, 20 miles from the central range. "Prospects" of gold have also been washed on the mountains of the

Thames, a continuation of the same range, at a distance of 45 miles from Coromandel.

Relations of the gold to its matrix, and to the deposits in which it is found.—Where large quartz boulders appear denuded on the surface, gold is generally found in the black sand (Specimen K.) of the adjacent stream. When the gold is found in clay, it is generally in contact with a fragment of the matrix—a brittle quartz, of a grey or amethystine colour. When found in the stream, it is either in pure scales (Specimens O.), or associated with a quartz (Specimens I.) coloured red, apparently by the oxide of iron. It is probable that this combination imparts to it that degree of hardness which causes the stone to withstand the crushing action of the rolling stones of the stream-bed. The purer gold found may have been freed from its more brittle matrix by the attrition.

The gold is but rarely found in contact with the prismatic crystals of the quartz. It is generally ramified with but little regularity through the mass. In some cases where it lay between lamellar plates of quartz it was the richest. In larger fragments (Specimens L.) of the stone the gold existed only in spangles at a distance of an inch or more apart. From this and from other indications presented by the matrix, I infer that the gold in a quartz-vein is diffused where the vein is broad, and concentrated where it is narrow; the quantity of the metal existing in a similar length of the vein under either circumstance being perhaps the same.

The extent of the surface of ground that has been dug over is about 1500 square yards. The depth from which the gold has generally been taken is from 4 to 6 feet.

The total quantity of gold which has been obtained may be estimated at 340 ounces, the chief part of which has been extracted from an auriferous quartz yielding a mean of one-third of its weight of metal.

From the very general diffusion of small particles of gold over the surface of the district, experienced "Prospectors" are of opinion that a large quantity of matrix-gold exists in the mountains adjacent to the diggings. The dense forest and its tangled undergrowth are great hindrances, however, to the exploration of the country; and the large amount of water which, from the moist climate of New Zealand, is everywhere present, together with the looseness of the rock where the gold is found, have prevented the examination being carried to those depths where in the Australian and Californian Gold Fields the gold most abundantly exists.

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3. *On the* GEOLOGY *of the* VICINITY *of* NICE.

By Major CHARTERS, F.G.S.

[This Paper was withdrawn by permission of the Council.]

(Abstract.)

THE author, having first alluded to the geological researches of Sir H. De la Beche * in this district, noticed the more recent additions

* Trans. Geol. Soc. 2nd ser. vol. iii. p. 171 *et seq.*

to our knowledge of the geology of Nice accruing from the observations of the Marquis L. Pareto, Prof. A. Sismonda, and Prof. A. Perez.

The views of the last-named gentleman especially, by whom the proofs of the identity of the divisions of the cretaceous series in that region with those of England have principally been obtained, were brought forward by the author in this communication.

Prof. Perez has studied the structure and succession of the rocks of this district in great detail, and accumulated a large series of fossils; but his only publication on the subject hitherto has been a summary of his observations, read before the Italian Association at Genoa in 1846. Major Charters, having seen many of the principal sites along with Prof. Perez, and conversed much with him, concurs fully in his views.

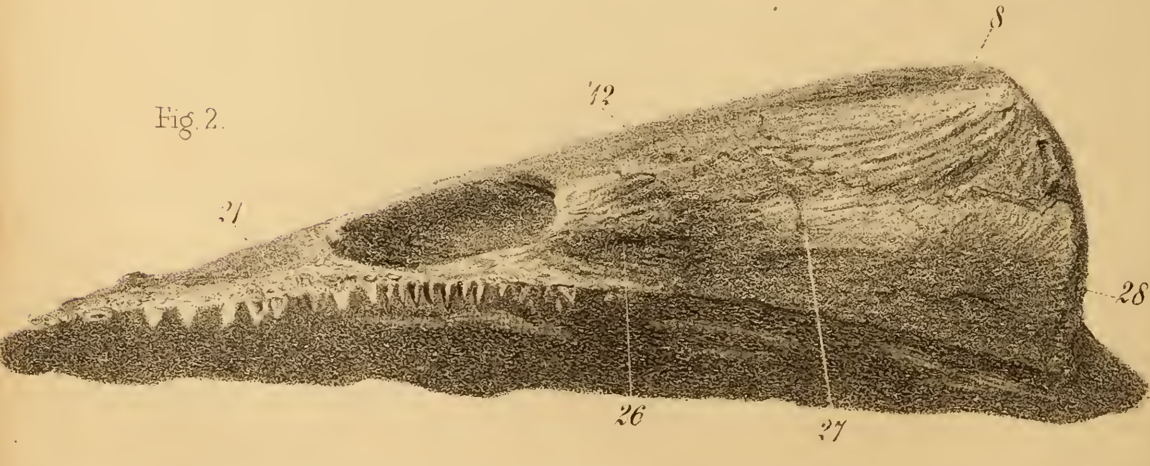
Major Charters described the topography of the district, with its three river-basins and its numerous mountains, and then noticed the geological formations in the following order: — 1. Postpliocene (*quaternaria* of the Italians); 2. Pliocene; 3. Eocene; 4. Cretaceous; 5. Jurassic, including the Dolomite.

This memoir had special reference to the following points of interest:—The separation and definition of the nummulitic and the cretaceous rocks; the subdivision of the latter; the association of the gypsum of the Hill of Cimies with the cretaceous series; and the intimate relation of the dolomite with the Jurassic series.

Major Charters also mentioned his visit to a volcanic district about ten miles west of Nice.

Fig. 1.

Fig. 2.



BRACHYOPS LATICEPS (Owen)·from Mángali, Central India

Jos. Dinkel lith. Ford & West Imp.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

Description of the Cranium *of a* Labyrinthodont Reptile, Brachyops laticeps, *from* Mángali, Central India. By Professor Owen, F.R.S., F.G.S.

[Plate II.]

[This Paper was read June 21, 1854*.]

The fossil obtained by the Rev. Messrs. Hislop and Hunter† from the sandstone series of Mángali, about sixty miles to the south of Nágpur, and transmitted for my examination, is a considerable portion of a skull, wanting chiefly the tympanic pedicles and the lower jaw; it is imbedded in a block of bright brick-red compact stone, with its upper surface exposed. The skull (Pl. II.) is broad, depressed, of an almost equilateral triangular form; the occipital border or plane rather exceeding in extent each lateral border, which borders converge with a slight convex curve to the rounded obtuse muzzle. The breadth of the occiput is 4 inches 9 lines, and the extent of each lateral border of the skull in a right line is 4 inches 6 lines. Most of the cranial bones are impressed by rather coarse grooves, radiating in each from a prominence which indicates the primitive centre of ossification; the intervening ridges being in some parts broken up by communicating grooves into tubercles. The orbits (*o, o*) are entire, of a moderate size, of a full oval form, and situated in the anterior half of the skull. The middle line of the upper surface of the skull is slightly depressed; at the upper and fore part of the skull on each side, there is a smooth continuous groove of a sigmoid form, with a strong curve, convex outwards anterior to the orbit, and with a less strong curve, convex inwards on the inner side of the orbit: between the orbit and the occiput there is on each side a shorter groove,

* For the other communications read at this Evening Meeting, see Quart. Journ. Geol. Soc. vol. x. p. 454, &c.

† See Quart. Journ. Geol. Soc. No. 40, p. 472.

extending from the exoccipital forwards and a little outwards to the postfrontal, where it bends more directly outwards and downwards behind the orbits: these grooves probably lodged large mucous canals. Portions of small, conical, pointed, subequal teeth extend in a single series along the alveolar border of the upper jaw (fig. 2, 21), from the muzzle, along the lateral borders of the fossil, to two-thirds of an inch behind the orbits. At the bases of some of these teeth may be discerned indentations converging from the periphery towards the centre of the dentine.

The entire orbits, closed below by a backward extension of the superior maxillary (21), and the connexion of this bone by a malar (26) and squamosal (27) with the mastoid (8) and tympanic (28), forming a complete zygoma, prove that the fossil did not belong to the class of fishes: whilst the strong points of resemblance which the skull presented to the *Labyrinthodonts*—in its broad and very depressed figure (especially the great breadth of the occiput), in its external sculpturing (especially the number and position of the mucous grooves), in the form and position of the orbits, and in the characters of the teeth—led me to investigate the structure of the deeper part of the occiput which was concealed in the matrix, for the more decisive character which that part of the cranium affords of the batrachian affinities of the singular reptiles to which the Mángali skull seemed by its more obvious characters to be most closely allied.

I was gratified by finding that the occipital bone (which like the rest of the skull was distinguished from the red matrix by its yellow colour) terminated posteriorly in two well-defined subdepressed convex condyles, 2, 2, not so close together as in the great *Labyrinthodon salamandroïdes* (*Mastodonsaurus* of Jaeger), but separated as in the *Trematosaurus* of Burmeister†. A part of the broad atlas (*a*) was found in connexion with these condyles.

The superoccipital region is formed by a pair of bones, 3, 3, each with a slightly prominent centre at the angle between the horizontal and backwardly-sloping part of the occiput: they may represent a divided superoccipital bone, but I cannot trace a suture separating them from the exoccipitals supporting the condyles, where it is represented by Burmeister in the *Trematosaurus*.

External to these is a large bone with a well-marked prominent centre, from which the grooves of the outer surface radiate: on the left side, a part of the tympanic remains in connexion with this bone, which I regard as the mastoid, 8, which bone occupies a similar position in the *Labyrinthodonts*. The parietal bones, 7, 7, continue the cranial walls in advance of the superoccipitals, and show a small oval vacuity in their median suture—the "foramen parietale," as in the *Trematosaurus*: the foramen is situated near the hinder part of the suture: an accessory parietal, 7*, extends outwards from the hinder half of the main body of the bone on each side, to the angle between the superoccipital and mastoid. Traces of a suture seem to show this to be a dismemberment of the parietal: it occupies the place of the bone marked *n*, and called "os temporale squamosum," in the

† 'Die Labyrinthodonten,' 4to, 1849, part i. pl. 1.

above-cited figure of the *Trematosaurus* ; but the true squamosal is always anterior and external to the mastoid in the reptiles in which it is unequivocally present; and it is restricted to its zygomatic place and functions, not becoming a proper cranial bone until the mammalian type is reached. The precise boundaries of the frontal, 7, and the sutures dividing it from the nasals and prefrontals cannot be traced, the skull being abraded at this part. The postfrontals, 12, have their centre as well marked and prominent as in the mastoids, and extend to those bones from the outer and back parts of the orbits. Traces of the malar, 26, and true squamosal, 27, may be discerned on the left side, extending from the slender maxillary beneath the postfrontal, to the tympanic, 28, beneath the mastoid, 8. The bone here called "postfrontal," is the "os orbitale posterius," *i*, of Burmeister, and the name "os frontale posterius" is restricted in the above-cited figure of the *Trematosaurus* to a supplementary bone which is interposed in that Labyrinthodont, as in the present, between the bone marked 12, the parietal 7, and frontal 9, where it forms the inner half of the back part of the orbit. This bone appears to me to be a dismemberment of an unusually developed postfrontal, and both it and the supernumerary bone, 7*, are remarkable departures from the normal cranial structure, characteristic of some, if not of all of the Labyrinthodont batrachians. The marked departure in the form and proportions of the present cranium from those of the equally well-preserved specimens of European Labyrinthodonts, leads me to the conclusion that the Mángali species indicates a distinct subgenus in that group of Reptiles, and I propose to designate the species so represented by the term '*Brachyops*† *laticeps*,' indicative of its peculiar proportions.

Although the abraded and otherwise mutilated state of the skull of the *Brachyops* is such as to prevent my giving a more extended anatomical description of it, and determining more precisely and satisfactorily the boundaries and homologies of the constituent bones, it nevertheless permits so many characters of the skull of the Labyrinthodont Batrachia to be determined, as can leave no reasonable doubt of its true nature and affinities ; and thus the results chiefly required by the geologist, in reference to the probable age of the stratum in which this fossil is imbedded, may have been attained.

DESCRIPTION OF PLATE II.

Fig. 1. Upper view of the skull of the *Brachyops*, nat. size.
2. Side view of the same, nat. size.

† From βραχὺς, *short*, ὢψ *face* ; in reference to the shortness of the facial part of the skull anterior to the orbits.

On the STRUCTURE *and* AFFINITIES *of the* HIPPURITIDÆ.

By S. P. WOODWARD, Esq., F.G.S.

[PLATES III. IV. V.]

[Read May 24, 1854 *.]

CONTENTS.

Introduction.—It is now forty years since Mr. Parkinson, the most distinguished palæontologist of his day, read a paper before this Society, descriptive of some *Hippurites* from Sicily. The paper was printed in the second volume of the 'Transactions' (p. 277); the specimens are yet in the Society's Museum. Mr. Parkinson adopted the notion of Baron Picot de Lapeirouse, that *Hippurites* were chambered shells related to *Orthoceras*, and pointed out the means by which he thought they might have been capable of "raising themselves occasionally to the surface of the sea" (*loc. cit.* p. 282).

Since that time many eminent palæontologists have devoted attention to the subject; but, owing doubtless to the incompleteness of their materials, scarcely two authors have formed a similar opinion, and some of the latest-published views are more improbable than those promulgated by Mr. Parkinson.

The collection of *Hippurites* and allied fossils in the British Museum has been rendered so complete by the liberality of Mr. S. Peace Pratt and Sir Roderick I. Murchison, and by the assistance of Dr. Krantz of Bonn and M. Saemann of Paris, as to leave very little to be desired in the way of additional data. It is due to M. Saemann to say, that some of the most instructive specimens were procured by him with his own hands, and that he was fully aware of their scientific value.

My own observations, so far as they are new, would be scarcely

* For the other communications read at this Evening Meeting, see Quart. Journ. Geol. Soc. vol. x. p. 397.

intelligible if stated alone, and not of sufficient importance to form the subject of a communication to the Society; and it is only upon the express invitation of the President that I have ventured to offer a general summary of a matter so often discussed.

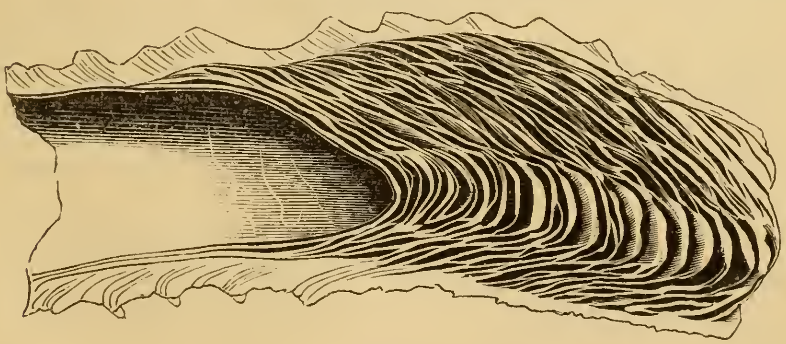
Description of the Shell of the Hippurites.—Hippurites are bivalve shells, which were attached to the sea-bed, and usually gregarious, like Oysters; often adhering together by their sides, or growing one upon the other. They are conical when young; but soon become cylindrical, as they lengthen upwards without increasing in diameter. Some are straight, others curved; one of the most common, *H. cornu-vaccinum*, is shaped like a cow's horn, and attains the length of a foot or more.

On one side there are three longitudinal furrows, extending from the base to the summit; the upper valve is nearly flat, and is perforated by numerous pores; sometimes there are two eye-like depressions, as in *H. bi-oculatus*.

When broken with a hammer, the shell is found to consist of two layers; the outermost is readily detached, leaving a core, which is furrowed lengthwise. The outer layer is compact and dark-coloured; its solidity is caused by the infiltration of carbonate of lime. Specimens, however, from the Chalk of Angoulême are quite porous and brittle. Here the outer shell consists of a succession of corrugated layers; the wrinkles radiate from the inner margin and subdivide and anastomose repeatedly, leaving interstitial pores. By the apposition of these pores in the successive layers, long unequal tubes are formed parallel with the long axis of the shell, and opening on its rim.

The inner layer is white and laminated, like the interior of an oyster-shell, with spaces between the laminæ, like those of the Water-Spondylus, and which are of frequent occurrence in the Oyster

Fig.* 1.—*Section of a fragment of* Ostrea cornucopiæ, *showing the spaces formed by the laminæ in the interior of the shell.*



also. The laminæ are as thin as writing-paper, sometimes vesicular,

* I am indebted to Dr. J. E. Gray, of the British Museum, for the use of the woodcuts, which have been prepared for the 'Museum Catalogue.'

as in *Ætheria*, sometimes wide apart and regular as the septa of an *Orthoceras*; the interspaces are occasionally empty, but are more usually filled with calcareous spar. The whole inner stratum of shell is frequently replaced by crystalline carbonate of lime.

Figs. 2 & 3.—*Sections of* Hippurites cornu-vaccinum, *Bronn.*

Fig. 2.

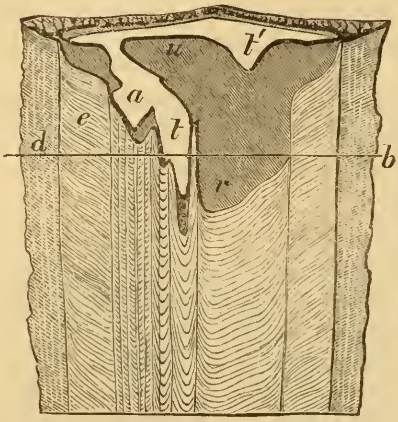


Fig. 3.

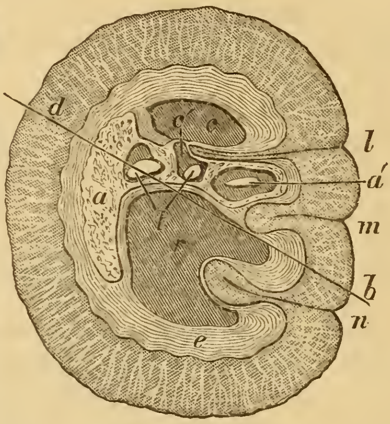


Fig. 2. Upper half of a longitudinal section (½ nat. size), taken in the direction *d, b* of Fig. 3, cutting only the base of the posterior tooth (*t′*).

Fig. 3. Transverse section of a larger specimen (⅔ nat. size) at about the level *d, b* of Fig. 2, cutting the point of the posterior apophysis (*a′*), and showing the peculiar shell-texture deposited by the anterior adductor (*a*): *l, m, n*, duplicatures; *u*, umbonal cavity of left valve; *r*, of right valve; *c, c′*, cartilage-pits; *t, t′*, teeth; *a, a′*, muscular apophyses; *d*, outer shell-layer; *e*, inner shell-layer.

A longitudinal section shows the laminæ of shell filling up the interior nearly to the summit, leaving but a small space for the body of the animal, now occupied by hard limestone.

The upper valve serves as an operculum to close the aperture of the lower valve, and does not thicken with age; its outer stratum is permeated by canals which radiate from the centre to the margin, and give off small branches which appear as pores on the outer surface. The inner layer is always metamorphic and crystalline; it gives off processes which penetrate to some depth the substance of the lower valve.

The *interior* of the lower valve has been figured and described by Goldfuss and D'Orbigny. Goldfuss's figure (Petr. Germ. t. 164. f. 1 *c*, p. 300) has been generally overlooked, perhaps because he described it merely as an example of *Radiolites agariciformis*, "wanting the upper layers."

The British Museum has lately acquired a specimen precisely similar (fig. 4). The inner layer exhibits an irregularly cellular structure, which I have not met with in any other Hippurite, and to which its excellent preservation is probably due. The cells are large, irregular, and empty, like the cellular structure between the laminæ of certain Oysters.

Figs. 4 & 5.—*Upper and lower valves of* Hippurites radiosus, *Desm.*

Fig. 4. Fig. 5.

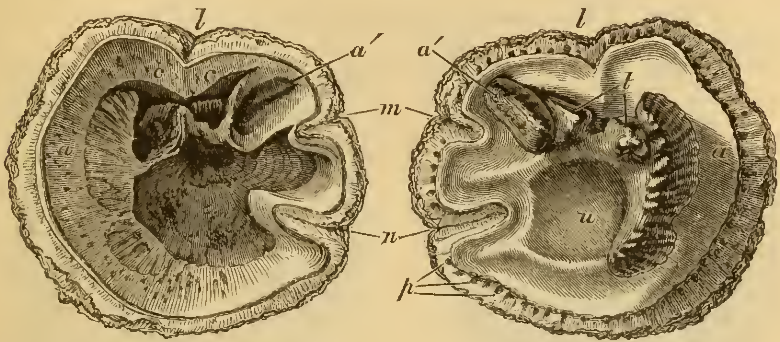


Fig. 4. Interior of lower valve (½).
Fig. 5. Model of upper valve: *a*, *a′*, adductor impressions and processes; *c*, *c*, cartilage-pits; *t*, *t′*, teeth and dental sockets; *u*, umbonal cavity; *p*, orifices of canals; *l*, ligamental inflection; *m*, muscular, *n*, siphonal inflections.

The umbonal cavity of the lower valve is contracted by three ridges, produced by inflections of the outer wall; they correspond to the three furrows on the outside. The first, or *ligamental*, inflection is very slight, and opposite to the centre of the hinge, which consists of two deep dental sockets, divided by a tooth-like process, and separated from the shell-wall by two narrow and deep pits for the internal ligament (*cartilage*). In front of the hinge is a large muscular impression consisting of two portions, and answering to the anterior adductor, which usually consists of two elements in ordinary bivalves. Behind the hinge, and between it and the second inflection, is a deep pit, marked inside with the impression of the posterior adductor muscle. This inflection, therefore, appears to represent the lamina which supports the posterior adductor in the fossil genus *Diceras*, and in the recent *Cardilia*.

The third inflection may possibly correspond to the ridge which indicates the division of the siphonal orifices in some bivalves, such as the *Ledæ* and *Trigonia aliformis*.

In *H. cornu-vaccinum* the form of the interior is rather different (fig. 3) *. See also Pl. IV. figs. 2 and 3. The ligamental inflection is very deep, and the dental sockets are placed across the interior of the shell, instead of parallel with the side, leaving a shallow cavity in front, which may perhaps have lodged the internal ligament, for there are no distinct ligamental pits in the lower valve of this species. Hippurites which have lost their inner layer exhibit either two or three longitudinal ridges, accordingly as they belong to the same division with *H. cornu-vaccinum*, or with *H. radiosus* and *bi-oculatus*.

The interior of the *upper valve* of the Hippurite appears not

* Compare D'Orbigny's figure, Paléont. Française, Ter. Crét. pl. 527. f. 2.

to have been figured or described; but Goldfuss and D'Orbigny have figured a mould of its interior, and I obtained a similar preparation (fig. 7) by removing the upper valve from one of Mr. Pratt's specimens with a hammer and chisel.

Figs. 6 & 7.—*Upper valve of* H. Toucasianus.

Fig. 6.

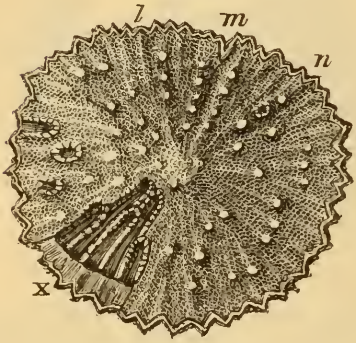


Fig. 7.

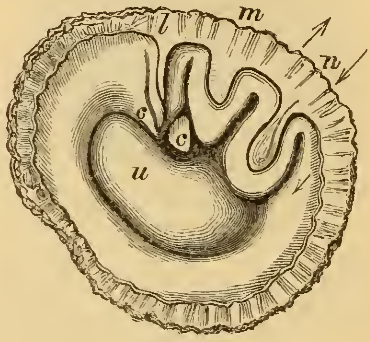


Fig. 6. Exterior of the upper valve ; ½.
Fig. 7. Mould of the interior of upper valve ; ⅔. *l, m, n*, duplicatures ; *x*, fracture, showing canals ; *c*, cartilage ; *u*, left umbo ;—the arrows indicate the supposed direction of the branchial currents.

This mould shows the *umbo* turned forwards, and having a deep furrow on each side, caused by processes from the upper valve. On the dorsal side of the umbo, close to the ligamental inflection, is a small conical elevation (omitted in the figures of Goldfuss and D'Orbigny) representing the cartilage or one of its divisions.

A plaster-cast taken from this mould gives the form of the interior, to a certain extent ; that is to say, it shows the umbonal cavity, the cartilage-pit, a deep furrow winding round the adductor and siphonal inflections, and the *bases* of the hinge-teeth.

With the help of this mould I filled up the umbonal cavity of the other specimen (the lower valve of *H. radiosus*), and then took from it a plaster-cast (fig. 5), which gives what I believe to have been the form of the upper valve with its processes complete.

To test the correctness of this model, I made a number of sections, both transverse and longitudinal, of Hippurites in which both valves were preserved. These show that the two prominent hinge-teeth were extensively under-cut by the umbonal cavity (fig. 8, *u*), so as to appear suspended by thin plates. Each tooth supports a process corresponding in shape to the muscular impressions in the lower valve ; the anterior projecting horizontally ; the posterior vertical and tooth-like, longer indeed than the tooth to which it is attached ; but thinner than in the model, not nearly filling the cavity for its reception (fig. 3, *a'*). Both these muscular apophyses are under-cut, so as not to interfere with the channel which winds round the inflections.

This explanation of the hinge-teeth and muscular processes has been approved of by M. Deshayes, to whom I submitted the specimens during his last visit to England.

Figs. 8 & 9.—*Longitudinal sections of* Hippurites *and* Radiolites: reduced ½.

Fig. 8.

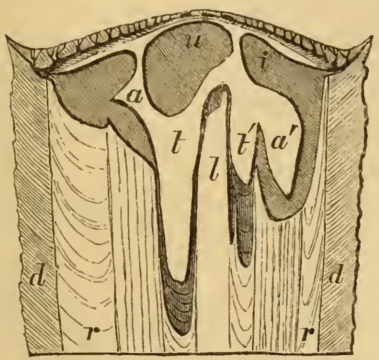


Fig. 9.

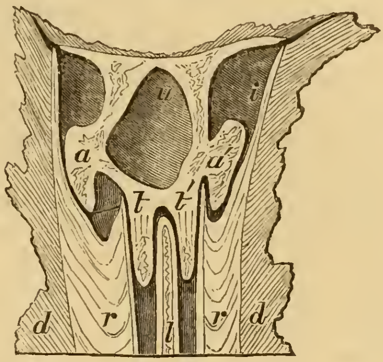


Fig. 8. *Hippurites cornu-vaccinum.* Fig. 9. *Radiolites cylindraceus.*
The sections are taken through the teeth (t, t') and muscular apophyses (a, a'): d, outer shell-layer; r, inner shell-layer; l, dental plate of lower valve; u, umbonal cavity of upper valve; i, intestinal channel.

Hitherto it had been supposed, either that the two divisions of the anterior muscular impression represented both the adductors, or that the posterior adductor occupied the channel between the second and third inflections,—where there is not the slightest indication of it.

Almost the last specimen I have obtained is a genuine *upper valve*, brought by Mr. W. K. Loftus from the Turco-Persian Frontier * (Pl. III. fig. 4). This fossil had been broken by an accidental fall, but enough remained, when the specimen was mended, to show many interesting particulars. Two small portions of the lower valve (s, s) —viz. the summits of the second and third inflections—remain adhering to the lid, surrounded by the channel before noticed, which seems intended to lodge some winding canal, or to allow the passage of a current. This example also shows the base of the posterior tooth (t), the deep conical cartilage-pit, and the curved umbonal cavity. The stony mould of this cavity was detached by the fall, and showed that originally it was covered up halfway by the base of the anterior tooth. The margin is perforated by a single line of circular foramina, the orifices of those radiating canals which are seen in the weathered outer surface.

* See Quart. Journ. Geol. Soc. No. 40. p. 468. For descriptions of the specimens of Hippurites brought home by Mr. Loftus, see the Appendix to this Memoir.

Genera related to Hippurites.

In searching out the affinities of a problematic fossil shell, it is desirable to inquire, first, whether any similar, but less abnormal, forms occur in the same stratum with it, or in formations immediately older or newer. For it may be doubted whether any quite isolated types exist in nature; and, although no well-disciplined naturalist dreams of the transmutation of organic forms, yet by those who regard genera as "ideas of the creating mind," there is held to be a relation of interdependence between those "ideas," as regards their development both in time and space, giving rise to a succession of forms, which may easily mislead a superficial observer to suppose they are related in the way of ancestry or descent.

Therefore, although we disbelieve the doctrine of transmutation, our first inquiry is—Are there any fossil shells which look like the progenitors or descendants of the Hippurite? We think it may be shown, that, by a complete series of cognate forms, the Cretaceous *Hippurites* are connected with the Oolitic *Dicerata* and the Tertiary *Chamæ.*

These forms belong to at least five genera; and some of the species are more problematic and extraordinary than the Hippurite itself.

Radiolites.—The genus most nearly related is the *Radiolites* of Lamarck (*Sphærulites* of De la Métherie).

Figs. 10 & 11.—Radiolites mammillaris, *Matheron.* Reduced $\frac{1}{2}$.
From the Lower Chalk, S. Mamest, Dordogne.

Fig. 10.

Fig. 11.

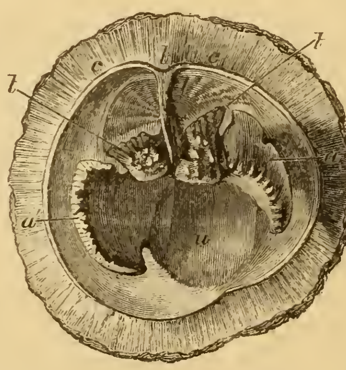


Fig. 10. Interior of lower valve. Fig. 11. Interior of upper valve. (See also figs. 13 & 14.)—*l*, ligamental inflection; *m*, pallial line; *c*, *c*, cartilage-pits; *a*, *a′*, adductor impressions and processes; *t*, *t*, teeth and dental sockets; *u*, umbonal cavity.

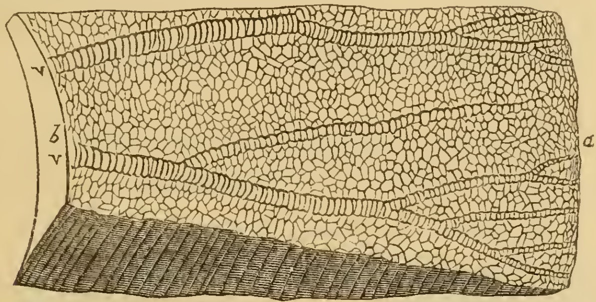
In general form the *Radiolites* resemble the *Hippurites*, but are more squamose or foliaceous externally; and the upper valve is not porous, differing but little in structure from the lower valve*. The

* Mr. D. Sharpe has called my attention to the existence of a third, superficial, shell-layer in all the genera of *Rudista*, similar to the "sub-epidermal" layer, described by Dr. Carpenter, in *Chama* and other bivalves. In the Radiolite (Pl. IV.

ligamental inflection is seldom indicated externally; but in those species which M. D'Orbigny has distinguished as *Bi-radiolites* (fig. 19) there is a peculiarly sculptured tract, or "cardinal area," on each side the ligamental line; and in *R. Fleuriaui* the upper valve is rendered subspiral by a ligamental groove*.

The interior of each valve is nearly symmetrical, but we may infer from the structure of *R. Fleuriaui*, that the Radiolite, like the Hippurite, was attached by the *dextral* valve; an inference which is confirmed by comparing *R. polyconilites* with *Caprotina*. The outer wall or shell-layer of the Radiolite is unlike that of the Hippurite. It consists of prismatic-cellular structure like the shell of the recent *Pinna* †; and in all specimens from chalk strata the cells are *empty*. As the shells of *Pinna, Inoceramus*, and *Belemnites* in the same formations are solid, we may conclude that this difference was original and essential.

Fig. 12.—*Part of the rim of* Radiolites Mortoni, *Mantell, from the Lower Chalk of Sussex. Traced from the original specimen in the Museum of the School of Mines.*



a, the outer edge; *b*, the inner edge; *v*, *v*, the dichotomous impressions.

fig. 1) it forms nearly all that usually remains of the upper valve, and all the squamose ornaments of the lower valve. In the Hippurite it is seldom distinguishable; but is quite distinct in *Caprina* and *Caprinella*. No such layer exists in any of the *Palliobranchiata*. Mr. Sharpe has also pointed out that the long prisms of the middle shell-layer are always parallel with the surface (and not always perpendicular to the laminæ of growth), like the tubes of *Caprina* and *Caprinella*. In the *Palliobranchiata* the slender shell-prisms cross obliquely from the inner to the outer surface, as shown by Dr. Carpenter. (See Davidson's Monograph of the Brachiopoda; Pal. Soc.)—Dec. 30, 1854, S. P. W.

* Specimens of *Radiolites Hœninghausii* which have lost their inner shell-layer present internally strong transverse furrows, or lines of growth, and a prominent ligamental ridge. The interior of the upper valve, when in this condition, shows that the umbo of the young shell was marginal, as represented in Pl. V. fig. 3. I cannot distinguish *R. acutus*, D'Orb., from the young of *R. Hœninghausii*.—Dec. 30, 1854, S. P. W.

† The cells of *Radiolites* from the English Chalk are twenty-five times as large as those of the recent *Pinna*; and those of *Pinna* are 250 times as large as the cells of *Pandora* (Carpenter).

The rim of this species and some others (but not of all the *Radiolites*) is marked with bifurcating impressions, which radiate from the inner to the outer margin (fig. 12). They owe their definition to a change in the form of the cells.

The inner layer of shell is often wanting, being only indicated by a space between the outer wall and the calcareous mould of the original interior. These moulds (figs. 15, 16), called *Birostrites* by Defrance, have greatly puzzled naturalists, especially when imperfect *.

In the British Museum there are several specimens of *R. calceoloides* and *R. mammillaris* in which the inner layer of shell is replaced by spar, whilst the interior was filled with soft chalk, and allowing the separation and development of the valves.

The interior of the lower valve of *R. mammillaris* (fig. 10) exhibits no inflections of the outer wall, or only a slight ligamental ridge; the cartilage-pit is deep and furrowed, and divided by an inflection of the inner wall. The dental pits are deep, subequal, and strongly grooved. The muscular impressions are shallow, striated, and nearly equal.

The interior of the upper valve (figs. 11, 13, & 14) has an umbonal cavity turned towards the hinge, and slightly under-cutting it. In young specimens it is deep and conical, but becomes shallow, or completely filled up, with age. The teeth are straight and prominent, fitting accurately the grooves in the sockets.

Figs. 13 & 14.—*Two side-views of the upper valve of* Radiolites mammillaris, *from the same specimen as* Fig. 11.

Fig. 13.

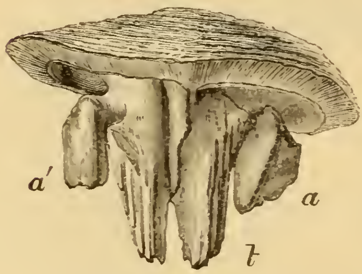
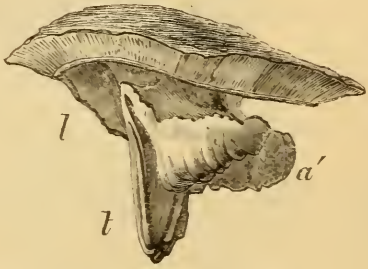


Fig. 14.



l, ligamental inflection; *t*, *t*, teeth; *a*, *a'*, muscular processes.

Each tooth supports a curved apophysis corresponding in form to the muscular impressions in the lower valve. In aged specimens the apophyses nearly rest upon the impressions; they are, however, seldom so prominent as in this species †. There is no longer any

* G. Sowerby figured a *Birostrites inæquilobus* in his 'Genera of Shells,' and rightly regarded it as the mould of a shell related to *Diceras*.

† The specimen of *R. calceoloides* in the British Museum, like that described by M. Deshayes, Bull. Soc. Géol. France, 2 sér. viii. 127, has lost almost all character from its hinge, as bivalves frequently do when aged.

difficulty in comparing the *Birostrites* (figs. 15, 16) and its "accessory apparatus" (*c, c*) with the complete Radiolite; the accessory apparatus representing the great furrowed cartilage and the dental processes.

Figs. 15 & 16.—*Internal mould of* R. Hœninghausii, *Desm.* Reduced ½. *From the Chalk.*

Fig. 15.

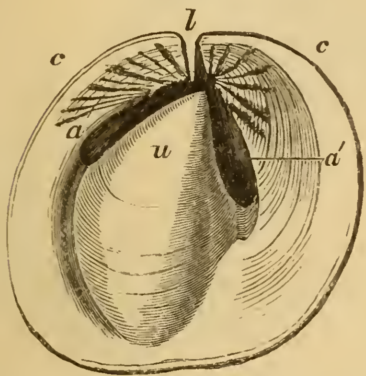


Fig. 16.

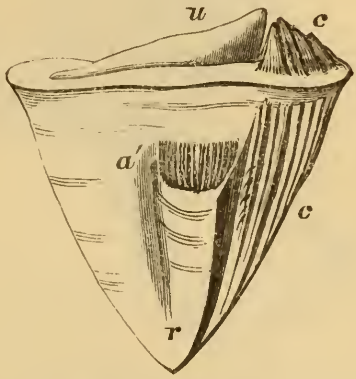


Fig. 15. Upper view. Fig. 16. Side view.

u, u, umbo of left valve; *r*, right umbo; *l*, ligamental groove; *c, c*, cartilage; *a*, anterior adductor cavity; *a′, a′*, posterior adductor.

From the close affinity between the Radiolite and the Hippurite, we must conclude that the tubular structure in the opercular valve of the latter possesses less importance, physiologically, than at first seemed probable.

The presence of canals in the Hippurite and their absence in the Radiolite is paralleled by the difference in the shell-structure of *Terebratula* and *Rhynchonella*, and in the test of *Cynthia* and *Ascidium*.

Caprotina.—Three other genera, *Caprina*, *Caprotina*, and *Caprinella*, are found in the Hippurite-limestone, and are more like *Chama* and *Diceras* in general form. They had an internal ligament, and were attached by the dextral valve, which is straight, whilst the upper valve is oblique or spiral.

In *Diceras*, however deep and spiral the umbonal cavity, there is no indication of septa; but they exist in all the *Hippuritidæ*, and in both valves, whenever the umbones are much produced.

In *Caprotina* the shell-structure is the same as in *Diceras* and *Chama*; the outer layer is solid, and consists of corrugated or obscurely prismatic-cellular layers; whilst the inner layer is subnacreous, and more easily destructible. The lower valve is always striated or ribbed, the upper plain, as in the fossil Oysters of Barton and Woolwich (*O. flabellulum* and *O. pulchra*)*. The hinge resem-

* Several of M. D'Orbigny's *Caprotinæ* present no character by which they can be distinguished from *Chama*; viz. *C. rugosa*, *C. navis*, *C. carinata*, *C. Delarueana*, and *C. Cenomanensis*. The *Diceras inæquirostratus*, Woodw. 1836, Geol.

bles that of the Radiolite in having two prominent teeth in the upper valve; but they are curved, so as to admit of oblique movement.

Figs. 17 & 18.—*Lateral views of the internal mould of* Caprotina quadripartita, *D'Orb.* Reduced ½. From a specimen collected by Mr. Pratt.

Fig. 17.

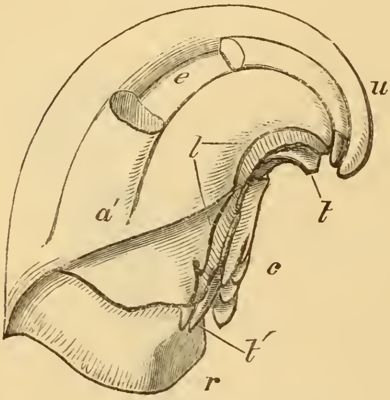
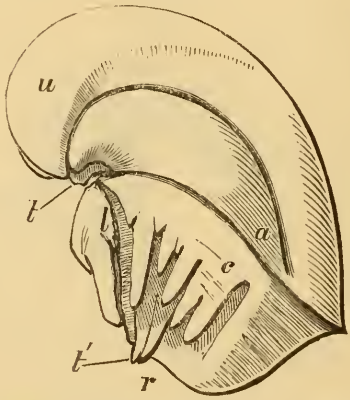


Fig. 18.



u, u, left umbo; *r, r*, right umbo; *l*, ligamental inflection; *c, c*, cartilage; *t, t, t′, t′*, dental sockets; *a, a′*, position of adductor muscles; *e*, portion of the third lobe is here broken away. (The first and fourth lobes, those on each side of the ligamental inflection, appear to be the two divisions of a great internal cartilage like that of the Radiolite, figs. 15, 16, *c, c*.)

Each tooth is supported by a plate, to which the shell-muscles were attached. The umbonal cavity of the upper valve is divided by a vertical plate (as in *Radiolites polyconilites*), so that moulds of the interior are four-lobed, two of the lobes representing the cartilage, and two the divided umbo.

A similar plate divides the interior of the upper (or spiral) valve in *Caprina* and *Caprinella*. In each case it supports the anterior hinge-tooth, but so obliquely that the posterior cavity (or lobe) is much the smaller. The interior of the lower valve is divided into two very unequal cavities by an oblique plate, answering apparently to the muscular inflection of *Hippurites* and *Diceras*. The ligamental cavity in the lower valve of *Caprotina* is subdivided into numerous unequal pits.

Some species of *Caprotina* are long and straight, with small flat opercular valves, like miniature *Radiolites*; they occur in groups, frequently attached to Oyster-shells.

Caprina.—In *Caprina* (figs. 21, 22) the fixed valve has the same structure as in *Caprotina*, whilst the upper is perforated by canals; another proof of the subordinate importance of shell-structure. These canals are simple tubes, extending from the umbo to

Norf. pl. 5. fig. 22 (= *Caprotina*, Morris, "Catalogue," 1st edit., *Caprina Russiensis*, D'Orb. 1845, *Caprotina Russiensis*, D'Orb. 1850, and *Chama cornucopiæ*, D'Orb. 1847), is undoubtedly a *Chama*.

the margin; not branching or communicating with the outer surface, as in *Hippurites*, but opening round the inner edge of the valve.

Figs. 19, 20.—*External views of* Bi-radiolites *and* Monopleura.

Fig. 19.

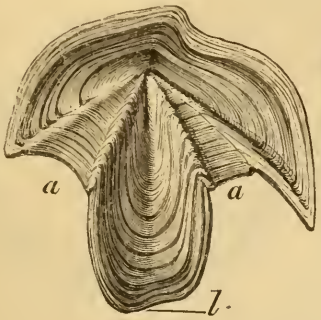


Fig. 20.

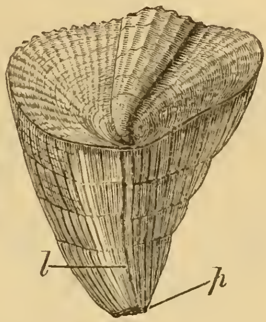


Fig. 19. Upper valve of *Biradiolites canaliculatus*, D'Orb. ($\frac{3}{5}$ nat. size): *l*, position of ligamental line; *a*, *a*, areas bordering ligamental groove.
Fig. 20. Upper and lower valves of *Monopleura imbricata*, Math. ($\frac{1}{2}$ nat. size): *l*, ligamental groove; *p*, point of attachment.

The genus *Monopleura*, Matheron, merged in *Caprotina* by M. D'Orbigny, appears to want the essential features of the latter genus, and at present we have no means of determining whether it belongs even to the same family. The following species may be referred to this provisional genus: *M. trilobata* and *lamellosa* (D'Orb.), *M. gryphoides*, *varians*, *sulcata*, *imbricata*, and *Marticensis* (Matheron), *M. Texana* and *triquetra* (Rœmer).

Figs. 21, 22.—*Interior and Exterior of* Caprina.

Fig. 21.

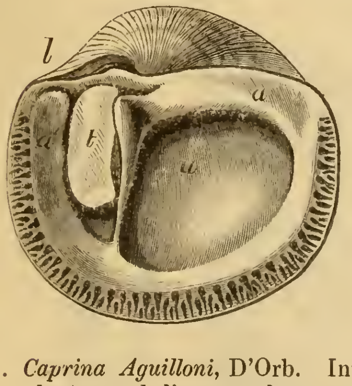


Fig. 22.

Fig. 21. *Caprina Aguilloni*, D'Orb. Interior of left valve: *a*, *a'*, position of adductors; *l*, ligamental groove; *u*, umbonal cavity; *t*, tooth of fixed valve, broken off and remaining in its socket.
Fig. 22. *C. adversa* (after D'Orb.): *c*, point of attachment.

The single tooth of the lower valve is sometimes enormously developed (fig. 21, *t*). The upper valve is convex or spiral. The cartilage is lodged in a shallow groove or in numerous deep pits.

Caprinella.—In *Caprinella* both valves are tubular; indeed the shell is made up of tubes, the inner layer being evanescent, whilst the surface is formed by an extremely thin compact lamina. That the tubes

Figs. 23, 24.—*Sections of* Caprinula Boissii, *D'Orb. From Lower Chalk near Lisbon* (Mr. D. Sharpe).

Fig. 23. Fig. 24.

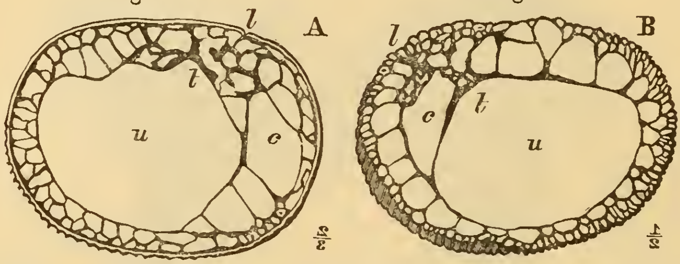


Fig. 23. (A) Transverse section of straight valve.
Fig. 24. (B) Transverse section of spiral valve of a weathered specimen which has lost the outer layer: *l, l,* position of ligamental inflection; *t, t,* teeth; *c, c,* cartilage-pits; *u, u,* umbonal cavity.

were open is proved by the limestone and small shells contained in them; and it is very improbable that even in the lifetime of the animal they were permanently occupied by processes of the mantle. They are rather to be compared to the tubular ribs of *Cardium costatum,* which remain open, simply because the animal does not secrete sufficient lime to render them solid.

Figs. 25, 26, 27.—Caprinella triangularis, *Desm.* $\frac{2}{5}$ nat. size. *From the Upper Greensand of Rochelle.*

Fig. 26. Fig. 25. Fig. 27.

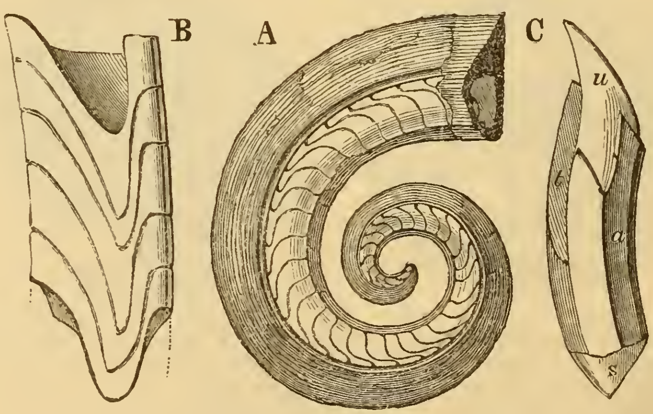


Fig. 25. (A) Portion of the left valve, after D'Orbigny; the shell-wall has been removed by weathering, and the camerated interior exposed.
Fig. 26. (B) Mould of five of the water-chambers.
Fig. 27. (C) Mould of the body-chamber: *u,* right umbo; *s,* left umbo; *t,* dental groove; *a,* surface from which the posterior lobe has been detached.

The *Caprinellæ* have been described, and some new species figured, by Mr. D. Sharpe *, in his memoir "On the Secondary Rocks of Portugal †." I am disposed to agree with Mr. Sharpe in combining D'Orbigny's genera *Caprinella* and *Caprinula*; but there does not appear to have been so many and such regular "water-chambers" in the spiral valve of *Caprinula* as in that of *Caprinella*.

Figs. 28, 29.—*Internal casts of* Diceras *and* Requienia.

Fig. 28.

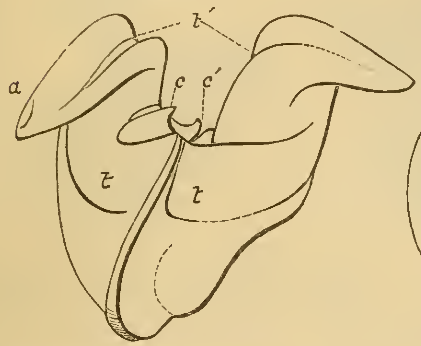


Fig. 29.

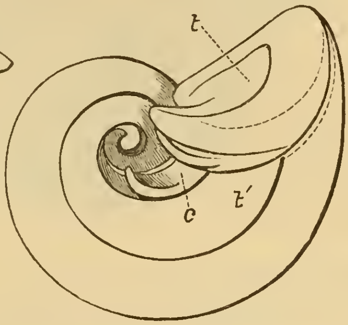


Fig. 28. *Diceras arietinum.* ¼. Fig. 29. *Requienia Lonsdalei.* ½.

a, point of attachment; *c, c, c′*, casts of dental pits; *t, t, t, t′, t′*, furrows produced by muscular ridges.

Requienia.—A still further connecting link between the Hippurite and ordinary bivalves is supplied by the genus *Requienia* (Matheron), of which one species, well known as the *Diceras Lonsdalei*, is found in the Neocomian of Wilts and Spain. M. D'Orbigny has merged *Requienia* in *Caprotina* in his latest publication (*Cours élémentaire Paléont.*), placing it amongst the *Palliobranchiata*; whilst Mr. Sharpe regards it as at best only a subdivision of *Diceras*.

Eight species of *Requienia* are known, ranging from the Neocomian to the Chalk, and found in France, Spain, England, and lately in Texas by Dr. F. Rœmer. They are attached by the left valve, the right being usually much smaller, and sometimes round and concave, as in *R. ammonia*, Goldf. (fig. 31). The interior, however deep and spiral, is not camerated; the hinge, as indicated by casts, must have resembled that of *Diceras*.

The Hippuritidæ and their Geological Distribution.—Excluding *Requienia*, there are four genera,—*Caprotina*, *Caprina*, *Caprinella*,

* The *Caprinellæ* are described by Mr. Sharpe as "probably attached when young by the spiral valve," which is contrary to analogy, and opposed to the observations of M. D'Orbigny. Mr. Sharpe also regards the ligamental furrow as indicative of an external ligament; whilst it is unquestionably a mere inflection of the shell-wall, leading to the cavity of the internal cartilage. In the same description, the oblique plate which divides the umbonal cavity of the straight valve is confounded with the transverse septa which form the water-chambers; whereas it corresponds to the posterior "adductor-inflection" of *Hippurites, Caprotina*, and *Diceras*.

† Quart. Journ. Geol. Soc. 1849, vol. vi. p. 178. pl. 16–18.

and *Radiolites*,—which appear to constitute together with *Hippurites* a natural and well-defined group, possessing the rank of a Family, in the sense in which that term is employed by the most

Figs. 30 & 31.—*External views of* Diceras *and* Requienia.

Fig. 30.

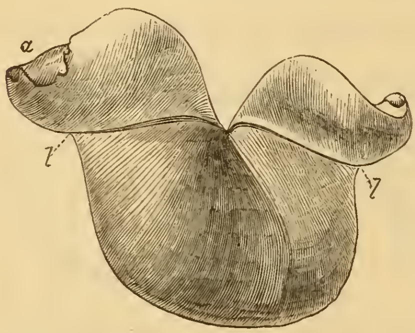


Fig. 31.

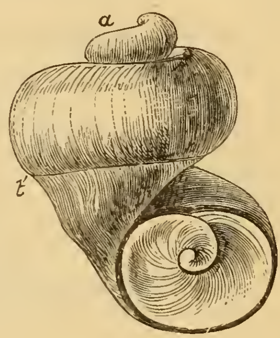


Fig. 30. *Diceras arietinum*, Lamarck. ½. Fig. 31. *Requienia ammonia*, Goldfuss. ¼. *a*, *a*, point of attachment; *l*, *l*, ligamental grooves; *t'*, posterior-adductor inflection.

orthodox conchologists. It includes above 80 species, which are found in all four quarters of the world, and never beyond the limits of the Cretaceous strata.

Like many other groups of animals, it gradually attained a maximum development and then declined. Thus, only 3 species are found in the Neocomian, 13 in the Upper Greensand, 50 in the Hippurite-limestone, and 15 in the Chalk.

Several families of Lamellibranchiate Bivalves were more abundant in the ancient seas than at the present day. The species of fossil *Anatinidæ* are four times as numerous as the recent; and more than half the genera of *Cyprinidæ* and *Trigoniadæ* are lost. But the *Hippuritidæ* form the only instance in which a whole family of bivalve shells has become extinct.

Affinities of the Hippuritidæ.

I. In the work of M. Picot de Lapeirouse (1781), the *Hippurites* are described as *Orthoceratites*; the *Radiolites* as *Ostracites*. This view was adopted by Mr. Parkinson.

II. Von Buch, so late as 1840 (*Leonh. u. Bronn's N. Jahrb.* 1840, p. 573), regarded the *Hippurites* as corals.

III. Prof. Steenstrup, of Copenhagen, announced to the British Association (through Prof. Forbes) in 1850 that they were *Anellides*, allied to the *Serpulæ cymospiræ* of Savigny.

These, however, differ—1st, in being symmetrical and bi-lateral; 2ndly, they have no muscular attachment to their shell; 3rdly, the operculum is not articulated; it is one of two organs attached to the head, of which sometimes one, sometimes the other is developed into an operculum, the second remaining filiform ; 4thly, the shell-structure is different *.

IV. M. Charles Desmoulins (*Bull. Soc. Linn. Bordeaux*, 1827) regarded the *Hippurites* and *Radiolites* as a peculiar order of Mollusca, combining the attributes of the Tunicates and Sessile Cirripedes.

These views appeared less unreasonable at a time when the Cirripedes were supposed to be Molluscous animals. Nevertheless, this was strongly contested by M. Deshayes, and by M. Sander Rang, who gives an excellent summary of the arguments on both sides, in his *Manuel des Mollusques* (1829). He terms the connection of the Hippurites with the Cirripedes and Tunicates "an unnatural association," and says that the arguments for it are contrary to reason and experience. The cellularity of the Hippurite is, like that of a shell, independent of the animal, and not like the tubes of a *Balanus*, which are occupied (as Cuvier showed) by processes of the mantle. The shell of the *Balanus* is conical, and consists of several elements which enlarge independently. Its operculum also consists of several pieces ; and both are symmetrical †.

V. Dr. Carpenter, in his "Report on the Structure of Shells" (*Trans. Brit. Assoc.* 1845, p. 15), expressed his opinion that the *Hippurites* were intermediate "between the *Ostraceæ* and sessile *Balani*." Dr. Carpenter informs me that he was led to think they could not be bivalves, on account of their openly cellular walls ; but the numerous instances of strata of empty cells in both recent and fossil Oyster-shells proves that this character cannot be relied on ‡.

Sir C. Lyell formerly entertained the conviction that the *Radiolites Mortoni* of Mantell belonged to the genus *Conia* (*Mag. Nat. Hist.* 1836, vol. ix. p. 104).

VI. Dr. Goldfuss, at the conclusion of his great work, *Petref. Germ.* (1840), describes the *Hippurites* as *Brachiopoda*, placing them next to *Crania*. Some of the difficulties in the way of this view were, however, unknown at the time.

The essential characters of the *Hippurites*, which separate it from the *Brachiopoda*, are—

1. The shell is composed of three layers, which is not the case in any Brachiopod.
2. The prismatic-cellular structure is like that of *Pinna* and *Ætheria*, and not like that of the *Brachiopoda*.
3. No Brachiopod has a sub-nacreous shell with water-chambers.

* The shell-structure of the *Anellides* has been usually described from preparations of *Dentalium* or *Vermetus*, both of which are Gasteropods.

† *Verruca* is unsymmetrical, only because a portion of the operculum is cemented to the shell, indifferently right or left (*Darwin*). *Tubicinella*, the only cylindrical *Balanus*, is so from its peculiar habitat, in the skin of the Whale ; it is conical when young, but, as the skin of the Whale wears away, the *Tubicinella* also sheds the summits of its valves, and grows downwards deeper and deeper (*Gray*).

‡ Especially the recent *Ostrea purpurea*, Gray, and the fossil *O. vesiculosa* and *O. bellovacina*.

4. The upper valve has a different structure from the lower.
5. Each valve is unsymmetrical.
6. The valves are right and left,—not dorsal and ventral.
7. They are articulated by teeth and sockets,—which is not the case with *Crania*; and the teeth are developed from the free valve;—in all hinged Brachiopods the teeth are in the fixed valve.
8. The *Hippuritidæ* had a large internal ligament (like *Spondylus*) for opening the valves.
9. The muscular impressions are two only.
10. The so-called "vascular impressions" are on the rim of the shell, not in the disk, as in *Crania*, &c.
11. The *Hippurites* have a distinct pallial line.

VII. M. D'Orbigny also regards the *Hippuritidæ* (including *Requienia*) as *Brachiopoda*; but he does not place them with the normal Families, or even with *Crania*. In his latest work, the *Cours élémentaire* (1849), p. 90, he proposes to associate them with the still-existing genera *Argiope* and *Thecidium*, under the term "*Brachiopodes cirrhides*: Cirrhidæ," with the rank of a Sub-order; and describes them as having no oral arms, but a mantle fringed with long *cirri*, performing the function of the *brachia*.

When Prof. E. Forbes returned from the Ægean, he furnished me with specimens of *Argiope decollata*, and with a sketch, from memory, of the oral arms of *A. cuneata*. In some of these specimens I detected a well-developed *loop*, and in others the animal itself. Mr. Davidson, who examined them with me, has published our drawings and notes in the "Introduction" to his Monograph. There is no doubt that *Argiope* is very nearly allied to *Terebratula*, the differences having reference chiefly to the minute size of all the species. *Argiope* has cirrated oral arms, supported by a distinct loop; the mantle-margin is quite simple. We could not ever detect the presence of *setæ*, such as exist in *Terebratula* and *Rhynchonella*.

We have also seen examples of the recent *Thecidium mediterraneum*, which differs from *Terebratula* chiefly in being fixed by the ventral valve, and not by a pedicle. It has a developed loop, supporting cirrated oral arms, and can only be regarded as an aberrant member of the family *Terebratulidæ*. The mantle-margin is quite simple.

VIII. Those authors who have regarded the *Hippurites* as Bivalves, forming a distinct Order (*Rudista*), intermediate between the *Pallio-* and *Lamelli-branchiata*, viz. Lamarck, Blainville, and Rang.

M. Sander Rang adopted this opinion on account of the difficulty of reconciling the supposed characters of the *Rudista* with the known characters of the ordinary *Conchifera*. He could not account for the two holes in the lid of the Hippurite, and the ridges (*arêtes*) inside its lower valve.

The "holes" in the upper valve are only found in a few species (*H. bi-oculatus* and *H. dilatatus*, Defr.); they are mere depressions,—points at which the lid rests on the two posterior inflections of the lower valve.

The "ridges" are the smallest difficulty in the structure of the Hippurite,—indeed they form a strong point of analogy with *Diceras* and *Requienia*.

IX. Those authors who have regarded the *Hippurites* as true Lamellibranchiate Bivalves have not agreed as to their Family-relationship.

Cuvier placed them with the Oysters, to which they present the strongest analogies; but from which they differ in having two adductor muscles.

Prof. Owen adopted Cuvier's view generally as to the position of the *Rudistes* amongst the *Lamellibranchiata*, and pointed out the difficulty of ascertaining their true characters, on account of the general absence of the inner layer "which alone receives the impressions of the soft parts*."

M. Deshayes in his latest work (*Traité élémentaire de Conchyliologie*, Nov. 1848) proposes to include the two families *Ætheriæ* and *Rudistes* in the same group,—thus characterized: "*Animaux irréguliers; manteau ouvert, sans siphons, sans perforations.*"

I am indebted to Dr. Gray for the opportunity of examining the remains of an authentic example of *Ætheria*, brought from the Nile many years since by Sir Gardner Wilkinson. The animal is *entirely apodal*. The body (consisting chiefly of the mass of the liver) has been mistaken for a foot; it projects backwards, as in *Lima* and the Scallop. The gills are subequal, and are united behind the body; they are also united by all their dorsal border to the body and mantle, so as to leave no passage into the dorsal channel and cloaca. The *palpi* are of a form peculiar to the *Iridina* of the Nile and some other *Unionidæ*, viz. semi-oval, attached by the straight side, and receiving the gills between their ample and striated inner surfaces.

Considering the freshwater habitat of *Ætheria*, the pearly interior of its shell, the absence of hinge-teeth, and its analogies with the *Unionidæ*, I cannot but regard it as a very bad type for comparison with the deep-sea *Hippuritidæ*.

Prof. Quenstedt (of Tübingen) in his excellent *Handbuch der Petrefaktenkunde* (1852), has placed the *Hippurites* in a more natural position,—between the *Chamaceæ* and the *Cardiadæ*†.

They resemble *Chama* in being fixed, in the character of the large adductor impressions, and in the well-developed hinge. Three of the five genera further resemble it in the spirality of the upper valve. They also resemble *Diceras* (a member of the *Chamidæ*) in the adductor muscles being supported by prominent plates.

There does not appear to me to be any evidence that the mantle-lobes of the *Hippuritidæ* were free. Important as that character is in Malacology, it is of no avail to the Palæontologist. In the family *Mytilidæ* it is impossible to tell by the shell alone, which of the re-

* 'Lectures on the Invertebrate Animals,' 1843, p. 287.

† The late Prof. E. Forbes also adopted this view, in his lectures at the School of Mines in 1853, after examining the British Museum Collection, as he acknowledged with his wonted generosity.—Dec. 30, 1854, S. P. W.

cent genera have a closed (viz. *Dreissena* and *Modiolarca*) and which have an open mantle (*Modiola, Mytilus*).

Description of New Species.

In conclusion, I am desirous of noticing a few species of Hippurite and Radiolite which appear to be new, or hitherto insufficiently described; the species are in the British Museum.

1. Hippurites Loftusi, n. sp. Pl. III.

Shell inversely conical, or elongated: *upper valve* convex, with about twenty rounded ribs, of unequal length, radiating from the centre; pores very conspicuous, about one-third the diameter of the ribs; canals large, opening in a single series upon the inner margin: *lower valve* furrowed and striated lengthwise; ribs about twenty, obscure, rounded; cardinal side with a few prominent lines of growth; cardinal furrows three, distinct; ligamental inflection deep; dental processes and pits placed across the interior.

Length 4 inches and upwards; diameter 2½ inches and more.

This species belongs to the typical division of *Hippurites*, like *H. cornu-vaccinum*, in which the teeth are placed at right angles to the hinge-line. The pores in the upper valve are larger than in any species I am acquainted with; but, as names derived from comparative characters are inadmissible, I propose to call this fossil after its discoverer, Mr. W. K. Loftus, who obtained it with the three following species from a limestone in the Bákhtíyárí Mountains on the Turco-Persian Frontier.

2. Hippurites colliciatus, n. sp. Pl. IV. fig. 5.

Upper valve unknown: *lower valve* conical, furrowed lengthwise by about twelve unequal rounded channels, divided by prominent acute ribs; cardinal side flattened, with a small rib in the furrows opposite the inflections; shell-wall thick (3–6 lines), with two short and thick inflections; no ligamental inflection; inner shell-layer thickened in the cardinal region, and perforated by two dental pits close to the side.

Length 3 inches, diameter 3 inches.

This species agrees with *H. oculatus* and *radiosus* in having the interior divided by only two duplicatures, and in the dental pits being close to the shell-wall in front of the adductor inflection.

Locality: Bákhtíyárí Mountains.

3. Hippurites corrugatus, n. sp. Pl. IV. fig. 4.

Upper valve unknown: *lower valve* nearly cylindrical, with about ten deep longitudinal furrows, divided by rounded corrugations, each with several small ridges and striæ, slightly tuberculated, and squamose with lines of growth; interior furrowed lengthwise; ligamental inflection angular.

The corrugations of this fossil are not superficial furrows, but are foldings of the shell-wall, and project internally almost as much as the hinge-inflections.

Locality: Bákhtíyárí Mountains.

4. HIPPURITES VESICULOSUS, n. sp. Pl. IV. fig. 6.

Upper valve unknown: *lower valve* conical, furrowed lengthwise with regular shallow grooves (at most 2 lines wide); cardinal inflections scarcely marked externally; outer shell-wall 4 lines thick at most; ligamental inflection deep and very narrow; muscular inflection short, round, and constricted; siphonal inflection deepest; inner shell-layer composed of vesicular plates.

Length (of a fragment) 8 inches, diameter $1\frac{1}{2}$–4 inches.

Locality: Bákhtíyárí Mountains.

5. RADIOLITES MORTONI, Mantell sp. Pl. V. figs. 1, 2.

Upper valve unknown: *lower valve* found usually in groups; inversely conical or elongated, the free surfaces ribbed lengthwise; ribs narrow (about 1 line in breadth), subequal, angular, in pairs or groups; shell-wall very thick, entirely composed of large and regular cells; rim slightly inclined, impressed with a few radiating dichotomous lines in which the cells are transversely oblong; inner layer usually wanting, leaving a smooth cavity, originally partitioned off below into large irregular water-chambers, and furnished with two striated dental pits, close to the side, and separated by a wide interval.

Length of fragment 1 foot, diameter 6 inches; shell-wall 2 inches thick.

Found in the Upper and Lower Chalk of Kent and Sussex *, and in the Upper Greensand of Cambridge and Warminster. A fragment of the rim apparently of this species, from Gosau, measures 4 inches from the inner to the outer edge (British Museum). The *Radiolites Austinensis* of Dr. F. Römer, from Texas, is probably identical (Römer's Texas, t. 6. f. 1).

Radiolites Mortoni is the only British fossil of the family *Hippuritidæ* at present known; it was noticed in 1833 by Dr. Mantell, in his 'Geology of the South-East of England.' In 1836 it was again figured and described by Mr. Hudson (as a *Conia*) in the 'Magazine of Natural History' (vol. ix. p. 104). Several figures are given in the 26th Plate of Mr. Dixon's posthumous 'Geology of Sussex,' but these figures only represent the general form and mode of aggregation, and there is no accompanying description.

Dr. J. E. Gray, who gave an account of these fossils in the 'Magazine of Zoology,' observed the *Ostreæ* and *Spondyli* growing far down their cavities, and remarked that, if there had ever been an internal shell-layer, it must have been removed whilst they were still in the position where they grew on the bed of the sea †. In the

* Remains of this species have been found in the Chalk at Lewes, in Sussex, at Purfleet, Essex, and at Gravesend, Burham, and Lenham, in Kent.

† Magazine of Zoology and Botany, 1838, vol. ii. p. 228.

specimen of *R. Mantelli* in the British Museum, small Oysters were attached to the interior at least 10 inches down the cavity. I find, however, that in Dr. Mantell's specimens a portion of the thin nacreous layer of the Radiolite is preserved beneath these parasitic bivalves.

A very instructive specimen of *R. Mortoni* has lately been obtained by Mr. Matthew Wright from the Upper Chalk of Kent* (Pl. V. fig. 1). It consists of the upper portion of a large cylindrical example, measuring 6 inches across; the cellular tissue is empty, except in two places where nodules of flint seem to grow from it; and the rim is broken, and incrusted with Oysters. The cavity is oval, and occupied at the lower end by a mould of indurated chalk, rather smaller than the cavity; the space between, from $\frac{1}{2}$ line to 3 lines, was filled with very soft ferruginous chalk, representing the inner layer of shell. On one side of the mould are two pairs of longitudinal furrows, indicating projections from the shell-wall, which originally received the dental processes of the upper valve. Part of this mould has been detached, and a reduced side-view of it is given in Pl. V. fig. 2. It is divided into joints by partings of soft chalk, replacing the *septa* of the water-chambers. These septa, as well as the outer wall, had been perforated by *Clionæ.*

The upper end of Mr. Wright's fossil was filled with soft white chalk, on removing which with great care several Oysters and *Spondyli* were found to have grown inside, in places where the nacreous layer was less than half a line in thickness. One of the *Spondyli* bends outwards just at the point where the anterior dental socket is still indicated. The dental sockets are grooved, as in *R. mammillaris* (fig. 10), but are situated close to the shell-wall, and at some distance apart, as in *R. calceoloides.* This species, *R. Mortoni,* is most nearly allied to *R. cornu-pastoris,* Desm., the type of D'Orbigny's genus *Bi-radiolites,* a section the value of which is not yet known.

6. Radiolites Mantelli, n. sp. Pl. V. fig. 4.

Shell elongated, grouped, furrowed and striated lengthwise; furrows large, rounded, divided by acute ribs; rim steeply inclined, radiately striated, cellular near the inner margin; shell-wall thick, finely laminated, the laminæ divided vertically by very close radiating plates, passing into minute cells near the interior; interior smooth, marked by lines of growth and a narrow ligamental furrow: inner layer wanting. Upper valve unknown.

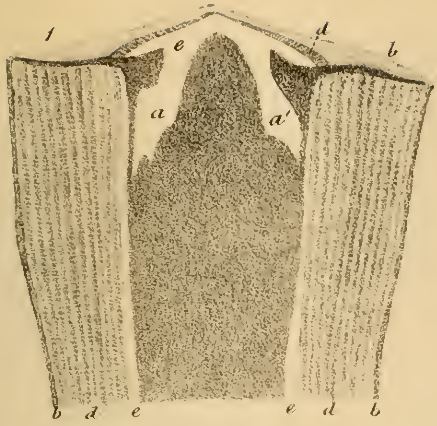
Length of fragment 10 inches.

This species occurs in the Upper Greensand of Cap la Hêve, near Havre; it is very distinct from any species described by M. D'Orbigny, and being likely to occur in England, I have noticed it here, and named it after the distinguished geologist who first discovered *Radiolites* in this country.

* Mr. M. Wright has obligingly informed me that this specimen was found in the Upper Chalk in the quarry to the west of and contiguous to the Rosherville Gardens, in a horizontal layer of flints, at about 30 feet from the surface.

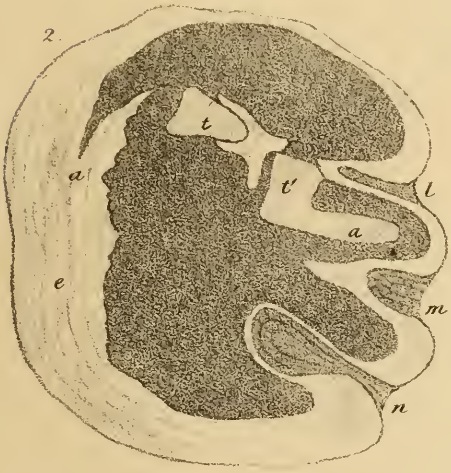
Hippurites Loftusi.

S. P. Woodward del. G. West lith. Ford & West Imp.



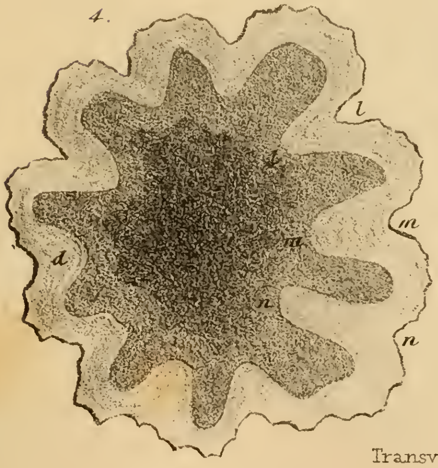
Longitudinal section
Radiolites cylindraceus

Transverse section
Hippurites vesiculosus



Transverse section
H cornu-vaccinum

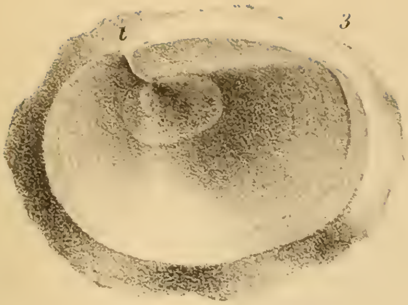
Transverse section.
H. cornu-vaccinum.



Transverse sections

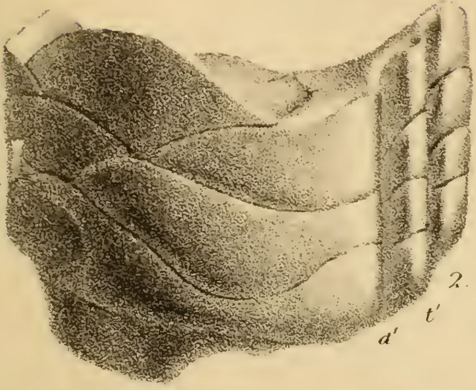
H. corrugatus.

H colliciatus

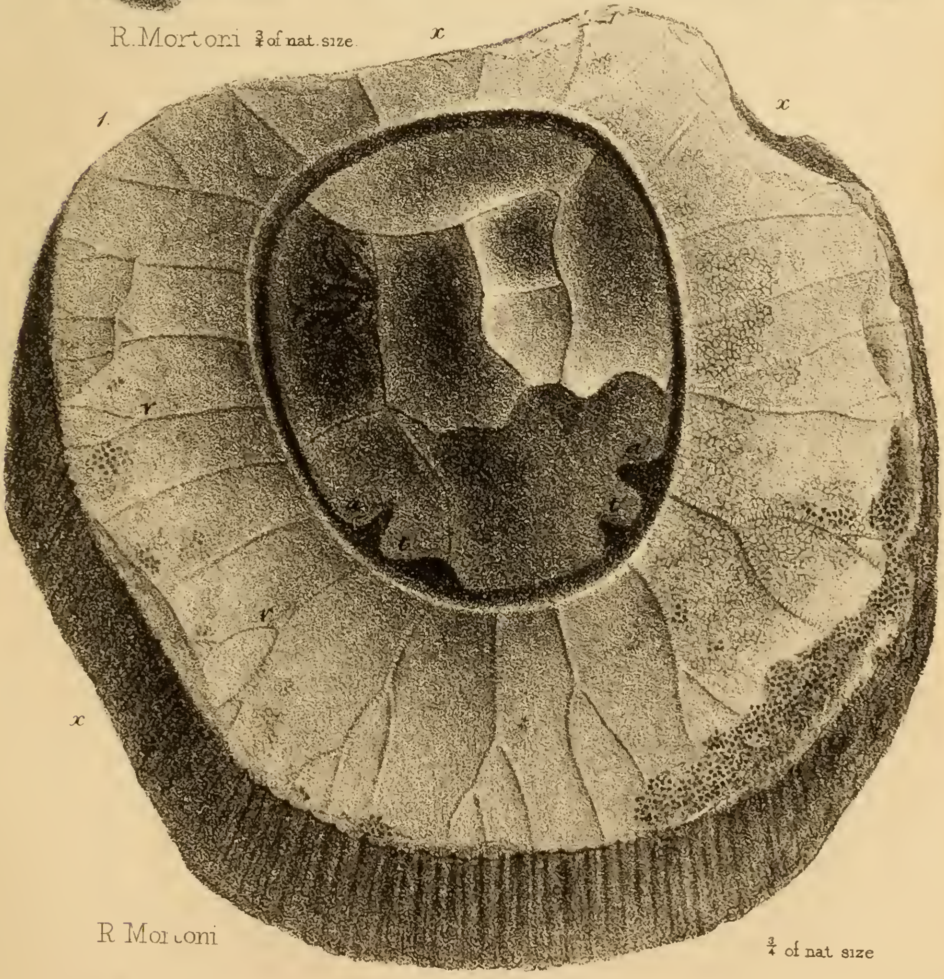


R. acutus. nat. size

R. Mantelli. nat. size



R. Mortoni ¾ of nat. size



R. Mortoni

¾ of nat. size

RADIOLITES.

F. Woodward del. G. West lith.

Ford & West Imp.

EXPLANATION OF PLATES III. IV. V.

Plate III.

Fig. 1. Hippurites Loftusi, *n. sp.*, ½ natural size.
Fig. 2. A small portion of the upper valve, natural size.
Fig. 3. Transverse section of the lower valve, reduced.
Fig. 4. Interior of the upper valve, natural size.

l, m, n. Inflections of the outer shell-wall.
d. Outer shell-wall, with tubular structure.
e. Inner layer of shell, with laminated structure.
t, t'. Teeth, or dental processes, of upper valve.
u. Umbonal cavity.
c. Ligamental pit.
s, s. Portions of the longitudinal ridges (inflections) of the lower valve, broken off and remaining adherent to the upper valve. The arrows indicate the supposed direction of the alimentary canal and branchial currents.

Plate IV.

Fig. 1. Radiolites cylindraceus, *Desmoulins*; upper half of a longitudinal section, in the cabinet of Mr. Sharpe.

a, a'. Adductor processes of upper valve.
b, b. Superficial layer of shell, rarely preserved.
d, d. Principal, or cellular, layer of shell.
e, e. Internal, or subnacreous, layer, replaced by spar.

Fig. 2. Hippurites cornu-vaccinum, *Bronn*; reduced. Transverse section of the lower valve: from a specimen wanting the outer shell-wall; and Fig. 3. Section of the same specimen, lower down.

l, m, n. Inflections of the outer shell-wall (*d*).
e. Inner layer, with finely laminated structure.
a. Position of anterior adductor.
a'. Posterior adductor-process.
t, t'. Dental processes of upper valve.

Fig. 4. Hippurites corrugatus, *n. sp.* Transverse section of lower valve; the interior obscured by crystallization.
Fig. 5. Hippurites colliciatus, *n. sp.* Transverse section of lower valve; *t, t'*, dental pits.
Fig. 6. Hippurites vesiculosus, *n. sp.* Transverse section of lower valve; the interior partly metamorphosed.

N.B. The letters in figs. 4, 5, & 6 have the same meaning as in figs. 2 & 3.

Plate V.

Fig. 1. Radiolites Mortoni, *Mantell*; reduced. A considerable portion of a lower valve, seen from below. In the collection of Matthew Wright, Esq., of Stoke Newington.

x, x, x. Surfaces from which other individuals have been detached.
v, v. "Vascular" markings on the rim of the shell.

Fig. 2. Internal mould (of the same specimen) composed of hard chalk, representing some of the water-chambers of the original shell, perforated by *Cliona*. (See fig. 1.)

r, r. Joints produced by the decomposition of the septa.
a, a'. Furrows produced by the adductor-ridges.
t, t'. Furrows produced by the dental ridges.
(These letters refer to both figures.)

Fig. 3. Radiolites acutus, *D'Orb.* Interior of an upper valve, presented to the British Museum by S. P. Pratt, Esq. The inner shell-layer with its processes is entirely wanting; *l*, the ligamental inflection, showing that the umbo was marginal in the young shell.
Fig. 4. Radiolites Mantelli, *n. sp.* From the Upper Greensand of Cap la Hêve. Fragments consisting of portions of two lower valves, adherent.

i. Inner surface, wanting the inner layer.
l. Ligamental line.
e. External surface.

Additional Observations on the Occurrence of Pipes *and* Furrows *in* Calcareous *and* Non-calcareous Strata*.

By J. Trimmer, Esq., F.G.S.

[Read June 21, 1854†.]

The following observations, which are necessary for the full understanding of the views I have taken on the origin of sand-pipes and furrows in and on the surface of strata, are offered in support of some positions I have taken in my former papers on the subject, and which, from their not having been fully elucidated, require some explanatory remarks in their defence.

1. It was not my intention to assert in a former paper‡ "On Pipes and Sand-galls in the Chalk of Kent" that the Thanet Sands are calcareous, as Mr. Prestwich has been very naturally led to infer in his memoir read before the Society, Jan. 18, 1854, from the expression, "The sand with which the pipes are filled contains much calcareous matter." This calcareous matter was chalk, redeposited near the lining of the pipe from water charged with bicarbonate of lime. Having sent a specimen of it with the paper, I did not think it necessary to enter into fuller explanations.

2. I have stated§ that I saw miniature pipes actually forming by the mechanical action of water on blocks of siliceous sandstone, on the sea-shore near Reculver. Mr. Prestwich replies, that this sandstone contains some carbonate of lime. It appears by Mr. Prestwich's papers‖ on the Eocene Tertiaries, that the cliffs at Reculver yield two sandstones, the one belonging to the Thanet Sands, the other to the London Clay series,—the former calcareous, the latter but slightly so. On blocks of one of these, I saw the flux and reflux of the waves drilling small cavities, analogous to the pipes in the chalk. Mechanical action may take place on calcareous as well as non-calcareous rocks; and it is no proof that the mechanical action which I saw in actual operation was chemical action, even if the stone on which it was taking place effervesces in an acid.

3. With respect to the blocks scattered about the neighbourhood of Faversham, on which there are furrows and pipes similar to those of the chalk, though of smaller dimensions, and which I regard as the completion of the process which I saw in operation on the sea-shore, Mr. Prestwich admits the blocks to be siliceous, but considers the furrows and cavities to be the result of concretionary structure. This is a point which I am content to leave to the verdict of geologists. Even, however, if in this case the appearances on these blocks are of concretionary origin, it is an undoubted fact that pipes are seen occasionally on siliceous rocks, those of the Greensand for instance, and even in sand and gravel.

* See Quart. Journ. Geol. Soc. No. 39. p. 231.

† For the other Communications read at this Evening Meeting, see vol. x. p. 454.

‡ Quart. Journ. Geol. Soc. vol. i. p. 300, &c.

§ Proc. Geol. Soc. vol. iv. p. 7.

‖ Quart. Journ. Geol. Soc. vol. viii. p. 243, &c. and vol. x. p. 125.

Mr. Prestwich exhibited sections of furrows in clay, which he ascribes to the mechanical action of water. But similar furrows in chalk are so intimately associated with pipes, that they must have had a common origin; and, if the mechanical action of water be capable of producing both pipes and furrows, why should we suppose two different causes to have been acting in close contiguity for the production of effects to which one of them is adequate?

4. It has been objected that the vorticose action of water would not drill a hole so deep in proportion to its diameter, as the pipes in the chalk. In order to test the validity of this objection, I filled a precipitating jar, 14 inches deep by $2\frac{1}{4}$ in diameter, with water, putting a little sand at the bottom. These proportions are, in this case, nearly the same as those of a pipe 4 feet in diameter, and 24 feet deep. On stirring the water to the depth of less than half an inch, the whirlpool thus formed speedily extended to the bottom of the jar, and set the sand in motion. This action of water would of itself be capable of removing so soft a substance as chalk, even without the aid of sand and pebbles, leaving the flints undetached and unabraded. The objection is thus obviated which has been raised against my views, from the general condition and position of the flints in the pipes of the chalk which are unabraded and on the sides of the cavity, instead of water-worn and at the bottom of it.

5. It has also been objected, that if water in vorticose motion were capable of boring the pipe, it could not remove the excavated matter. When I saw similar cavities forming on a chalky shore by the flux and reflux of the waves, the chalk removed in the process of excavation was flowing out of the cavity in a milky stream. Whoever will take the trouble of repeating the experiment which I have described above, will find that the vorticose motion, produced in the water of the precipitating jar, raises the finely comminuted particles of sand from the bottom to the upper part of the vessel; and if the bottom of the whirlpool acted upon chalk instead of on glass, and if the mouth of the pipe were immersed beneath a stream of water, not only would a deep and narrow hole be bored in the chalk, but the hole would be cleared of the waste as the drilling of it proceeded.

My papers on the subject of pipes in chalk have been directed against the doctrine promulgated by Sir Charles Lyell, that these cavities are now in the course of formation by the chemical action of rainwater charged with carbonic acid and percolating the strata above them, which are supposed to have subsided, and to be subsiding into the cavities. I have endeavoured to prove that their formation was completed before the matter filling and covering them was deposited.

The views of Mr. Prestwich so far coincide with those of Sir Charles Lyell, that he attributes the formation of the pipes to the solution of the chalk by acidulated water, after the deposition of the strata above them. He considers, however, that they were formed under different conditions of level from the present; and that the operation is not now in progress, except in the case of swallow-holes.

In the preceding remarks I have confined myself to a defence of my own conclusions. The only objection which I shall advance at present against the theory of Mr. Prestwich is, that while it supposes the cavities to have been filled by the subsidence of strata horizontally deposited before the formation of the pipes, some of his sections show a band of clay containing green flints at the base of those strata, which is continuous between the pipes and on the sides of the cavities. If, therefore, its position within the cavity is the result of subsidence, and not an original condition of deposit, that portion which originally extended over the mouth of the cavity now covers an area within it much more extensive than any over which it could have been spread without such a degree of stretching as would have been inconsistent with the continuity of the band, and of which it exhibits no evidence.

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.

[This paper was read January 18, 1854*.]

[PLATE VI.]

§ 1. *Introduction.*

THE peculiar funnel- and shaft-shaped cavities, so common in many places on the surface of calcareous rocks, sometimes only a few feet but not unfrequently many yards deep, and filled with sand, gravel, and loam belonging to deposits of various subsequent dates, form a very remarkable geological feature, especially in Chalk districts. They have long been the object of occasional attention, and various suggestions have been made to account for their origin. The explanations, however, have mostly had reference only to the mode in which these cavities could have been excavated, and have not often embraced any general view of the conditions which led to the wide-spread operation of the required causes. The Chalk district around London is peculiarly favourable for the study of this phænomenon; and my object in the following pages is to endeavour to determine the general law which has led to a result so common here, and so universal in almost all calcareous districts.

Cuvier and Brongniart† make frequent mention of sand-pipes (*puits naturels*) in the Chalk and the *Calcaire grossier*, ascribe their origin to the percolation of water, and show that they belonged to different geological periods. Of the exact mode of operation, or the causes which produced the phænomena, they offered no explanation.

These general views, as guiding the line of argument, have, with few exceptions, been usually received by geologists. Amongst others M. Passy‡, in describing the Chalk district of Normandy, alluded to

* For the other communications read at this Evening Meeting, see Quart. Journ. Geol. Soc. vol. x. p. 231 *et seq.*

† Description géognostique des Environs de Paris, edit. 1822, p. 76, 134, 141.

‡ Desc. géogn. du Dépt. de la Seine inférieure, p. 139.

the gravel-pipes, and briefly ascribed their origin to the eroding action of water percolating through the gravel or sand.

In August 1839 Dr. Buckland* read a paper before the British Association, in which he described several of these pipes in the neighbourhood of London, and expressed an opinion that they 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 or gravel.

Sir Charles Lyell†, in a paper on the "Sand-pipes" in the Chalk near Norwich, expressed a similar opinion, gave some very illustrative examples in support of that view, and concluded that these cavities were "due to rain-water impregnated with carbonic acid from the atmosphere and vegetable soil, and descending into pits or furrows which may have existed on the surface of the Chalk," and "that the excavation and filling-up of the pipes were gradual and contemporaneous processes." Sir Charles further considered "that land consisting of Chalk covered by Crag was first laid dry before the origin of the sand-pipes," and "that the denudation which gave the district its actual valleys" must have taken place subsequently.

In opposition to this, if it may be so termed, chemical theory, Mr. Trimmer‡ has come to the conclusion that both in Kent and Norfolk the sand- and gravel-pipes in the Chalk are to be attributed to the mechanical action of the breaking of the sea on a low shore antecedent to the formation of the deposit with the materials of which the pipes are filled. In corroboration of this opinion, Mr. Trimmer states that the pipes are vertical terminations to horizontal furrows on the surface of the chalk; that many of the flints in the pipes are water-worn; that the apices of the pipes are 3 or 4 inches broad, and not pointed; that certain blocks of Tertiary sandstones on the shores near the Reculvers are marked by like pipes and furrows, though of smaller dimensions (only a few inches deep and wide); whence, as those sandstones are siliceous, the excavations on them could not have been formed by the action of acidulated water; and further, that near Canterbury the sands with which the pipes are filled contain much calcareous matter, and consequently that any carbonic acid in the water must have been saturated by it before it could have reached the Chalk. He therefore suggested that it must have been mainly by the action of the waves, charged with sand and small pebbles, wearing furrows and hollows on the surface, and then, by the rotatory motion communicated to the water, sand, and pebbles in these hollows by the influx and reflux of the waves, that these pipes were drilled. Further, Mr. Trimmer mentions that the sand- and gravel-pipes are confined to the edges of the seas preceding the spread of the materials, whether eocene sands, crag, or drift-gravel and sand, which ultimately filled up these excavations.

Other theories have been subsequently expounded by M. Leblanc

* Trans. Brit. Assoc. for 1839, Sect. p. 76.

† L. and E. Phil. Mag. 3rd Ser. vol. xv. p. 257, Oct. 1839.

‡ Proc. Geol. Soc. 1840, vol. iii. p. 185; 1842, vol. iv. p. 6. Quart. Journ. Geol. Soc. 1844, vol. i. p. 300; 1852, vol. viii. p. 273.

and M. Melleville. These geologists argue, chiefly from the lenticular shape and chemical composition of several of the large rock-masses composing the French Tertiary series, and from the connexion of the pipes with the several rock-masses in which they end upwards, that such cavities are old channels connected with subterranean sources by which water charged with calcareous matter, with sulphate of lime, with sand, or with mud, has been ejected from beneath at one time into the sea of the Paris Tertiary basin, and at others into its lakes. M. Leblanc* connects this process with some former operation like that of existing hot-springs, whilst M. Melleville† gives a section showing that when the French Tertiary area was covered by the sea, the older and deeper-seated deposits beneath it, cropping out on high ground inland, might conduct waters through any permeable strata down beneath that sea, and into which the waters then rose through these vertical channels (*puits naturels*), charged with the materials, soluble and insoluble, collected during their subterranean course.

Other geologists, again, have referred the sand- and gravel-pipes to the former action of brooks and streams, analogous to that by which swallow-holes are now excavated in chalk‡ and limestone districts; in such a case the filling up of the cavities would be caused by subsequent changes brought about upon the surface of the land. That such swallow-holes must have existed at all periods cannot be doubted; but the phænomena which they present will hardly agree with that presented by the sand- and gravel-pipes: the one evidently depends solely upon the action of running surface-water, and always exposes open cavities, whereas the other is always in connexion with, and dependent upon, some overlying stratum deposited before and not after the excavation of the pipes,—are cavities formed, as it were, under cover.

With regard to the theory of ejectment, it is attended with great difficulties, and, the hypothesis which I have to suggest being based upon the very reverse action of injectment, I will not stop to discuss it separately, as the argument brought forward in the following pages will, if true, render this other theory inapplicable in this particular case §. As Mr. Trimmer's views, however, will not be subject to this antagonistic argument, I must notice them in greater detail, the more especially as his observations are numerous and his facts are carefully recorded, though I cannot agree in the conclusion which he has drawn from them.

1st. As to the connexion of furrows on the surface of the Chalk with the pipes. This is an argument which suits the hypothesis of the chemical theory as well as his own; for a constant slow current passing from the superincumbent strata into the pipe must, as it is presumed to wear the pipe, wear furrows in the chalk before reaching

* Bull. Soc. Géol. de France, vol. xiii. p. 360, 1842.

† Ibid. vol. xiv. p. 184, 1843. See also Forchhammer on the tubular pipes in the Faxoe Chalk, Quart. Journ. Geol. Soc. vol. vi. part 2. Miscel. p. 52.

‡ Quart. Journ. Geol. Soc. vol. x. p. 222.

§ Not but that there may be cases in which such an agency may be applicable.

the pipe, as well, or I should conceive, better than the action of the sea on a shore; for in the former case the water would keep to any given channel more constantly than in the latter.

2nd. Mr. Trimmer states that many of the flints are water-worn. This is not sufficient: the majority, or rather all those at the bottom of the pipe, should be water-worn, and all should show more or less wear; whereas the majority in general, and those especially on the sides and at the bottom, are decidedly *not at all water-worn*; on the contrary, they are always at least as sharp and angular as those in the superincumbent strata, and often as those in the Chalk itself. That flint pebbles and worn subangular flints do occur in these pipes, cannot be doubted; but the former are derived from the Tertiary strata (a fact to which Mr. Trimmer himself makes allusion), and the latter are from some of the beds of drift-gravel.

3rd. When we consider that these pipes are often 20, 40, or even 60 feet or more deep, with an average diameter varying from about $\frac{1}{3}$ to $\frac{1}{10}$ of their depth, an apex of 3 to 4 inches (it is sometimes more and sometimes less than that) can hardly be objected to as not being such a point as we might expect to be caused by the infiltration of water. If the water escaped through a single point only, as in the tube of a funnel, the argument would be good; but as the whole body of chalk is porous and soluble, we can readily conceive the apex of the tube to be more or less sharp or blunted according to various conditions of the chalk. The chalk, in fact, is the filtering material and not merely the filter-holder, and the water passes in a body downwards by the ordinary laws of hydraulics, and is not otherwise directed by any mechanical arrangement to one particular point.

4th. Mr. Trimmer states that the Tertiary sandstones on the shore at the Reculvers are not calcareous, and that they, as well as other blocks scattered over North Kent, show traces of hollows worn out by the sea. On this point there is apparently some mistake with respect to the Reculver sandstones, for I have found them readily acted upon by dilute acids and containing a considerable proportion of carbonate of lime; those, however, scattered over the surface near Faversham are certainly purely siliceous, but then also they are concretionary, and as usual in such cases they present very irregular and often mammillated surfaces, with numerous small natural hollows and cavities on either side. But even if these latter were holes worn by subsequent sea-action, I do not see the force of the argument which compares indentations and furrows to be measured by inches with the comparatively gigantic ones we are dealing with in the Chalk.

5th. The Thanet Sands near Canterbury can scarcely be called in any degree calcareous. I have examined several specimens, not only from that locality but also from other parts of Kent, and have found that the great majority of them, especially those forming the lower beds of this deposit, show scarcely a trace of carbonate of lime, and that they are composed essentially of siliceous sands more or less argillaceous. The shells which occasionally occur in some of the upper beds of these sands near Canterbury have almost all been dissolved out by the percolation of water, leaving merely casts in the semi-indurated sand.

In support of the foregoing arguments, I would further observe that the sand-pipes do not, any more than the gravel-pipes, appear to be confined to any particular zone or belt marking ancient coast-lines. Taking first the Thanet Sands. The outcrop of these beds extends from Ramsgate to Deptford, with a width generally (taking the detached outliers) of five or six miles, and often of ten to twelve. Sand-pipes are common across the breadth as well as along the length of this tract, which can hardly be reduced to the compass of a beach-line. Besides, there is no appearance anywhere of beach-action. The structure of the sands is throughout uniform, and the same in, over, and around the sand-pipes. The same argument applies with greater force to the gravel, which has a still longer and broader extension. Lastly, I can readily conceive small indentations and furrows to be worn by river or sea-shore action *, but I cannot imagine the possibility of hollows, sometimes almost as narrow and as straight as an inverted chimney-shaft, to have been formed by any such operations: the sea-action might form broad saucer or cup-shaped hollows above low-water level, but it could never drill cylindrical holes 40, 60, or 80 feet deep, for at such a depth they would in all probability be in greater part far below low-water mark, and therefore below a permanent water-level, where tidal water action would necessarily cease, and their excavation by the operation of wave-action would become therefore a physical impossibility. Also such sea-shore hollows would contain within themselves the instruments which had worked them out, and the deeper they were the more rounded and worn would be the pebbles. These again would differ from the material subsequently washed into these cavities, and which material in that case would consist of the first sediment subsequently spread over that spot; whereas, as a rule, no distinct accumulation of worn pebbles is found at the bottom of the pipes, the contents of which are always similar in lithological structure to the material forming the general superincumbent mass, and are composed, not of successive additions horizontally superimposed and derived only from the same sediment as the layer next upon the chalk, but of all the layers successively superimposed; and an inverted cone is thus formed, with a core derived from the higher and later-formed portions of the superincumbent beds. It even sometimes happens, when the pipes are filled with clay, sand, and gravel-drift, that the sides and *lower part* of the pipe contain *perfectly angular and unworn* flints, while the rounded and worn flints form the *centre* of the pipe—an arrangement the very reverse of what we should expect if the cavities had been drilled by mechanical agency, the agents being the worn pebbles, which should therefore occupy the place here held by angular and unworn flints only.

I have been thus particular in examining Mr. Trimmer's views,

* I have seen them on the coast about a foot deep. The gully-holes in many rivers form also a well-known phænomenon; these however arise from the infiltration of water, but belong to the same class of phænomena as the swallow-holes.

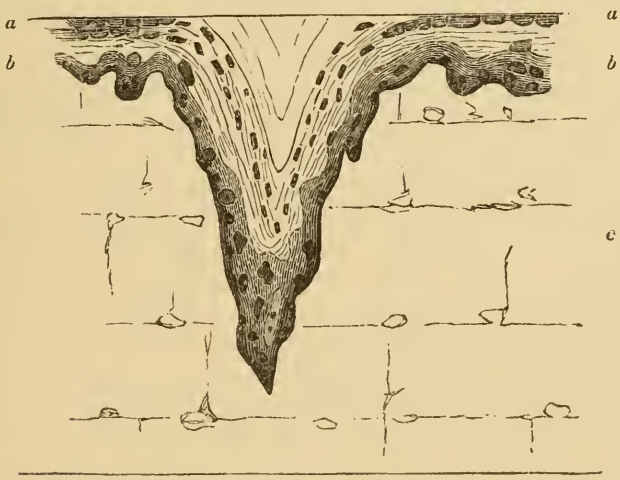
as from his long-continued study of the superficial deposits of the south of England his opinions are necessarily entitled to considerable weight. In this examination also, as the main features of these sand-pipes have been brought forward, much further description will be obviated. With the general view advanced by Cuvier and Brongniart and by Dr. Buckland, and more critically laid down by Sir Charles Lyell, I fully agree; and my object now will merely be to adduce some fresh proofs in its favour, and to suggest a general cause for the formation of these peculiar excavations.

§ 2. *Special Phænomena.*

As the name implies, the pipes are common both under sand and gravel beds. They occur in fact wherever a loose and non-calcareous permeable stratum of any extent overlies the Chalk or some calcareous rock. They present an infinite variety, but I will confine myself to the few essential points.

Some years since I met with an instance of one of these pipes in a chalk-pit near Lower Elmsden, a few miles south-west of Canterbury, which seemed to me conclusive of their formation by the slow and gradual action of water after the deposition of the superincumbent strata. The following is a section of this sand-pipe.

Fig. 1.—*Section of a Sand-pipe in a Chalk-pit near Lower Elmsden.*

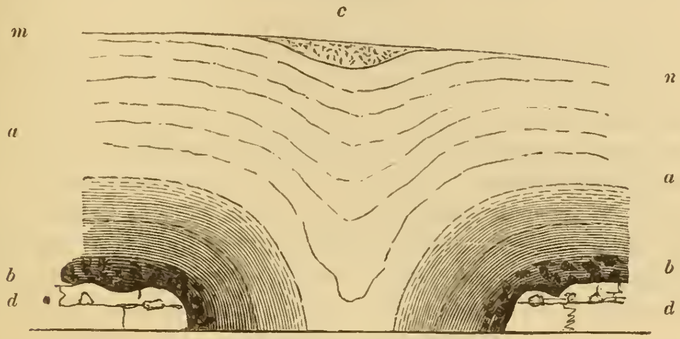


a Thin stony band in the Thanet Sands. *c* Chalk.
b Seam of clay and sand with green-coated flints.

It will be observed that this pipe, which is about 12 feet deep, is filled with the Thanet Sands, underlaid by the seam of clay and sand (*b*) with the angular green-coated flints which always occurs at the base of this deposit. It is not often that these sands are solidified, but in this case a thin band (*a*) is semi-indurated—just hard enough to hold together in blocks when broken, but not hard enough to allow of any wear or exposure. This layer of soft stone runs horizontally about 2 feet above the surface of the chalk. When, however, it reaches the sand-pipe, its continuity is interrupted, and it is broken into a great number of small fragments. These are perfectly sharp, angular, without any trace of having been worn, and follow in a continuous line (but as it were stretched out) the curve of the pipe. Now it is evident that this layer of friable sandstone must have been at one time continuous; that it has been fractured and its fragments disjointed and spread out by some operation subsequent to its consolidation; and that this must have been effected very gradually, and whilst in a supporting medium, to admit of the perfect preservation of the sharp angles of the fragments of so soft a stone, and to retain them in their original relative position. Further, the large flints with which stratum "*b*" always abounds are here, as usual elsewhere, scattered down (or rather held up) on the nearly perpendicular sides of the pipe, and are not accumulated at the bottom, as they necessarily would be if the sands above had not existed to keep them in place by their pressure. With few exceptions also these flints are the green-coated flints from the Tertiary bed, and not the flints fresh out of the Chalk. When however the pipe traverses layers of flints, these large white unworn flints are left after the chalk is dissolved, and remain in the outer clay-seam usually forming the sides of the pipe: these flints are generally in a vertical position at right angles to that which they held in the chalk,—a downward pitch caused, I consider, by the slow downward movement of the mass of matter in the pipe, whilst the flint was gradually detached from its matrix, the one end being free and giving way before the other. In a pipe on the Downs above Westerham, I met with an instance where this pressure has been such that that portion (about 10 inches) of the flint which projected into the angular flint-rubble forming the sides of the pipe is snapped off from the portion remaining attached to the chalk, and is slightly bent downwards, though it had not had time to become removed from the other portion before the pipe-making action ceased.

There are certain features common in all the sand-pipes under the Thanet Sands; a central core of sand always exists with an outer layer of sandy clay with flints, which latter lie in all positions, perfectly independent of the relative weight of the materials, and more often than otherwise with their longer axes directed downwards. The sides of the pipes also are rubbed and striated vertically, presenting a sort of slickenside, indicative of a slipping-downwards motion. The lamination or bedding of the sands follows the sides of the pipe in curved lines, gradually lessening in curvature as we ascend, until at some feet above the chalk, the strata resume their horizontal position. The sand above these pipes is also always looser and less compact than usual. These characters are well exhibited in some large sand-pipes at Grays Thurrock. In the following section (fig. 2) the overlying indent of gravel further shows, that not only was the action subsequent to the deposition of the sands, but that, in this instance, it was subsequent to the spread of the gravel, *c* being a small portion of a bed of gravel belonging to a higher level, and of which this fragment, let down into the depression caused by the sand-pipe, has escaped denudation. No later subsidence can have taken place, as no further depression occurs on the surface of the gravel, and the line "*m, n*" is perfectly straight. This section also corroborates the inference drawn from fig. 1.

Fig. 2.—*Section of the upper part of a Sand-pipe in the Chalk at Grays.*



Drawn on the same scale as Fig. 1.

a Thanet Sands.
b Seam of clay and sand with green-coated flints.
c Gravel. *d* Chalk.

The general arrangement is the same in the gravel-pipes, only it is rougher and less apparent*; for as the gravel is usually spread over the chalk in a large unstratified sheet of one rough homogeneous structure throughout, it necessarily follows that, however slow its subsidence at any point into a pipe penetrating the chalk may have been, the absence of straight lines of bedding would prevent the clear exhibition of any lines of flexure in the gravel of the pipes, and would cause it to retain the same apparent want of structure which characterises the mass of the gravel itself. But it sometimes happens that the gravel is roughly stratified, or rather spread out in layers of variable texture; or at times a bed of sandy gravel full of Tertiary flint-pebbles overlies another bed containing almost solely subangular and unrolled flints. In cases where pipes have been formed under such gravels, the curved or inverted conical arrangement of the mass, and the descent of the central core from the higher beds, generally become apparent, as in the sand-pipes. Some good examples of these pipes are common on the Chalk downs, especially in some pits above Westerham and Wrotham. The sides of most of these pipes are there formed of an extension of the layer of perfectly angular flint-rubble 1 to 4 feet wide, occurring at the base of the drift, whilst the core consists of worn gravel, or often of round flint-pebbles and sand derived from the Tertiary beds which formerly overspread that area.

The size of the sand- and gravel-pipes is very variable, some being only a few feet deep, and others reaching to a depth even of 100 feet or more, with a diameter of 20 to 40 feet. They are very common all over the Kent and Surrey Chalk district; also in Berkshire, Wilts,

* There are some very good instances of gravel-pipes in the Chalk-pits at Greenhithe. The neighbourhood of Watford, Henley, and the Downs a few miles N.E. of Maidstone also offer convenient localities for studying this phænomenon; there are, in fact, few places in the Chalk district where it may not be observed to a greater or lesser extent.

Oxfordshire, Bucks, and Hertfordshire. The general features described above, and those given more in detail by Sir Charles Lyell, may apply to them all. Care, however, must be taken to discriminate between pipes produced by the slow percolation of water, and those formed in part or wholly by the wear and battering to which the chalk, as well as other strata not always calcareous, has been subjected by certain drift-action. Such excavations are, however, on the whole, shallower, more irregular, and do not show the same internal structure as the true pipes. In this case many of the apparent pipes are mere sections of deep furrows, ploughing up the surface of the substratum, and filled with drift of various ages. In one of my papers recently published *, a case of this description incidentally occurs where a mass of subangular ochreous sandy gravel reposes on a deeply furrowed surface of impermeable clay and siliceous sands †.

§ 3. *General Phænomena.*

Such being the ordinary features exhibited by the sand- and gravel-pipes, it now remains to consider when and under what general conditions they were formed. As before mentioned, the percolation of rain-water, holding in solution carbonic acid derived from the atmosphere and the vegetable soil, from certain permeable strata into the chalk has been the cause most frequently suggested. The question, however, involves some further considerations which this hypothesis does not embrace. These tubular excavations are evidently to be attributed to some very general cause, and one operating at different periods; and it is with respect to the greater number a cause no longer in action, for not the slightest subsidence or indentation of the ground at the surface is perceptible above them, although it is evident that whilst they were being formed the superjacent strata were gradually depressed and indented (see figs. 1 and 2, pp. 69, 71).

The Thanet Sands and the sands associated with the Reading and Woolwich Series afford numerous examples of pipes passing down into the underlying Chalk. These pipes are not only common in the localities where the sands are in connexion with the main mass of the Tertiaries and in all their detached outliers, but portions or tail-pieces of such sand-pipes are also found on bare chalk-hills, above which once extended those lower tertiary sands from whose mass these pipes must necessarily have originally projected. This is sufficiently evident in all the Chalk district of Kent. In illustration of this point I have selected for a section the line of country between Chatham and Crayford, along which instances of these unattached pipes are in places numerous. The dotted lines mark the probable extension of the Tertiaries before the denudation of the present valleys (see Section No. 2, Pl. VI.).

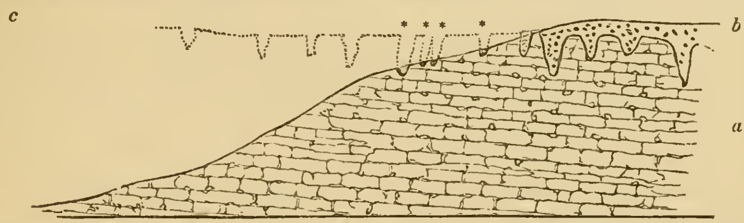
* Quart. Journ. Geol. Soc. vol. x. p. 88.

† Considerable complication is often produced by drift-action on the surface over the pipes, as the drift, being often local, can hardly in some cases be distinguished from the materials in the pipes. The inclination at which the section is taken also gives rise at times to deceptive appearances.

This phænomenon is not confined to these eocene sands, but is equally common in connexion with one of the most recent of our drift-gravels, and in beds of various other ages. In the instance of the drift-period, this is shown in the line of section (No. 1, Pl. VI.) extending from the neighbourhood of Rickmansworth to the hills above Wycombe, where the gravel caps a succession of Chalk hills and exhibits a considerable number of very illustrative gravel-pipes, including the fine case mentioned by Dr. Buckland between Beaconsfield and Wycombe. Both this section and the other (No. 2), referring to the sand-pipes, are actual sections, in which all the pipes found on the lines of section are introduced and distinguished from those supposed to exist where the chalk is not exposed. The relative position of the pipes and their distance from the main masses are maintained, the height of the ground at the various points where they occur having been approximately determined by the aneroid barometer.

Some of the most remarkable instances of these detached gravel-pipes, and instances affording a test to a much-debated period of denudation, occur in the slopes of the North Downs. A thick drift of ferruginous clay, sand, and gravel extends generally to the very edge of this escarpment, and is there abruptly truncated, whilst the slopes of the hills present a bare and clean chalk surface; but dotted a considerable way down these slopes may often be found portions of detached and isolated gravel-pipes,—the termination of pipes descending from the main mass of the gravel when prolonged above them. Such tail-pieces may readily be observed above Charing, Wrotham, and Westerham. The annexed sketch gives a section of the hill above the latter town (see fig. 3). This fact is important, as it affords a

Fig. 3.—*Section of the hill-side above Westerham, showing the pipes on the top of the hill filled with drift, and the terminations only of similar pipes some way down the slope of the hill.*



Drawn on scale. The height from the dotted line to the base line is about 300 feet.

* Pipes of which the ends still exist on the slope of the hill. Descent by the London road.
a Chalk.
b Ferruginous clay, sand, and gravel filling pipes on the surface of the chalk.
c Outlined continuation of former surface of the chalk with similar pipes.

strong proof that the final excavation of the valley of Holmesdale, including, I believe, that of the Weald, was not effected until after this comparatively recent drift period. This, however, is a point I had not intended to have entered upon at present, and the further consideration of which I must reserve until I have occasion to treat of the drift as a separate question.

§ 4. *Theoretical Considerations, and Conclusion.*

On reference to the Sections 1 and 2 (Pl. VI.), which give the present configuration of the surface and the actual distribution along certain lines, in the one case of the sand-pipes connected with the Tertiary strata, and in the other of the gravel-pipes connected with the drift, it will be seen by the dotted lines that all these pipes are related to the sands and gravel before the continuity of the latter was interrupted and when they extended in unbroken beds over the face of the land; that, in fact, the present valleys have all evidently been excavated since the formation of these pipes, which consequently belong to an older and anterior state of things. If, therefore, we restore that state, it will appear that over the areas under examination, the Tertiary sands at one period and the gravel at another formed extensive and nearly level beds stretching, without apparent break, over large tracts of country.

Now, as these deposits are extremely permeable, they would under these conditions naturally constitute water-bearing strata, reposing in either case on the thick mass of the Chalk. The water in both these masses of water-bearing strata would also naturally descend to the lowest level and there remain until it found vent.

The Chalk, although it absorbs water in large quantities and with great facility, is not properly a freely permeable deposit. When saturated it will in fact hold up water, which then only passes through it with excessive slowness if not assisted by cracks and fissures. Now it is a well-known fact that the rain-water, which filtrates through the mass of any permeable deposit or percolates through the fissures of any impermeable one, tends to descend in both cases to a certain level, dependent on the one side upon the nearest sea-level (if one be near), and on the other on the level of the adjacent valleys; and that a slightly curved line drawn between these points will always give the height at which the water in the intermediate hills stands with certain limited variations throughout the year *. This surface is called the line of water-level. Of course when these water-bearing strata are overlaid by an impermeable deposit supporting another permeable bed at a height rising above this main and lower level, this second deposit will form an exception to the general law and present a higher and independent water-level of its own. As, therefore, during this former period, the mass of the Lower Tertiary sands would hold and transmit water with great facility, that water would everywhere press on the chalk, and tend to penetrate into it through cracks and fissures, or to permeate into its general mass with extreme slowness at the points of least resistance, a slowness in some measure assisted by the thin seam of sandy clay with flints at the base of the sands. If, under these circumstances, the mass of the chalk stood much above the sea-level on one side, and the mean level of any large inland plains on the other, then the water which escaped from the sands would pass downwards through the chalk, and form a second water-

* I have treated these questions at some length in "The Inquiry on the Water-bearing Strata of London;" Chapter on the Chalk, p. 57.

level at a depth, below the water-level in the sands, dependent upon the general elevation of the country above the sea*.

Thus, supposing the mass of Chalk and the overlying Tertiaries to have been placed at the period we are now considering at about the same altitude that they at present occupy, but that the valleys which now traverse the country were not then formed,—supposing, in fact, that the country were restored to that state in which it would seem to have been before some later denudation swept away the beds which must have been continuous in the way represented by the dotted lines in Section 2. Pl. VI., we should then have a state of things represented by Diagram B, where the Lower Tertiary sands would form an upper water-bearing stratum rising some few hundred feet above the sea; whilst, supposing the Chalk had some lower outcrop further inland, the water-level in it would stand, at a certain distance from the sea, at one or two or more hundred feet below that level; but as the beds dipped and the country lowered towards the sea, then these two water-lines would gradually converge towards and ultimately merge in the same common plane (see Diagram B, Pl. VI., where *x*, *y* shows the line of water-level in the chalk C, and *m*, *n* the water-line in the overlying sands *S*). Or if we restore, as in Diagram A, the conditions prevailing during the gravel period, we might then have the case of an inland plain or valley at some height above the sea, covered by a bed of permeable gravel reposing upon the thick bed of the Chalk, and flanked on either side by higher ground. Under these conditions the calcareous strata would again have a line of water-level lower than that which would exist in the overlying mass of gravel (see Pl. VI., Diagr. A, *x*, *y* being the line of water-level in strata C, and *m*, *n* the level in the overlying beds *G*)†.

Referring now to the supposititious cases represented in the Diagrams A and B, the consequence would be that the water in the sands *S* or in the gravel *G* throughout the higher districts, having little or no natural lateral vent, would tend to escape downwards to the lower water-level in the Chalk C, and a constant flow would be established through any small fissures that might originally exist or else by general permeation through the body of the Chalk. I do not, however, consider the sand-pipes as necessarily or essentially dependent upon cracks or fissures in the chalk. These, probably, would rather

* When the table-land of permeable strata reposing upon chalk is much intersected by valleys, as for example in the case of the sands of Blackheath, Plumstead Heath, and Bexley Heath, which are bounded by the valleys of the Ravensbourne and of the Cray, the ready lateral flow afforded to the water by these valleys and their branches prevents any large accumulation or much vertical pressure of water in these sands. Still it is more than probable that in such a case some water will pass from the sands into the chalk, and that therefore some amount of wear is continued.

† We have an extreme case of such conditions in the "Yailahs" of Lycia, noticed by Prof. E. Forbes and Lieut. Spratt. These are more or less basin-shaped valleys of various extent at an elevation of from 2000 to 6000 feet, and with no outlet for the streams which water them. During the wet season the water collects and often forms a lake at one end of the valley: this apparently passes away by infiltration. The rivers pour into caverns and are lost among the precipitous cliffs which form the sides of the valleys.—See their "Travels in Lycia."

tend to form narrow and tortuous water-channels, such as are occasionally met with in that deposit, and through which the water, from the rapidity of its escape, would not act so fully as when filtering slowly through the solid beds. It is easier also to drill a straight hole in a mass which is uniformly compact and solid, than in one in which weak points and cavities interfere with the regularity of the drilling action, and I believe that it will be found that these sand- or gravel-pipes are not usually connected with fissures, but that they have generally worked their way into the solid chalk*.

To understand this mode of operation, we have to suppose the superincumbent strata constantly filled with water to a given level, as happens with all water-bearing strata under certain conditions. If these strata reposed upon an impermeable deposit, and the water had no underground means of escape, the additions incessantly made to it by the fall of rain would cause it to overflow the edges of this natural reservoir and so carry off the surplus supply in the form of springs; but if the water had the means of escaping by any underground vent, the ordinary hydrostatic pressure would cause it to take that course in preference to the other.

As, therefore, in the case before us, sands or gravel saturated with water repose upon a deposit, which, notwithstanding its not being freely permeable or allowing of the escape of the water in bulk, but rather holding it up, still imbibes water readily, and transmits it, although with extreme slowness, to the lower level which it seeks; it would follow that the surface of the chalk being exposed to the action of the water, with which these overlying beds are constantly saturated, would imbibe and transmit it downwards, at first through its mass generally, but ultimately passing, probably, into some of the numerous fissures which traverse this deposit, and which would afford it a more rapid passage. But as rain-water contains carbonic acid, which carbonic acid would not be lost by the filtration of the water through these quartzose sands or gravel, a certain proportion of that part of the chalk through which the acidulated water first passed must necessarily be dissolved and carried away in solution.

Under these circumstances, any slight original depression on the surface of the chalk tending to give a direction to the water; any point where the texture was looser than usual, and presenting therefore less resistance; or any greater permeability at some given point of the superincumbent bed allowing a freer access at that spot, would tend to facilitate and direct the passage of the water at and to those places, and the inevitable consequence would be to establish necessarily a greater wear there than elsewhere. By these means, the chalk at these points would become more porous and less resisting, and certain water-channels there would soon be fixed, which, as they offered the readiest passage for the water, would draw it off from the adjacent portions of the superincumbent strata. This action once established

* Still it is quite possible that slight crevices and cracks may frequently have been predisposing causes: what I wish to point out, is, that the pipes are not usually connected with faults and large fissures in the chalk, that they are not dependent upon any lines of disturbance.

would be maintained, and, in consequence, the original small water-channels would be gradually worn larger by the continued solvent action necessarily kept up by the continuous supply of water, receiving into their cavities, as they formed, the loose and yielding materials of the superincumbent mass, and which, from the extreme slowness of their fall and from all their parts being kept, by the uniformity and steadiness of the superincumbent pressure, in their original relative positions, would, as it were, be merely stretched out, and would conform almost exactly to the irregular surface of the produced cavities* (see fig. 1, p. 69).

Further, the peculiar funnel-shaped and cylindrical forms of these pipes admit of ready explanation on this hypothesis, for when any point on the surface of the Chalk, owing to the causes above mentioned, gives a freer passage to the water than it can obtain through the adjacent portions of the strata, then, the superincumbent mass of sand or gravel being of uniform or nearly uniform texture, the water would flow towards this channel from all points of the circumference, and cause therefore a nearly equal wear on all sides, tending, as the cavities deepened, to give them a circular form more or less perfect. At the same time, as the hollow became deeper, the body of water passing down the centre of the pipe would be greater in proportion to the surface of the chalk to be acted upon than that which would fall upon its sides, and a more rapid wear would take place on the lower or central part of the tube than on the upper; also the water passing down the centre of the pipes would retain its erosive action undiminished by previous contact with the chalk.

The consequence of these conditions would necessarily be to transform the original hollow first into a funnel-shaped cavity, and then, as it got deeper, into one gradually assuming a more tubular and cylindrical form. For if we divide a line, drawn through the centre of the horizontal section of the top of a pipe, into three equal parts (*Aa, ab, bB,* fig. 4), and carry down two perpendicular lines from *a* and *b*, until they meet the sides of the pipe at *c* and *d* in the vertical sections, figs. 5 & 6, it is evident that in fig. 5 the relative dimensions of *Ac, cd,* and *dB* are very nearly the same, the line *cd* being very little less than *cA* or *dB*; still the difference is sufficient, supposing equal quantities of water to pass in equal time through the equal widths *Aa, ab, bB,* to

Figs. 4, 5, & 6.—*Diagrams illustrative of the Structure of Sand-pipes.*

Fig. 4.

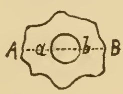


Fig. 6.

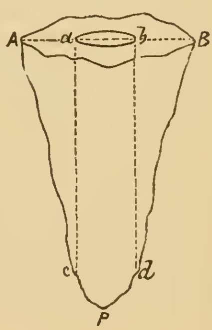


Fig. 5.

* The comparative fluidity of the sands produced by their saturation with water would necessarily facilitate this operation. The vibrations caused by earthquake movements might also co-operate from time to time, especially where any temporary obstruction had caused a stoppage of the descending materials, in maintaining a continuous fall into the increasing cavities.

make the relative quantity supplied to *cd* greater than that supplied to *Ac* and *Bd* in the proportion as the distance between *cd* is less than the distances between *Ac* and *Bd*; consequently, in fig. 5, the water-wear between *cd* would be slightly greater (aided also by the tendency of the water to converge at *P*) than between *Ac, Bd,* and the cavity, or incipient pipe, would increase in magnitude more rapidly in the direction of *cd,* than of *Ac, Bd,* or in other words would deepen more rapidly than it widened. Further, as the dimensions of the pipe increased, so would the disproportion between *Aa* and *Ac,* and between *bB* and *Bd* constantly increase; and as only the same relative quantity of water would pass over the surfaces *Ac, Bd,* whatever their dimensions might become, its effect would be one gradually diminishing, and consequently the lateral growth of the tube would tend to become less from day to day; whilst, as the proportion of *cd* with regard to *ab* would continue with little variation whatever the size of the pipe, the relative quantity of water passing on the surface *cd* would remain constant or nearly so, and the downward growth of the pipe would continue unimpaired. Thus the dimensions of *Aa, ab, bB* to *Ac, cd,* and *dB* in fig. 5 are nearly equal; but in fig. 6, *Ac* and *Bb* are five times greater than *Aa* and *bB,* whereas *cd* retains nearly the same proportion to *ab* that it did in fig. 5, or the erosive effect of the water passing *Aa, bB* being spread over an area five times larger would have become five times less; on the contrary that passing *ab,* acting upon an area of the same dimensions as at first, would possess its original erosive power, one now five times greater than that acting upon the sides.

Consequently the action on the sides of the pipe would tend to become, in process of time, comparatively insignificant, whilst that on the base of the pipe retained its original force; therefore the water-channel would pass from a slight hollow to a funnel-shaped cavity, and then into an indefinitely prolonged cylinder with a pointed end. The points *ab* are of course arbitrary*, but wherever we place them with regard to *AB, cd* will always exhibit the same constant character with regard to *ab*; and *Ac, Bd* the reverse with regard to *Aa, bB.* Practically, also, a portion of the water falling on the sides *Ac, Bd* would tend, from the obstruction presented by the partially impermeable lining of the pipe, to be thrown off from those surfaces and pass through the central area *cd.*

With respect to the adjacent chalk surface, it may be observed that, whilst the pipes were forming, the water would at the same time be scoring and corroding that surface with conducting furrows and channels converging in these absorbent cavities, and producing much of the furrowed and worn surface apparent on the chalk when freed from its superincumbent sands or gravel.

* Nor is this intended to give more than a rough, but, I believe, at the same time a correct general sketch of the process. For a more exact calculation, which could easily be made, it would be necessary to take the relation of the superficial area at the top of the pipe to that of the sides, and not the merely linear measurement adopted above.

The difference of the two water-levels assumed above (Diag. A & B, Pl. VI.) is not, I should mention, a merely hypothetical case. On the Chalk hills of Kent and Surrey the water-line in the Chalk often lies at a depth of from 300 to 400 feet, whilst in the small outliers of Tertiary sands and in the gravel on these hills a small body of water, where the mass of strata is large enough and other conditions favourable, is held up by these beds at a depth of 10, 20, or 30 feet only.

As the gravel is generally without any such partially impermeable seam at its base as occurs in the Tertiary sands, the underlying chalk surface seems to have been liable to be attacked by the acidulated waters in a greater number of places, and to present a larger proportion of pipes and indentations than when overlaid by the sands. In the case both of the sands and the gravel, I presume the strata to be fully charged with water accumulating and lodging in them, and not merely giving a temporary passage to an occasional rain-fall. This is an essential condition. A seam of clay is occasionally met with at the base of the gravel, and a thin layer of tough clay is of common occurrence on the sides and at the base of the pipes. It has the appearance of having been washed out of the superincumbent gravel and stopped by the chalk, as in the case of an ordinary filter. It is less apparent in the pits under the sands which are cleaner.

With regard to an objection which has sometimes been raised to this view of the formation of sand- and gravel-pipes, viz. that the water does not hold a sufficient quantity of carbonic acid to operate on so large a scale, it must not be overlooked that it is not only the quantity obtained by the rain directly from the atmosphere and from the ground, but also the additional and constantly forming supply that is evolved by the action of the air, likewise held in solution by rain-water *, upon the remains of organic matter, whether vegetable or animal, dispersed in however small quantities throughout the strata, and tending to the renewal of the carbonic acid removed, or rather, if the expression may be used, rendered latent, by coming into contact and combining with any carbonate of lime occurring perchance in these otherwise generally non-calcareous water-bearing strata. The length of time during which the operation continued I also suppose to have been exceedingly great.

Although these old channels (the pipes) have ceased to act, similar phænomena to that which produced them may still be occasionally observed, or rather it is possible that some existing phænomena may be referred to the same agency. Mr. Strickland pointed out this fact to Sir Charles Lyell in the neighbourhood of Henley; and I have had my attention directed to a spot of ground in Rickmansworth Park, where a bed of gravel caps a chalk hill overlooking the valley of the Colne. Circular indentations are there formed on the surface of the ground, which I was informed kept constantly

* Rain-water absorbs air in the proportion of about $\frac{1}{25}$th of its volume, but the oxygen is always in excess to the proportion in the atmosphere. The water from the Artesian well of Grenelle, after having passed 100 miles underground, still contains small proportions of air, carbonic acid, and organic matter.

deepening, so much so that it was necessary every few years to fill them up. I have however some doubts on this subject*.

In the case, again, of the swallow-holes described in a previous paper†, we witnessed a somewhat similar action of the escape of water from a higher level to a lower one in the Chalk. In such cases, however, the more free and rapid flow of water has probably worn a continuous passage in the mass of the Chalk. These funnel-shaped holes also are caused by the dissolving power of water holding carbonic acid in solution, and not by mechanical agencies, for the feeding stream is usually unimportant, transports but little sediment, and filters quietly through the small quantity of sand and gravel that remains undisturbed at the bottom of these excavations.

In conclusion, therefore, I view these sand- and gravel-pipes in the chalk and other soft calcareous strata‡ as extinct natural water-conduits, which the waters, at different periods, through incessant filtration from a higher water-bearing stratum in their tendency to reach a lower level, gradually and quietly wore for themselves by their solvent action alone ; the size of the pipes mainly depending both upon the length of time the operation continued, and also upon the extent of difference of level between the two water-surfaces.

EXPLANATION OF PLATE VI.

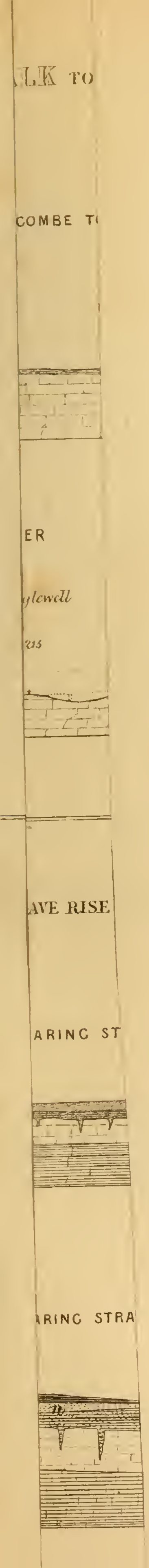
The two Sections (1 and 2) are from actual survey across parts of the neighbourhood of London, where the sequence of the phænomena over a length of country, easily accessible (and at the same time offering some very attractive scenery), presents the required conditions of showing the relation of the pipes to the main masses of sand and gravel, and also the independence of the whole to the existing configuration of the surface. The heights are taken approximately with the aneroid barometer and may not be perfectly exact, but I believe them to be sufficiently so for the purpose in view.

The scale of heights to distances is inevitably greatly exaggerated, in consequence of the diminutiveness of the subordinate features to be noticed. The scale of distances is the same as that of the Ordnance

* It has since been suggested to me that these depressions may be caused by old chalk-holes filled up with rubbish over which the grass has grown, but the decay of which leads to a constant falling in of the surface. This is likely enough to occur, and it would be difficult without opening some of these hollows to determine the point. The record of such places having been chalk-holes is of course likely soon to be lost, although at the same time one would have expected the frequent excavations of such holes would have caused the resulting appearances to be better known. Might not, however, the circumstance of decaying vegetable or animal matter being accumulated in the excavations tend to the evolution of a larger proportion of carbonic acid, which, taken up by the water draining from the adjacent surface, would tend to set in operation the action we have been alluding to ? It is, I think, quite possible that both the natural and artificial causes may produce the same result.

† Quart. Journ. Geol. Soc. vol. x. p. 222.

‡ The pipes in the harder limestones, which, where these same conditions prevailed, would necessarily operate a similar water-wear, are more likely to have resulted from this wear having been directed into given channels by pre-existing cracks and fissures. Some gravel-pipes in the Ragstone at Maidstone afford excellent illustrations of such results.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SECTIONS SHOWING THE RELATION OF THE GRAVEL AND SAND PIPES IN THE CHALK TO THE PRESENT SURFACE OF THE COUNTRY

Scale — Vertical 1 Inch = 1000 feet.
— Horizontal 1 Inch = 1 mile.

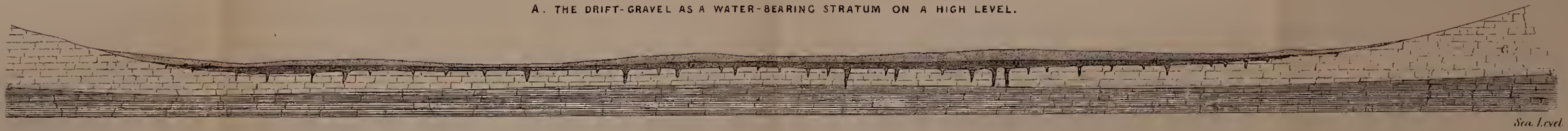
Drift Gravel
London Clay
Woolwich and Reading Series
Thanet Sands & other beds of the Lower London Tertiaries
Chalk
Pipes laid down from actual survey are marked with ×
See Explanation of Plate

1. FROM THE HILLS SOUTH OF HIGH WYCOMBE TO THE CHALK PIT AT HAREFIELD COPPER-MILLS NEAR RICKMANSWORTH.

2. FROM CRAYFORD TO UPNOR NEAR ROCHESTER

THEORETICAL DIAGRAMS IN ILLUSTRATION OF A PAST CONDITION OF THE LAND WHICH GAVE RISE TO THE FORMATION OF GRAVEL AND SAND PIPES

A. THE DRIFT-GRAVEL AS A WATER-BEARING STRATUM ON A HIGH LEVEL.

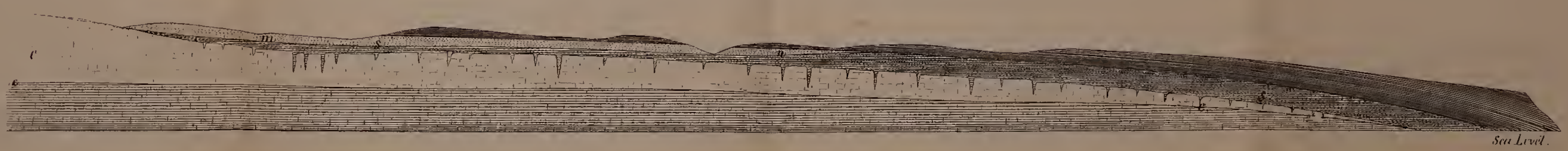


4

Permeable Gravel
Impermeable Clays
Permeable Sands
Calcareous Strata, Chalk

The Extent of the fine horizontal lines marks the height at which the water might permanently stand in the water-bearing strata. The cavities in the surface of the chalk show the channels worn by the water in passing from the higher to the lower water level and now forming the sand and gravel pipes.

B. THE LOWER TERTIARY SANDS AS WATER-BEARING STRATA RANGING TO A HIGH LEVEL.



Vincent Brooks Lith. King St. Covent Garden.

Map, on which the sections are planned. The numbers over the sections refer to the elevation in feet above the mean sea-level.

The pipes which are laid down from personal observation are marked with a small cross. Those portions of the lines of section which did not admit of examination show merely the probable position of the pipes.

The faults are omitted in the sections.

Section No. 1.—In this section the base was taken at the river-level in the valley of the Colne between Uxbridge and Rickmansworth, estimated at about 150 feet above the sea-level (the level of the Grand Junction Canal at Uxbridge being 113 feet), nearly three miles in a direct line S.S.W. from Rickmansworth. On the banks of the Grand Junction Canal, and a few hundred yards northward of the Harefield Copper-mill, is a large chalk-pit on the side of the hill, showing a section of from about 80 to 100 feet deep. The chalk is capped at the highest points by a thick bed of ochreous flint gravel, with pebbles of the older rocks. This gravel here occupies a nearly level plane on the hills, and is distinct from the gravel which occupies the adjacent valleys; between the surface covered by the former, and the gravel in the valley, the face of the chalk is denuded and comparatively bare. The chalk in this pit is full of gravel-pipes, many of them of a very large size, and descending to a depth of 40 to 60 feet. On the slope between the main mass of the gravel and the river-level, isolated portions of gravel-pipes are common. As, however, the hill is here very steep, these latter are confined to a small breadth, and the phænomenon is not so well shown as at many other places. In a pit near Troy Farm, on the west side of the valley, two small ends of gravel-pipes are seen about 40 feet above the canal level. Our line of section, however, passes up the lane by Corner Hall, a third of a mile west of which the cutting on the lane-side (10 to 20 feet beneath the level of the main mass of gravel, here denuded) shows three or four small terminations of gravel-pipes in the bare chalk. The summit of the hill by Warren Farm and Ninnings is covered by the main mass of the gravel, without any sufficiently deep sections; but in descending the lane by Hill Farm down to Chalfont St. Peter, the chalk comes to the surface, and, at an elevation of about 50 feet above the valley, exhibits sections of part of several large and deep pipes, into which a mass of angular flint debris and of tertiary pebbles and sand has been let down. Crossing the valley, the gravel sets in again on the opposite hill, but no sections are exposed until we reach a small wood through which the lane from Later's Green to Stampwell passes. In descending the hill at this point there is a chalk-pit on the right-hand side of the road. The chalk is quite bare, but contains one good detached gravel-pipe 12 feet deep, and about 10 to 15 feet beneath the level which the hill gravel, if prolonged, would occupy. On Stampwell and Pitland's Wood Hill the ground rises rather higher, in consequence of a thin outlier of the mottled clays and sands, round which the gravel sweeps, barely spreading over it in places. Continuing our line over these hills and through

Beaconsfield we meet with no deep sections, and the level of the ground does not vary very materially. Between this town and Holtspur Heath the gravel is again found, and worked in several places, but the underlying chalk is not exposed.

The cutting made to lower the road in descending from these hills to the valley of Loudwater exposes on the top of the hill a fine section of the gravel; and, as the slope of the hill is not very rapid, we have beneath this level a section continued for some distance through the outcrop surface of the chalk below the level of the gravel, in which remnants of the latter are however preserved in pipes; the upper portion of these and of the chalk, and all the overlying gravel, have been removed. There are seven of these isolated pipes which can be well made out within a distance of a few hundred yards. They decrease in size as we descend the slope of the hill; those near the summit are from 20 to 50 feet in diameter, but, as they go below the level of the road-cutting, their apices are not visible. Lower down the hill, on the contrary, we find the apices only of some of the deeper pipes. All, however, are confined to a depth of from 50 to 60 feet beneath the level of the gravel on the top of the hill. The sloping surface of the chalk below that depth is free from any traces of pipes. So also is the chalk in all the cuttings in the valley of Loudwater.

Carrying the line of section over this valley and across the top of the lane up the hill from the Loudwater station, a pipe 12 feet deep and 5 wide occurs. On the summit of the hill at Flackwell we again meet with the gravel in considerable thickness, and in a pit on the heath, where the chalk is worked, a few large gravel-pipes are well exposed. At a short distance further on the ground rises 30 to 40 feet higher, in consequence of an outlier of the sands and mottled clays of the Lower Tertiaries at the spot marked Mount Pleasant on the Ordnance Map. The gravel merely overlaps the edge of this mass, and does not appear again for some miles.

The feature to be observed therefore along this line of section is the permanence of a high-level gravel on the hills at an elevation of from 100 to 200 feet above the present valleys. Where this bed is in contact with the chalk, large and numerous gravel-pipes are always found wherever sufficiently deep sections are opened; and in descending the slopes of the hills all through this district, wherever there is a cutting in the chalk, at points not exceeding usually 50 to 60 feet lower than the hill top (though sometimes extending to 80 or 90 feet), detached portions of gravel-pipes are constantly met with; but lower in the valleys than this level the chalk is invariably free from any traces of these pipes.

Section No. 2.—Starting from where the chalk rises on the river side, between Rochester and Upnor, no sand-pipes are seen in the pit there opened. Rather higher, in a pit N. of Frindsbury Church, I found three small ends of pipes containing portions of the Thanet Sands, the mass of which sets in a few feet higher on the hill; these detached pipes are here covered by drift. In a pit by the side of the lane leading N. from the high road to Stroud Hill windmills are two well-marked detached pipes, both filled with the Tertiary sands; one appears 15 feet deep and 20 broad, but this arises in consequence of the section only exposing the upper and outer portion of the pipe; the other is 12 feet deep by 1 and 2 in diameter. Passing then on to the lane which leads from Stroud to the "Three Crouches," at a distance of about $\frac{1}{4}$ to $\frac{1}{3}$ of a mile from the high road, the sides of the lane, which are 4 to 8 feet deep, exhibit a series of segments of sand-pipes, some of which must be of great depth and size. I counted eight, varying in diameter from 4 to 50, 80, and even 100 feet, within a distance of less than a quarter of a mile. A few feet higher up the lane the Thanet Sands set in. Two small chalk-pits, a short way beyond the Three Crouches, show bare chalk and no pipes, but on the road-side, between the two, I found traces of one in a cutting 2 feet deep. A little further on is a considerable outlier of the Lower London Tertiaries, capped at Shorne Wood Hill by a small patch of the London Clay. Traversing this Cobham ridge, we meet with the chalk again as we approach Singlewell.

The country between these hills and the next important tertiary outlier at the Swanscomb hills forms an extended chalk plain with here and there small cappings of Thanet Sands, the elevation of which is on an average from 150 to 200 feet above the Thames. There are many shallow chalk-cuttings and several chalk-pits in this district, but not many sand-pipes are exposed. There was one in a pit opened a few years since near Ifield Church; traces of one are also visible on the road-side just W. of Singlewell. I could find no other until near Dundle Farm, where the shallow lane-side cutting showed indistinct traces of several. Next in a pit, half a mile N. of Betsham, remains of a sand-pipe are seen*. Then, crossing the Swanscomb hills, in a pit by the lane skirting the W. side of Hockenden Wood, and at a depth of 5 to 10 feet beneath the Tertiary base, is a well-marked sand-pipe, measuring 12 feet by 6.

Beyond this spot there are few good sections and fewer sand-pipes. Some years since I remember seeing one or two in some old pits, now grown over, on the hill E. of Dartford. Between this town and Crayford the chalk is bare or else capped by drift.

The same general facts are observable along this line of section as along the other. The sand-pipes are confined to a vertical zone of chalk not extending usually to a depth of more than 60 to 80 feet beneath the base of the Tertiaries. Where there are cuttings in this zone, pipes are constantly exposed, but in the numerous cuttings situated lower in the valleys than this zone, as a general rule no traces of sand-pipes are to be found. Both in Sections 1 and 2 the chance of meeting with pipes decreases, even in this pipe-zone, the deeper we get from the parent beds.

Diagram A represents a theoretical restoration of the surface at

* A clearer instance however occurs, at a short distance from our line of section, in a pit just N. of Swanscomb, where the chalk is traversed by a sand-pipe 15 feet deep, 130 feet above the Thames level, and apparently at about the level of the base of the Tertiaries.

one of the drift periods. A continuous bed of gravel is supposed to occupy a plain situated a few hundred feet above the sea-level. The constant infiltration of water from this gravel is presumed to have eroded the surface of the chalk, until ultimately the passage of the water has centred in numerous channels or pipes, into which the gravel sank as the cavities enlarged; and these vertical channels, now that the country has been drained and opened out by another and deeper system of valleys, exist as dry gravel-pipes.

Diagram B.—In this case we have a continuous tertiary sand bed occupying a level ranging from the sea-level to 500 or 600 feet above it, and reposing upon a mass of chalk which, beyond the range of these Tertiary Sands, is traversed by a deep river-valley. This valley consequently gives vent to the water in the chalk and establishes a low water-level, and therefore the water in the sands S, not being permanently held up by the slight argillaceous bed at their base, passes into the chalk and escapes to the lower water-level in that deposit. The indentations on the surface of the chalk represent the cavities worn by the water in thus effecting its escape. As in Diagram A, a fresh system of drainage has since dried up these old water-channels and left them as disused sand-pipes.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

December 13, 1854,

James Colquhoun, Esq., George Burnand, Esq., and R. B. Grindrod, Esq., M.D., were elected Fellows.

The following communications were read:—

1. *On a* Fossiliferous Drift *near* Salisbury*. By Joseph Prestwich, Jun., Esq., F.R.S., F.G.S., and John Brown, Esq., F.G.S.

The great extent of bare and clean-denuded chalk hills forms a very striking feature of the scenery around Salisbury. But, although the more prominent parts of the country are so free from drift, the small valleys which traverse these great undulating downs contain, scattered along their base and often extending for a short distance up the slopes of the adjacent hills†, a considerable quantity of gravel,

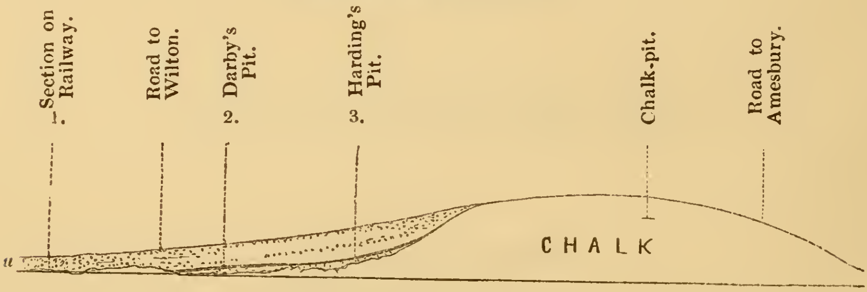
* An unforeseen circumstance has caused me to bring this paper forward earlier than I intended. It was rather my intention to have embodied it in a more general inquiry on the Drift. Not having as yet made all the preliminary inquiries, I was not, when I wrote it, aware of a paper on the same subject communicated to the Society by Sir Charles Lyell in June 1827, and of which an abstract was published in the first volume of the 'Proceedings,' p. 25. Sir Charles enumerates the same fossil animals, with the exception of the Deer, and states also that Land-shells are said to occur in this deposit. No lists, however, are given of the organic remains, and the present paper may serve, therefore, to complete this former notice of a very interesting locality.—[J. P., Jun., Feb. 1855.]

† There is, however, some drift of a different age at a higher level.

flint- and chalk-rubble, and brick-earth. This drift is, in greater part, of local origin, and is very irregular in its structure and distribution; one material predominating at one spot, and another taking its place close by. Flint-rubble and sandy clays preponderate usually in the lower parts of the valleys, chalk-rubble being more common on the hill-slopes, whilst the brick-earth is irregularly and only occasionally patched on the base of the hills, alternating with and replacing the flint- and chalk-rubble.

Three of these small valleys are confluent at Salisbury. It is on the north-eastern side of the one through which the Willey flows that one of the best exhibitions of the Drift is obtained. The following section shows the prevailing relation and structure of this deposit, which here rises about 30 to 40 feet above the level of the Willey*.

Fig. 1.—*General Section of the side of the Valley of the Willey at Fisherton, Salisbury.*

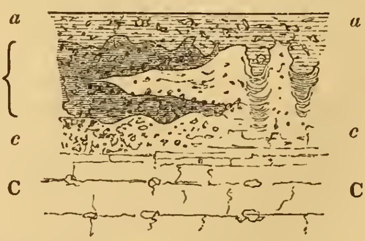


a. Gravel and Brick-earth.

The railway-cuttings between Salisbury and Wilton expose some good continuous sections, whilst several brick-fields give a few deeper excavations. In a cutting adjoining Wilton, large subangular gravel, chalk-rubble, and coarse rubbly brick-earth alternate and pass laterally one into the other. The following section of a portion of this cutting will serve to show the general character of the drift at this place. It varies, however, every few yards.

Fig. 2.—*Section in the Railway Cutting E.N.E. of Wilton.*

a. Brown earth and flints; 2 to 3 feet.
b. Coarse gravel, consisting chiefly of subangular flints, with pieces of chert, ironstone, sandstone, and some flint-pebbles, in brown clay more or less sandy; 5 feet.
c. Chalk-rubble, upper portion waved; passing laterally* into *b.* (a few *Succineæ* and *Helices* are found in this rubble); 7 feet. C. Chalk.



(* The line of division is too strong in the woodcut.)

* It is rarely that this deposit reaches a greater height above the base of the valleys in which it is found.

Half-way between Wilton and Salisbury, and nearly on the same level as the above, the section of the Drift presents a very different appearance.

Section on the Railway beneath the High-road near Bemerton.

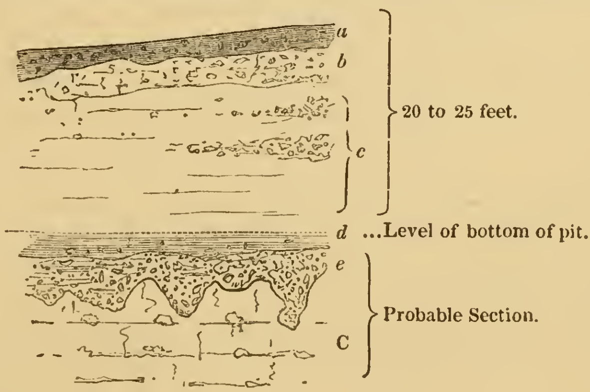
a. Earth and gravel; 1 foot.
b. Gravel, chalk-rubble, clay, and brick-earth, mixed; 3 feet.
c. Brick-earth, with a few dispersed angular flints and some shells (*Succineæ* and *Helices*); 8 feet.
d. Patch of coarse gravel, as above, with a base of brick-earth; 1 foot.
e. Brick-earth, rendered porous by numerous very fine Serpula-like perforations; only a very few angular flints, and no shells; 10 feet.

The bed *e'* is underlied by flint-rubble; but the base of the deposit is not shown.

At the shallow cutting adjoining the Fisherton Station at Salisbury, 5 to 10 feet of coarse gravel-drift, mixed with much green sand and some clay, and abounding with most of the same shells as occur at Mr. Harding's pit, repose upon a very irregular and much-indented surface of the Chalk (fig. 1). Near this spot, but higher on the slope of the hill between the Devizes and Bath roads, are several large brick-pits (figs. 1, 2, 3).

The occurrence of Bones had long been noted at these pits, but it was only two years since that my attention was drawn by Mr. Harding, the proprietor of one of the pits, to a bed full of shells under 20 to 25 feet of drift of a similar character to that which has been described in the preceding sections, except that here it is freer from flint-rnbble and exhibits a preponderating mass of brick-earth. The following section shows the relative position of the layers of Drift at this spot:—

Fig. 3.—*Section at Mr. Harding's Brick-pit, Fisherton, Salisbury**.



a. Earth and flint-rubble, variable; 1 to 2 feet.
b. Rubble of angular flints, fragments of chalk, and flint-pebbles, in clay and brick-earth; 4 to 6 feet.
c. Brick-earth, mixed with variable masses of flint- and chalk-rubble, and containing bones and a few shells, chiefly in the lower part; 10 to 18 feet.

* The exact bearing of this pit is 0·7 mile in a direct line N.W. from Salisbury Cathedral.

d. Light-coloured fine marl, full of well-preserved shells, with a few bones; 1 to 2 feet.
e. Flint- and chalk-rubble, with sand and clay, only upper surface exposed; 3 to 4 feet?
C. Chalk.

The shells in the brick-earth, *c*, are here, as in this same drift in the other parts of the valley, few and irregularly dispersed; but in the underlying marl, *d*, they occur in the greatest profusion, in a very perfect state of preservation, and with traces of colour still discernible in some specimens. Since my visit to this pit, my friend Mr. J. Brown of Stanway has passed several days there for the purpose of following up this inquiry, and has brought to light a very interesting series of land and freshwater shells, of which the particulars are given at page 106. It is, however, in the brick-earth, *c*, that most of the bones are found. They sometimes occur in considerable quantities, especially at the base of the brick-earth and on the surface of the shell-marl, but are generally broken and in fragments, the teeth excepted.

The greater part of the bones belong to the small long-fronted Ox (*Bos longifrons*) and the Red Deer (*Cervus elaphus*). I have found, however, remains of the Elephant and of the Tichorhine two-horned Rhinoceros, and probably of the Horse*. The Rhinoceros is rare at this spot; but I am informed that in digging the foundations of the jail, a few hundred yards distant, a remarkable number of the teeth† and bones of this animal were found.

Mr. Brown enumerates 12 species of land-shells and 8 species of marsh and freshwater shells. They are all, without exception, recent species, and the greater part are now common in the same district; one, in fact, the *Pisidium amnicum*, was first described from specimens found in the valley of the Avon near Salisbury. All the species found here have been met with in several other Pleistocene deposits of England; but it is not often, except probably at Copthorne and Stutton, that so large a number of land-shells have been found together. There are no less than 7 species of *Helix*; the *H. hispida*, *H. arbustorum*, and *H. pulchella* are plentiful, the latter especially. So also is the *Pupa marginata*; the *Limax agrestis* is only rather less so. The water-mollusks, with the exception of the *Succinea putris*, which is abundant, are not so numerous, and form a group such as we might expect to find in a spring or shallow pond rather than in a river.

This character of the fauna, taken together with the mineral character and the limited volume of the bed *d*, seems to indicate the former existence at this spot of a pool, or of a small shallow stream fed by springs rising out of the subjacent chalk, and supporting a few freshwater mollusks. The numerous land-shells, mostly of moisture-seeking species, may have been carried down by rains or destroyed by occasional floods.

The mass of debris spread over this remnant of an ancient land-

* These are not mentioned by Mr. Brown, p. 106, as he describes only that which he obtained during his few days' visit.

† Several of these are preserved in the Museum of the Society.

surface consists of materials derived from the destruction chiefly of the chalk, but in part also of the Tertiary strata, and of the Greensands; for, with a large preponderance of flint- and chalk-rubble, there are also found round flint-pebbles and masses of saccharoid sandstone from the Woolwich and Reading series, which, there is reason to believe, once extended over this area. This debris also contains many fragments of chert and grit from the greensand, probably from the neighbouring vale of Wardour; whilst the finer materials from these several deposits have formed, when well mixed together, the calcareous loam called brick-earth*. The whole of this drift is spread out without order or regular structure, without regard to the specific gravity of the materials, and comparatively without wear; sometimes the light porous brick-earth, and at other times the heavy flint-rubble is at the top of the mass, whilst it often happens that heaps of the broken flints are entangled singly, or in irregular layers in the midst of the brick-earth. This flint-rubble is perfectly angular, and exhibits scarcely any traces of wear from rolling. The only specimens, in fact, exhibiting any long-continued wear are the flint-pebbles derived from the Tertiary beds, and the older origin of which, as pebbles, admits of no doubt. The greater part of the bones also are broken, and retain their sharp fractured edges. The underlying shell-marl, on the contrary, is the result probably of a perfectly quiet, local, and uninterrupted accumulation, for the shells are of all ages of growth, generally perfectly uninjured, and are imbedded apparently on the spot where they lived†.

It is probable that the physical features of this district at the very recent geological period when the two above-named large extinct mammals‡, associated with the Ox and Deer referred to species of which the descendants are supposed still to exist, roamed over the land, and the minute mollusks identical with recent species swarmed on the surface of that land and in its waters, differed to no great extent from those prevailing at the present day. The valleys are possibly rather deeper, and may be a few feet higher above the sea-level than they were at that period.—[J. P., Jun.]

* I have not thought it necessary to repeat in each separate section the whole of the rock-debris forming the beds of drift-gravel. The preponderating mass merely is defined. Debris from these Tertiary and Cretaceous beds is found scattered irregularly throughout the drift (and also in the surface-bed), but the flint-rubble forms in all cases the distinguishing feature. In the bed beneath the shell-bed at Mr. Harding's pit, specimens of these rocks are, however, scarcer; though in this bed Mr. Brown found a subangular fragment of limestone, apparently from some of the secondary rocks of the vale of Wardour.

† I purposely confine myself in this and the following two papers merely to a statement of the probable conditions prevailing in the several localities at the life-period of their respective faunas, reserving the more general theory, connected with the extent and nature of the geological changes of the Pleistocene period, until I shall have brought a greater number of facts, properly grouped, before the Society.

‡ From the character and age of the deposit, and from the numerous undeterminable fragments of bone which I have seen, I believe that the group of Mammals will prove to be far larger than here described. It will be important to collect further evidence on this subject.

Organic Remains.—My attention having been directed by Mr. Prestwich to the above-named locality, I went to Salisbury and spent several days there, during which I received every assistance from Mr. Harding, the proprietor of the pit. The freshwater-shell-bed is 1 foot 6 inches thick, and is composed of calcareous matter and fine sand, the latter insoluble in acids. I could not well ascertain the order in which the shells lie. They are perfectly white, and the land and freshwater shells are apparently intermingled. The condition of some of the very thin, delicate shells, such, for instance, as *Pisidium*, *Ancylus*, and others equally thin and fragile, would indicate that they cannot have been drifted far. Many of the shells are as perfect as when living, and as much so as the shells from the Copford or Clacton freshwater deposit, where the shells are lying about apparently where they died. There are, however, fragments of shells in greater number at Fisherton. It is difficult, therefore, to say, until further investigation is made, how far the fossils of that bed or beds have been drifted, or whether they have been drifted at all.

Fossils from the Freshwater Deposit at Fisherton, Salisbury.

MAMMALIA. (See also p. 104.)

Cervus elaphus ...	Distal end of tibia. Second phalanx (2 specimens). Base of antler.
Bos longifrons ...	Metacarpal of young animal. Fragment of tibia. Second phalanx (3 specimens). Proximal portion of radius. Distal portion of radius.
Bos (large animal).	Molar tooth of upper jaw.

LAND SHELLS.

Helix arbustorum, *Linn.* Numerous; many broken.
—— pygmæa, *Drap.* Many, but not abundant; unbroken.
—— radiatula, *Ald.* One fragment only.
—— pulchella, *Müll.* Numerous; unbroken.
—— rufescens, *Penn.* Numerous; unbroken.
—— fulva, *Müll.* Plentiful; unbroken.
—— hispida, *Linn.* Numerous; unbroken.
—— ——, var. concinna, *Jeff.* Numerous; many unbroken.
Pupa muscorum, *Linn.* Numerous; many unbroken.
Zua lubrica, *Müll.* A few; perfect.
Carychium minimum, *Müll.* Fragment; scarce.
Limax agrestis, *Müll.* Numerous; perfect.
Acme lineata, *Drap.* One fragment.

FRESHWATER SHELLS.

Valvata piscinalis, *Müll.* Not numerous; a few unbroken.
Succinea putris, *Linn.* Numerous; in all stages of growth.
Ancylus fluviatilis, *Müll.*
Limnæus truncatulus, *Müll.* A few whole specimens.
—— pereger, *Müll.* Rare.

Pisidium amnicum, *Müll.* —— pulchellum, *Jen.* —— pusillum, *Turt.*	Not numerous. Valves separate.

FRESHWATER CRUSTACEAN.

Candona? Fragment.

Portions of Bryozoans and other minute fossils derived from the Chalk also occur in this deposit.

I am indebted to the kindness of Prof. Owen for the determination of the Bones enumerated in the above list of the *Mammalia*; and for ascertaining several of the species in the list of shells from the Fisherton deposit, I have to thank my friend Mr. John Pickering.—[J. B.]

Since Mr. Prestwich's paper was read before the Society, I have further examined the gravel under the shell-bed, and I have found it composed of numerous flints, of all forms, from the size of the fist to an inch in diameter, angular; of grey quartz-sandstone in pebbles, 1 to 2 inches in diameter; limestone, angular in form and highly crystalline; chalk, both hard and soft, in nodules of various sizes and in angular portions, angles smoothed by trituration; flint-sponges (and other chalk-fossils, see below); the whole are imbedded in a mixture of clay and sand. Amongst this debris I have found the following Microzoa derived from the Chalk:—

List of minute Chalk-fossils from the Gravel below the Freshwater bed, Fisherton.

Nodosaria Zippei. Abundant; fragments.
Cristellaria rotundata. Abundant; worn.
Marginulina ensis. Fragment.
Inoceramus, fragments of. Abundant.
Bourgueticrinus, ossicles of. Not rare; some worn.
Echinodermata, spines of. Not rare; fragments.
Bryozoa. Abundant; fragments, mostly worn.

For the determination of these minute and beautiful fossils I am indebted to Mr. Rupert Jones.—[Feb. 1855. J. B.]

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2. *On a* FOSSILIFEROUS DEPOSIT *in the* GRAVEL *at* WEST HACKNEY. By JOSEPH PRESTWICH, Jun., Esq., F.R.S., F.G.S.

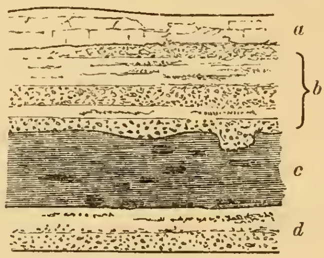
IN the summer of 1853, Dr. Beeke informed me of the discovery of some large mammalian bones in a gravel-pit belonging to Mr. Hindle, at Shacklewell Lane, between Hackney and Stoke Newington*. In company with the former of these gentlemen, I visited the spot, which is 60 feet above the level of Trinity high-water mark, on several occasions, and found many points which I deem of sufficient interest to lay before the Society.

I found that the bones were not actually in the gravel, but in a bed of clay between two beds of gravel,—which clay forms a distinct and separate deposit with an abundance of freshwater and land shells. The occurrence of the bones was an exceptional case, no other

* The pit is in Hackney parish. It is only distant, however, exactly a quarter of a mile, in a direct line due east, from West Hackney Church, Newington high road.

bones having been previously met with at this pit, though common at some others in the neighbourhood. The following is a sketch of part of the pit:—

Section in Gravel-pit, Shacklewell Lane, West Hackney.



a. Brick-earth, removed at this spot, but worked in an adjoining pit .... 2 to 3 feet.
b. Ochreous flint-gravel, with subordinate irregular layers of ochreous and yellow sand. (This is the only bed worked at this pit.)...... 6 feet.
c. Dark-grey sandy clay, full of vegetable matter, with some bones and numerous shells. (This bed is only occasionally exposed.)... 2½ feet.
d. Light-yellow sands and ferruginous gravel. (Depth not proved at this spot.)

No fossils have been found in the brick-earth (*a*) of this district. The gravel (*b*) is spread out in large sheets which produce an appearance of rough stratification; it consists of subangular broken flints, with some very large nearly whole flints hardly at all worn, flint-pebbles from the Lower London Tertiaries, a few quartz and sandstone pebbles, and some rolled pieces of very hard, compact, siliceous sandstone. Only a few feet square of the underlying clay (*c*) was uncovered. The line of separation between these two beds is merely slightly waved, except at one spot, where the gravel lay in an indentation in the clay, filling a rectangular trough, one foot deep (see fig.). This bed (*c*) presents some features of considerable interest; it consists of a laminated clay more or less sandy, of a dark-grey colour, and abounds in many parts with the small broken branches and leaves of trees; scattered here and there are also found portions of the stems and trunks of trees, some 3 or 4 feet long and 6 to 12 inches in diameter, all lying prostrate and in no one given direction*. This clay also contains numerous very fragile but generally perfect shells. Of these ten are land shells, and thirteen are water shells; they are all of recent species, and constitute a group which seems to indicate a deposit formed in shallow fresh water.

The trees apparently did not grow on the spot, for no traces of roots *in situ* occur, although they probably flourished in the immediate neighbourhood; and as their remains are found dispersed irregularly throughout this clay, and are not confined either to the top or bottom of the bed, their presence here is not owing to the agency which spread the upper gravel (*b*) over this bed, or to that which

* Prof. Quekett, having kindly made a microscopical examination of the woody matter here referred to, informs me that he has recognized oak, elm, alder, and hazel amongst the fragments.

caused the extension of this deposit itself over the lower gravel (*d*), —that is to say, it was neither the flooding of a previously dry surface by the waters from which the shelly clay was afterwards deposited, nor was it by the detrital sweep of the upper gravel over this later area of water and dry land that the trees were destroyed. Their presence must, on the contrary, be due to some common cause in common operation during the whole period that the freshwater mollusks were living undisturbed in these waters. One cause might be occasional floods; although in that case we might have expected a greater change in the sediment, arising from the greater transporting power of the water,—the trees to have been more in seams, more of them showing uprooting, and more entire. Whereas the trees are in fragments, their branches and stems are sharply broken into short pieces, lying about without order, all prostrate, and in a sediment showing little or no change. I conceive such a result to have arisen partly no doubt from this cause, but probably chiefly from the occasional breaking off of boughs and the smaller stems of trees on the margins of these pools or meres, during gales of wind, which scattered them and the leaves over the surface of these waters, where they sank and got buried with the *Planorbis*, *Limnæus*, *Pisidium*, &c. The texture of the wood is generally but very little altered, and its colour is often almost unchanged. When dried, it becomes extremely light.

The bones were found at the base of the shelly clay, and consisted of part of the trunk of some large mammal (Ox?)*; nine vertebræ and some of the bones of the legs were found together, but the skull was missing; nor, notwithstanding the diligent search established by Mr. Hindle and Dr. Beeke for several feet around, could we succeed in obtaining any further remains of this animal. Unlike the wood, the bones were much mineralized and very heavy.

The evidence afforded by the remains of this animal agrees with that afforded by the remains of the vegetation. The bones were tranquilly imbedded in the mud of a freshwater deposit, the animal probably having after death floated on the surface of the waters, the bones subsiding here and there as the carcase decayed and fell to pieces; for it must be observed that the bones show no traces of wear or fracture,—nothing to denote violence or distant transport.

Under the clay (*c*) is found a bed of gravel and sands, some light-coloured and others ferruginous, in the upper part of which shells, I was told, similar to those found in the clay have occasionally been found; I however met with none. This gravel consists of subangular flints chiefly, with a few flint-pebbles; not enough of it was dug up to notice whether there were any pebbles of the secondary rocks. Its thickness is not shown here; but as the London Clay comes out on the side of the adjacent Hackney Brook on a level a few feet lower, I do not think it can exceed 6 to 10 feet.

The shells procured from the deposit we have here described, present a general close agreement with those found in the Salisbury drift (see p. 106), except that the group of marsh and pond shells is more

* The bones unfortunately have been mislaid.

developed; whilst land shells are scarcer and are in greater part such as frequent marshy places and damp woods.

With the Grays fauna, these two deposits present only a few species in common; but a difference of conditions, such as a greater body and depth of water, combined with a probable occasional slight brackishness, may account for this variation; for although many of the species are distinct at these three localities, yet they all agree in the common fact of the species being identical with recent species, and such as for the most part still remain associated in like position, under like conditions, in this country at the present day. All the three deposits belong, I believe, to a period subsequent to that of the Boulder Clay; but the arguments on this subject I must reserve to a future occasion, when I have gone into the evidence afforded by the various drift-beds of the valley of the Thames and of the adjacent counties more in detail.

One of the principal points of interest attaching to this particular section is the clear indication of two gravel-periods separated by an interval of dry-land surface,—a character common throughout this district, and to which also we shall have occasion to allude in greater detail on another occasion.

The following are the Mollusks I have found in this deposit. For the determination of the species I am indebted to Mr. J. Pickering:—

Shells from the clay beneath the gravel, Shacklewell Lane.

Bithinia tentaculata (*Linn*); and its opercula.
Valvata piscinalis, *Müll.*
Limnæus palustris. *Linn.*
—— truncatulus, *Müll.*
—— glaber?, *Müll.*
—— stagnalis?, *Linn.*
Succinea putris, *Linn.*
Planorbis marginatus, *Drap.*
—— spirorbis, *Linn.*
—— nautileus, *Linn.*
Clausilia, sp.?
Carychium minimum, *Müll.*
Zua lubrica, *Müll.*
Pupa muscorum, *Linn.*
Helix pulchella, *Müll.*
—— aculeata, *Müll.*
—— hispida?, *Linn.*
Zonites radiatulus, *Alder.*
—— nitidus, *Müll.*
—— crystallinus, *Müll.*
Pisidium pulchellum, *Jenyns.*
—— obtusale, *Jenyns.*
—— pusillum, *Turt.*

The shells of this deposit are in a very rotten and often fragmentary state, and it is probable that there are many more species.

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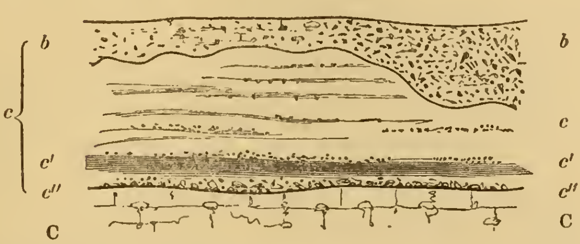
3. *On a* FOSSILIFEROUS BED *of the* DRIFT PERIOD *near the* RECULVERS. By JOSEPH PRESTWICH, Jun., Esq., F.R.S., F.G.S.

THIS deposit is, like the one described p. 101, spread over the base of a hill, which here slopes down to the marshes separating this part of Kent from the Isle of Thanet. It is exposed in two pits near Wear Farm (see Ordnance Map), on the road from Chislet to the Reculvers. The height of the ground above the level of the adjacent marsh or of the sea, does not exceed 20 to 30 feet. The pit in a field to the east of the road offers the best section; it is as follows:—

*Section of Sand-pit on Wear Farm, near the Reculvers**.



b. Gravel, flint-rubble, and brick-earth..3 to 8 feet.
c. Light quartzose sand, with seams of fine flint-gravel, in some of which shells are numerous; contains irregular subordinate layers of laminated clay, with traces of vegetables at *c'*. Immediately on the chalk is a band of large angular flints, *c''* ....8 to 12 feet.
C. Chalk.

The other pit shows, with a few general features in common, a very marked difference in detail. The upper bed *b* is much more developed and predominant.

The shells occur principally in seams of fine gravel in the lower of the section: in a few spots only are they numerous. The greater portion of the sands and gravel are without shells. *Entomostraca*, however, appear to be more abundantly diffused, but still they occur chiefly in certain seams or layers.

I found a few bones of large Mammals, some apparently belonging to the Ox. The shells are in a good state of preservation, and consist of the following species, which Mr. Pickering has kindly examined and determined:—

Bithinia tentaculata, *Linn.*
Ancylus fluviatilis, *Müll.*
Paludina or Rissoa; very like the one found at Grays.
Cyrena consobrina, *Caill.* (*C. trigonula*, Wood.)
Opercular valves of *Balanus*.

This list, although short, is of considerable interest, for we here find the Grays or Nile *Cyrena*, together with two more distinctly freshwater shells, associated with the distinctly marine genus, the *Balanus*. The opercular valves of this Cirriped were found in the fine gravel filling the interior of the *Cyrenæ*. The small *Paludina* and the *Cyrena* abound in places. Imperfect traces of vegetable remains occur in some thin seams of clay subordinate to the mass of sand and fine gravel. The general character of the organic remains indicates a local deposit accumulated on the spot, and in comparatively tranquil waters.

The fossiliferous bed is overlaid by a mass of gravel-rubble and brick-earth, varying in thickness from 3 to 8 feet, and presenting general phænomena with respect to angularity of many of the flints, rapid variation of structure, &c., analogous to that of the flint- and chalk-rubble described at p. 105. The rubble, however, instead of being derived chiefly direct from the chalk, is here com-

* The more exact bearing of this pit is $1\frac{1}{4}$ mile in a direct line N.N.W. from the Grove Ferry station (South-Eastern Railway), and 2·7 miles southward ($\frac{1}{4}$ mile west of due south) from the Reculvers old Church.

posed in greater part of materials derived from an older gravel, and from shingle-beds of the Tertiary period; still with a local admixture of angular flints and chalk-rubble.

As well as the few specimens will allow us to judge, this deposit may be correlated with the one at Clacton on the opposite Essex coast*, where also recent marine and freshwater mollusks have been found by Mr. J. Brown, associated together in a deposit underlying the gravel.

My chief object in making this short communication to the Society is to direct attention to a locality not hitherto noticed, and which I think likely to yield on further examination a far more important series of Pleistocene fossils than those here enumerated, which were procured during two very short visits.

Note.—I am indebted to Mr. Rupert Jones for the following interesting particulars respecting the microscopic fossils:—

"The Entomostraca comprise three forms. The first is very abundant; the other two are very rare:

Candona torosa, *Jones*. Cypris gibba, *Ramd.* A minute undeterminable form.

"There is also among the minute organisms picked out from these sands one Rhizopod,—a *Globulina*.

"The *Candona torosa*† is a minute bivalved Crustacean, inhabiting the brackish-water ditches near Gravesend. It occurs also plentifully in the Grays deposits, in company with other recent and some extinct (?) Entomostraca. *Cypris gibba*‡ is a recent form, very common in freshwater ponds.

"The Foraminifer (*Globulina*), by its presence in the deposit in question, may be regarded as evidence of the at least brackish-water character of the Wear Farm sands. Mr. Pickering, who first discovered the recent specimens of *C. torosa* in the Gravesend ditches, found also a Rosalina-like Foraminifer associated with them;—a parallel to the above.

"The valves of the Entomostraca are sometimes separate and sometimes united. The sand and fine gravel in which these pleistocene fossils occur, frequently contain also numerous minute chalk-fossils, such as *Cytherellæ*, *Buliminæ*, *Rosalinæ* and *Cristellariæ*, spiculæ of *Inoceramus* shells, &c."

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4. *On* Land-surfaces *beneath the* Drift-gravel. By R. Godwin Austen, Esq., Sec.G.S., F.R.S.

I stated several years since § that the thick gravel-beds of the valley of the Wey below Guildford were underlaid by an old terrestrial surface, indicated by peat, trees, and sedimentary deposits,—that the remains of the extinct mammalia were usually associated with this

* Also with Grays and Salisbury.

† For description and figures of *C. torosa*, Jones, see Annals Nat. Hist. 2 ser. vol. vi. p. 27. pl. 3. fig. 6 *a*, *c*.

‡ See Annals, *l. c.* pl. 3. fig. 4.

§ Quart. Journ. Geol. Soc. vol. vi. p. 90; and vol. vii. p. 136, Table.

old surface,—and that it was in mud and silt of this age that the nearly perfect skeleton was found on the Pease Marsh, as was also the other of the parallel valley of the River Mole. As the great end to which geological inquiry is now tending is that of the past physical conditions which the earth's surface has undergone, and as the value of such inferences is wholly dependent on the accuracy with which observed facts may have been described, I am desirous of adding to the instances I before adduced respecting this ancient terrestrial surface, more particularly as the facts referred to have been represented in another way by Mr. P. J. Martin, in his "Additional Observations on the Anticlinal Line of the London and Hampshire Basins," published in the Philosophical Magazine, March 1854.

With reference to the phænomena of the Wealden area, considered physically, Mr. Martin is of opinion that "the key to the whole is in the conception of the cotemporaneity of upheaval and denudation," and that "there is no drift that is not of the age of the denudation." The circumstance that there should occur marl-beds, showing tranquil accumulations for long periods,—peat-bogs in old valleys, with trees of large growth,—and all now overlaid and preserved by this very covering of drift-gravel, proves that an external configuration of the surface somewhat the same as is presented now existed before the Drift, and that the two phænomena of denudation and drift-beds cannot be coupled as cause and effect.

Mr. Martin therefore observes, "Of the fossil or diluvial wood and trunks of trees *in situ* amongst [? beneath] the gravel-beds of Surrey, below the chalk, spoken of by Sir R. Murchison* (on the authority of Mr. Austen) in attestation of 'a true terrestrial surface,' after the commencement of the denuding æra [subsequent to the completion of the process of denudation?], I cannot say that they do not exist, but I have looked into many gravel-pits there, and in the corresponding districts under the South Downs, and I have never seen any wood in drift which was not of the most modern description, such as would till lately have been called mere 'alluvium.' Carbonized trunks of trees are to be found in all the bogs and swamps, especially in the alluvium of the river-courses, as noticed in my early memoir on Western Sussex. On the banks of the Mole and the Wey, and of their affluents, I doubt not such prostrate and uprooted trees may be detected;—they are post-diluvial."

The "diluvial" has ceased to be a definite geological period for the last ten years or more; and it may seem to some that it was not necessary to notice such objections, more particularly as they were accompanied by such other representations as that "the raised beach at Brighton belongs to the Eocene æra."

The supposition that the terrestrial surfaces referred to truly formed part of the most modern or present period was altogether unnecessary, inasmuch as these peaty and alluvial accumulations were distinguished † from the older ones both by position and in the different assemblage of animal remains.

* Quart. Journ. Geol. Soc. vol. viii p. 375, &c. † *Ibid.* vol. vii. p. 281.

The older terrestrial surface does not occur anywhere, that I know of, on the immediate banks of the Wey or Mole. These rivers and their affluents now flow at levels much below the general outspread of the transported gravel. Even at the height at which it is now kept artificially, the River Wey, from Guildford to Godalming, does not come near the base of the gravel-beds vertically; nor at times of greatest flood does it occupy the space formed by the denudation which the gravel-beds themselves have experienced since their original distribution. Near Farnham, the gravel-beds are 30 feet above the level of the river; in the Pease Marsh the difference is not less. The modern alluvia and the drift-gravel beds, in the case of the rivers referred to by Mr. Martin, never occur together. But, as it is a matter of some interest to make out as many points as possible where vestiges are preserved of that old land-surface which was coeval with the fauna of large extinct Mammalia which once existed here, I would first indicate a locality at which it has been shown since my former communication on the valley of the Wey*.

The great sheet of gravel and brick-earth which is spread out over Wonersh Common (see Map, fig. 1) runs out to the edge of the depression in which the Tillingbourne stream flows. The gravel-beds are cut off abruptly, and are from 8 to 10 feet above the level of the water, measuring to their lowest line. In the course of some works connected with the formation of water-meadows in East Shalford, a water-course was carried along these beds for a considerable distance. They were seen to consist of gravel and sands, with diagonal bedding, showing an arrangement by running water, such as I have described†, and contained Elephant remains. At a spot near where the road from Wonersh Common to East Shalford Farm crosses the water-course, and afterwards the Tillingbourne, a good section was exposed, which had, when I first saw it, been swept clean by a large body of water having been turned through it. The section showed

1. Drift-gravel; 8 feet.
2. Bed with black vegetable matter, seemingly composed of matted roots, with occasional trees,—the whole associated with fine marly beds.
3. Neocomian clay.

The roots of the larger trees descended into the subjacent clays. There were also smaller stems, with a bark like that of the hazel; but the wood had perished.

This terrestrial surface was identified again about a mile higher up the valley, near Tangley Pond, beneath about 18 feet of gravel; and consists of marly beds with much vegetable matter, and blending with the sands and gravels above. This locality is not on the line of the present stream, but is a part of what formed a low tract before the overspread of the gravel; and, as a general rule, it will be found that the Elephant remains are always most abundant in the gravels which occur about such spots. In the instance which has just been

* Quart. Journ. Geol. Soc. vol. vii. p. 278. † *Ibid.* p. 284.

Fig. 1.—*Map of the Guildford Valley, showing the Distribution of the Gravels, and the position of the Sections exposing Land Surfaces beneath the Drift.*

a. Gravel-beds, continuous with those of the Wey Valley.
b. Lower Tertiaries.
c. Chalk.
d. Lower Greensand.

The Terrestrial Surfaces beneath the Drift have been observed at the localities lying between 1 & 2, 3 & 4, 5 & 6, respectively.

Remarks on the accompanying Plan, fig. 1:

The Gravel Beds (indicated on the Plan by dots) pass into fine sand, horizontally bedded, in the valley west of Peasemarsh, where the dotting of the Plan is discontinued.

The gravel consists of coarser materials on the tracts that are more thickly dotted.

On the Hill, marked "Down," thick masses of angular flint-gravel occur.

noticed, as in every other, there was a total absence of any detritus below this old terrestrial surface.

I am well aware that, in the majority of cases where drift-gravel beds are seen in superposition on inferior strata, there are no indications of terrestrial conditions; but it must be borne in mind that at every time, as now, the accumulation of peaty matter is a local and exceptional case; and all that can be expected is, that it should occur when the old configuration of the surface rendered its formation possible. This old land-surface supplies us with a definite and valuable, though isolated, date in the geological history of a large area north of the Wealden denudation.

I would here refer to one or two instances, in order to show that old terrestrial surfaces of like age with those in the north of the Wealden area exist elsewhere.

Isle of Wight.—I had previously visited the locality indicated by Sir H. Englefield, whose description* will still be found most accurate, that "near the top of the cliff lie numerous trunks of trees, not lodged in the undisturbed strata, but buried 8 or 10 feet under sand and gravel. Many are 1 foot or 2 feet in diameter, and 10 to 12 feet in length; their substance is soft, but their forms are distinct; and with them occur considerable quantities of small nuts, like those of the hazel." He adds that no hazel now grows upon the island; nor has the subversion of the trees been an event of recent occurrence. I had further an opportunity of seeing, in company with the late Prof. E. Forbes, his own discovery of an instance of terrestrial surface infraposed to the Drift-gravels, at the east end of the Isle of Wight, near St. Helens; which he noticed in a communication on the newer Eocenes of that locality, but which has been omitted in the published abstract. The beds themselves present the usual characters of all accumulations of vegetable matter in low damp situations, including the remains of trees of large size. The beds contained the remains of Insects.

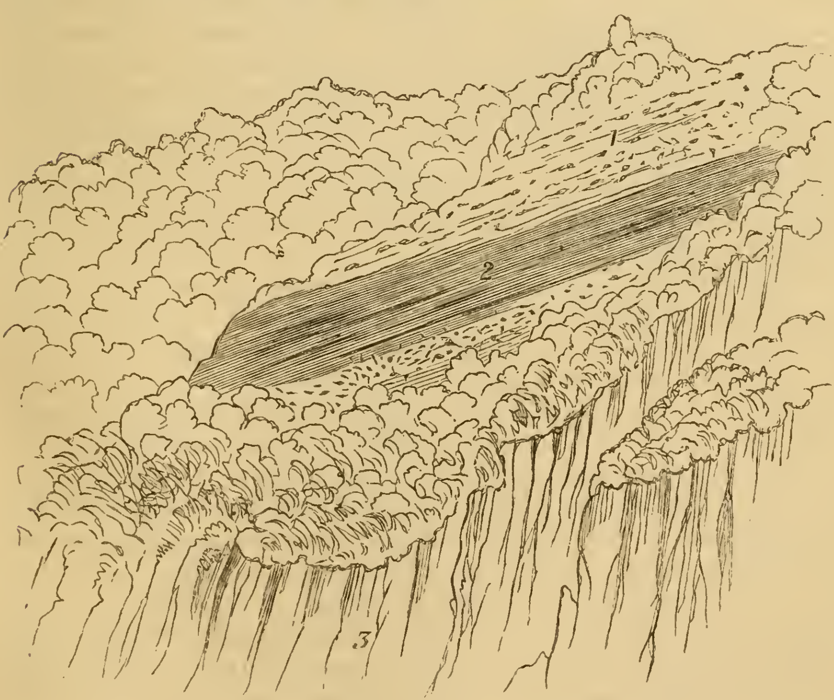
The overlying gravel-beds are developed on a grand scale, forming part of a band in the *north* of the central chalk-ridge of Brading and Bembridge Downs; and corresponding with that which occupies the central valley, along the line of the anticlinal of the island,—or to the south of the same ridge. The Brading gravels, where thickest, as near Foreland, have a marked bedded arrangement, which is not quite horizontal, but inclines towards the chalk-range. The materials have been derived from the chalk, but, though from Foreland the gravel extends southward over the edges of the upturned Eocene beds, they stop short, and do not reach the chalk-strata. The like happens with respect to the gravel-masses of the south side of the central range, along the Yar. They will be seen to be separated from, and to range below the level of the chalk,—in other words, they have not been produced by the abrasion of the chalk-strata now nearest to them; thus showing, in conformity with what has been noticed respecting the longitudinal valleys of the Wealden, that they were destitute of detritus before the Drift-gravel Period. The superposition of the

* Englefield's Isle of Wight, p. 132. pl. 22.

stratified gravel-beds of Brook, which belong to the central valley area, over a terrestrial surface of the same age as that of St. Helens, tends to refer all the gravels spread over the surface of the tertiary series to one and the same group.

Coast of France.—On the evidence that masses of peat were brought up in trawls from parts of the sea-bed off the French coast (Pas de Calais, Department of the Somme),—and that over the same spots the remains of *Elephas primigenius* were very frequent as well as perfect, I ventured on the opinion that these parts of the Channel had formed part of the dry-land-surface of the period of that fauna. Some observations by French geologists (Rozêt) respecting a *tourbe du Diluvium* indicated that they had seen instances of terrestrial surfaces beneath the gravel-drift; none of them, however, have been particularly indicated. It was therefore with much interest that, in conjunction with several members of this Society, I met with such a case in the course of a geological excursion in the spring of last year. The place at which the section, fig. 2, was taken, is about half-way between Dieppe and the Lighthouse of St. Marguerite. The beds are cut off by the cliff as represented in the sketch. The portion remaining has a slight basin-shaped arrangement, as if the vegetable and sedimentary matter had been collected in some local depression. The underlying beds belong to the lower Eocenes; and above are thick water-strewn beds of flint-gravel. Mr. D. Sharpe collected in the deposit in question the remains of insects.

Fig. 2.—*Cliff Section exposed near Dieppe.*



1. Gravel. 2. Peaty layers. 3. Tertiary beds.

These facts are offered as additional evidence in support of the conclusion I put forward in a communication on the area of the English Channel,—viz. that a very large portion of it formed a continuous surface of dry land with the adjoining parts of France and England, at the time of the Large Mammalian fauna in these countries. The geological phænomena of this age are in perfect harmony on either side of the Channel.

It may have been remarked by whoever has sailed along the French coast at the distance of a few miles, that the chalk-cliffs rise to a very uniform elevation along their whole course: they have the appearance of a vertical wall rising from the sea, with openings at intervals, where deep valleys open out at the sea-level; whilst at times such depressions in the outline only extend downwards for a portion of the height of the cliffs. The valley-systems of this chalk-area are somewhat remarkable; they take their rise at the very summit-level, descend rapidly, join others, and finally merge into one of the great lines of drainage: small streams flow down some, only occasional streams down others. They are all valleys of excavation; but in no instance has this process gone lower than, or so low as the sea-level, except perhaps in the estuary parts of one or two of the larger rivers. As we cannot imagine that the depths of these valleys can have had any influence in determining the amount of the general elevation of the chalk-formation over this area, the contrary may be assumed,—viz. that the amount of elevation has determined the extent of excavation.

Over the whole of the chalk-area here described, the upper tabular surfaces are covered with the accumulation of flint-drift, not in confused masses, but in alternating layers of clay, coarse detritus, and sands, with diagonal bedding, and all other indications of successive accumulation. The materials of the gravel occur in the valleys, but under totally different appearances. They here present no regularity in arrangement, conform to the slopes, and are mixed up with the subaërial accumulations of the hill-sides, which they seem to have incorporated with them. As a general rule, the heights are covered with gravel, and the valleys are free.

It follows then that the valley-systems must have been mainly formed since the dispersion of the Drift;—and this is confirmed by the fact that it is only in the deeper valleys before mentioned, such as those of the Somme, the Authie, and the Canche,—which are valleys connected with the axis of Artois,—that old terrestrial surfaces occur which were coeval with the extinct fauna of large mammals.

From this we may venture on one further inference,—that the agent which has produced the greater part of the existing valley-systems of the chalk-area of the North of France has been merely meteoric. Against this any denudation-theory is inadmissible, in consequence both of the irregularly diverging character of the valleys, and the loose materials on the summit-levels. Had these deep narrow valleys existed prior to the Drift, they must necessarily have been filled before any accumulation could form and be spread out uniformly over the higher levels.

The position of the gravels of the coast of France shows how very great has been the change of level around the English Channel area* since the period of their dispersion.

The formation of valleys, such as those of the French chalk-area, may seem to some to require an agency more powerful than that now suggested; but, taking as our guide the quantity of lime taken up by every gallon of rain-water which flows from our own chalk-district, the question becomes one of time, in the course of which every line of inequality along which water may flow must ultimately be deepened and widened out. This is not the place for details of such a calculation; which, with other effects of subaërial agency, I propose to submit collectively. If the cause be the true one, we have the data for the determining the lapse of time from the elevation of the Drift-beds down to the times in which we live; and, however vast that period may seem, which is but the newest date in our geological reckoning, we must not on that account merely reject the result.

The extent of the hydrographical area of the southern counties of England and of the opposite side of the Channel during the period of the distribution of the Drift-gravel can now be determined with tolerable accuracy, by combining the results of several observers (more particularly those of Mr. Prestwich and Mr. Morris) who have noticed and described them. Over the whole area I have never seen, or even heard of, the presence of a single form which would indicate marine origin. In spite of the great extent of the area, I believe the body of water to have been fresh; and, as a whole, it may be geologically the equivalent of some of the northern gravel-drifts, which were undoubtedly marine.

The climatal conditions are, I think, indicated by the manner in which large blocks of siliceous sandstone have been lifted and let fall amidst accumulations indicating no great moving power. Such appearances are well seen in the drift-area to the north of the chalk-range of Surrey, particularly about Ash. The distance from which these blocks have been moved cannot have been very great; and the only condition which seems to meet the requirements is one—where coast-ice was periodically formed and dispersed, carrying with it such materials as might be included in or attached to it.

January 3, 1855.

Dr. A. Halley was elected a Fellow.

The following communications were read:—

1. *On a* Modern Submerged Forest *at* Fort Lawrence, Nova Scotia. By J. W. Dawson, Esq., F.G.S.

The extraordinary tides of the Bay of Fundy, and its wide marshes and mud-flats, are well known to geologists as affording some of the best modern instances of rapid tidal deposition, and of the preserva-

* See Quart. Journ. Geol. Soc. vol. vi. p. 69, and vol. vii. p. 118.

tion of impressions of footsteps, rain-drops, and sun-cracks. Attention has not, however, been called to the fact which I propose to notice in this paper, that much, if not the whole, of the marine alluvium of the Bay of Fundy rests on a submerged terrestrial surface, distinct indications of which may be observed in the mud-flats laid bare at low tide, and in the deep ditches dug for drainage.

In their natural state, the alluvial soils of the Bay of Fundy are mud-flats overflowed by the high tide, and either quite bare or covered in part with salt-grass. Large tracts have, however, been reclaimed from the sea, and are distinguished by the name of "dyked marsh," or more shortly "dyke." There are in Nova Scotia 40,000 acres of dyked marsh, and in New Brunswick perhaps 10,000 acres. The soil of the marshes is everywhere a fine marine mud, deposited in thin layers by the tides, and of a brownish-red colour; except in the subsoil and in the lower parts of the surface where the colour has been changed to grey by the action of sulphuretted hydrogen on the ferruginous colouring matter. Though remarkably productive of grasses and cereals, no part of the marsh-land supports forest trees. Dyked and salt marshes occur in nearly every creek and inlet of the upper part of the Bay of Fundy, more especially in Minas Basin, Cobequid Bay, and Cumberland Basin; and it is in this latter that the submarine forest to which this paper refers is found to underlie the marine alluvium.

Fort Lawrence is a low point of upland, resting on Lower Carboniferous rocks, and separating the estuaries of two small streams, the La Planche and Missequash; the latter forming at this place the boundary between Nova Scotia and New Brunswick. Both of these rivers, as well as the other streams emptying themselves into Cumberland Basin, have at their mouths extensive tracts of marsh, and in this instance the marsh-land extends beyond and overlaps the upland point separating the rivers. At the extremity of the point the upland slopes gently down to the dyked marsh, beyond which there is a narrow margin of salt-marsh, scantily clothed with coarse grasses and *Salicornia*. This margin of marsh without the dyke is overflowed by the highest tides, and may therefore be taken as the high-water level. Owing to the toughness of the upper layer matted with roots, and the action of the neap tides, it presents at the outer edge a perpendicular front about five feet in height. Below this there is a sloping expanse of red mud, cut into many inequalities by the tidal currents, which appear here to be removing the old deposit rather than adding new material. On the surface of this mud I saw impressions of rain-drops and sun-cracks, tracks of sandpipers and crows, and abundance of the shells of *Sanguinolaria fusca**. There were also a few long straight furrows, which I was told had been produced by the ice in spring. Owing to the firmness of the mud, they remained (in August) quite sharply marked, though in places filled up with new mud.

At the distance of 326 paces from the abrupt edge of the marsh, and about twenty-five feet below the level of the highest tides, which

* Probably identical with *Tellina Balthica*, Linn.

here rise in all about forty feet, the mud becomes mixed with sand and gravel, with occasional large stones, probably dropped by the ice. At this level appear erect stumps and many prostrate trunks of trees. The stumps are scattered as in an open forest, and occupy a belt of 135 paces in breadth and extending on either side for a much greater distance. I saw more than thirty stumps in the limited portion of the belt which I examined. Between the lowest erect stumps and the water-level at low tide is a space of 170 paces, in which I observed only fragments of roots and prostrate trunks, which may, however, be the remains of trees swept away by the ice from the portion of the shore on which these fragments now lie.

On digging around some of the stumps, they were found to be rooted in ground having all the characters of ordinary upland forest-soil. In one place the soil was a reddish sandy loam with small stones, like the neighbouring upland of Fort Lawrence. In another place it was a black vegetable mould, resting on a whitish sandy subsoil. The smallest roots of all the stumps were quite entire and covered with their bark, and the appearances were perfectly conclusive as to their being in the place of their growth. I have no doubt that the whole of these stumps have been deeply covered with the marsh-deposit, and have been laid bare by the encroachments of the tides on this somewhat exposed point. In a few places the lowest layer of the mud originally deposited over the forest soil could be observed. It is a very tough unctuous blue clay, with a few vegetable remains resembling roots of grasses. This may have been the first deposit from sea-water, while the forest was still sufficiently dense to prevent the access of coarser sediment.

All the stumps and trunks observed were pine and beech (*Pinus strobus* and *Fagus ferruginea*), and it is worthy of notice that these are trees indicative rather of dry upland than of swampy ground. The pine-wood is quite sound within, though softened and discoloured at the surface. The beech is carbonized at the surface, and so brittle and soft that trunks of large size can be cut with a spade, or broken across by a very slight blow. Owing to this softened condition of the beech-stumps, they are rounded at top, and scarcely rise above the surface of the mud ; while some of the pines project more than a foot. Even these last, however, are much worn and crushed by the pressure of the ice. The largest stump observed was a pine, two feet six inches in diameter, and exhibiting about 200 lines of growth.

These appearances cannot be explained by driftage, for the trees are rooted in a perfect woodland-soil ; nor can they be accounted for by landslips, for the stumps are separated from the nearest upland by marshes nearly a quarter of a mile in width, and the upland is low and gentle in its slope. The popular explanation is that the tides have at some former period been dammed out, or their entrance obstructed by a narrowing of the mouth of the Bay. This theory is countenanced by the present state of the tideway of the St. John River, in which a ledge of rock so obstructs the narrow entrance, that, while at low tide there is a considerable fall outward, at half tide the water becomes level, and at high tide there is a fall inward; the level within not rising to that of high water without, except in times of flood, when the excess of fresh water in the river supplies the deficiency of tide-water. It is evident that the complete removal of this obstruction would enable every tide to overflow ground now covered only by the annual river-floods; and, on the other hand, the river would be daily drained out to the level of the low tide. Such an obstruction would without doubt produce a change in the water-level of Cumberland Basin, and might even enable trees to flourish a few feet below the present high-water mark; but it could not under any circumstances enable upland-woods to grow nearly at the level of low tide in a country so well supplied with streams.

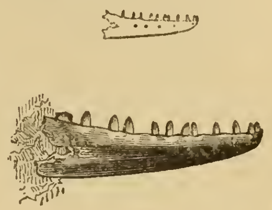
The only remaining mode of accounting for the phænomena is the supposition that a subsidence to the amount of about forty feet has occurred in the district. Such a subsidence is not likely to have been limited to Fort Lawrence Point; and accordingly I have been informed by intelligent persons, long resident in the neighbourhood, that submerged stumps have been observed at a number of other places, in circumstances which showed that they were *in situ*; and that trees and vegetable soil have been uncovered in digging ditches in the marsh. Nor are these appearances limited to Cumberland Basin. At the mouth of Folly River, on the southern arm of the Bay, a submerged forest on an extensive scale is said to occur; and in the marshes of Cornwallis and Granville vegetable soils are found under the marsh. These facts render it probable that the subsidence in question has extended over the whole shores of the Bay, and that the marshes have been deposited and the present lines of coast-cliff cut since its occurrence.

The marshes of the Bay of Fundy are known to have existed at or about their present level for 250 years. It is true that an opinion prevails in some of the marsh-districts, that the tides now rise higher than formerly, and in proof it is alleged that the dykes are now maintained with greater difficulty, and that tracts of marsh once dyked have been abandoned. The settling of the mud and the narrowing of the tidal channels by new embankments may, however, have produced these effects. For the antiquity of these submerged forests, we must therefore add to the two centuries and a half which have elapsed since the European occupation of the country a sufficient time for the deposition of the alluvium of the marshes. On the other hand, the state of preservation of the wood, after making every allowance for the preservative effects of the salt-mud, shows that its growth and submergence must belong to the later part of the modern period.

It is a singular coincidence that this comparatively modern instance of the submergence and burial of a forest should occur in the vicinity of the Joggins cliffs, which so well exhibit the far more wonderful events of a like character which occurred in the Carboniferous Period.

2. *Notice of some* New Reptilian Fossils *from the* Purbeck Beds *near* Swanage. By Prof. Owen, F.R.S., F.G.S.

Part of the right ramus of the Lower Jaw with teeth of Saurillus obtusus, Owen. (Nat. size and magnified.)



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a. One of the teeth magnified.

Having received from Mr. W. R. Brodie, of Swanage, a second collection of fossils from the Purbeck beds at Durdlestone Bay for examination, I find amongst the Vertebrate specimens some Ichthyolites and two examples of *Reptilia* : the latter seem worthy of a woodcut ; they are small, and may be described as follows :—

Specimen A, from the "dirt-bed *," no. 93 in Mr. Austen's stratigraphical list †. It indicates a Lacertian genus and species, for which I propose the name of *Saurillus obtusus*. This lizard is represented by the right dentary bone of the lower jaw (see fig.), containing 13 moderately long, conical, blunt-pointed teeth, differing in form from those of the *Nuthetes* and *Macellodus* described in a former communication ‡, and from the same formation and locality.

The teeth in *Saurillus* are not so long nor so recurved as in *Nuthetes*, nor are they compressed as in that genus ; and they are not broad and flat as in *Macellodus*. On the outer side of the dentary bone are six nervo-vascular foramina in a longitudinal row, relatively as numerous and large as in the *Iguanodon*, and indicating, as in that and other Saurian reptiles, the scaly covering of the jaws and the equally reptilian condition of the salivary apparatus in the little *Saurillus*. Supposing the fossil to have come from a mature individual, the size of the animal must have been equal to that of the common European lizard *Lacerta agilis*. It was most probably insectivorous. The specific name refers to the obtuse termination of the muzzle, as indicated by the form of the fore part of the jaw, and also to the blunt apices of the conical teeth. See figure.

Specimen B, from the same bed, is a portion of jaw with two long, slender, recurved, pointed teeth, of an almost circular transverse section, with two opposite low but sharp ridges along the enamelled crown, like those in Teleosaurian teeth. If this fragment formed part of a full-grown animal, it indicates a species of Saurian, probably Lacertian, reptile, distinct from any of the before-defined kinds from the Purbecks. The jaw-bone is, however, too much mutilated at the base of the teeth to determine their precise mode of attachment. The teeth are black, with the enamel unusually lustrous.

A portion of a jaw of a somewhat larger reptile, with empty sockets for simple teeth like those of a Crocodile, is imbedded in the same

* See also Quart. Journ. Geol. Soc. No. 40, p. 423 and p. 482.
† Guide to the Geology of Purbeck. 8vo. 1852.
‡ Quart. Journ. Geol. Soc. June 1854, no. 40, pp. 420–426, figs. 1–8.

slab. Neither of these indications call for a specific name; future explorations by their discoverer may bring to light more evidence of the animal so indicated. Already much valuable knowledge of the Vertebrate fossils of the Purbecks has been gained by the indefatigable researches and acute discernment of Mr. Brodie.

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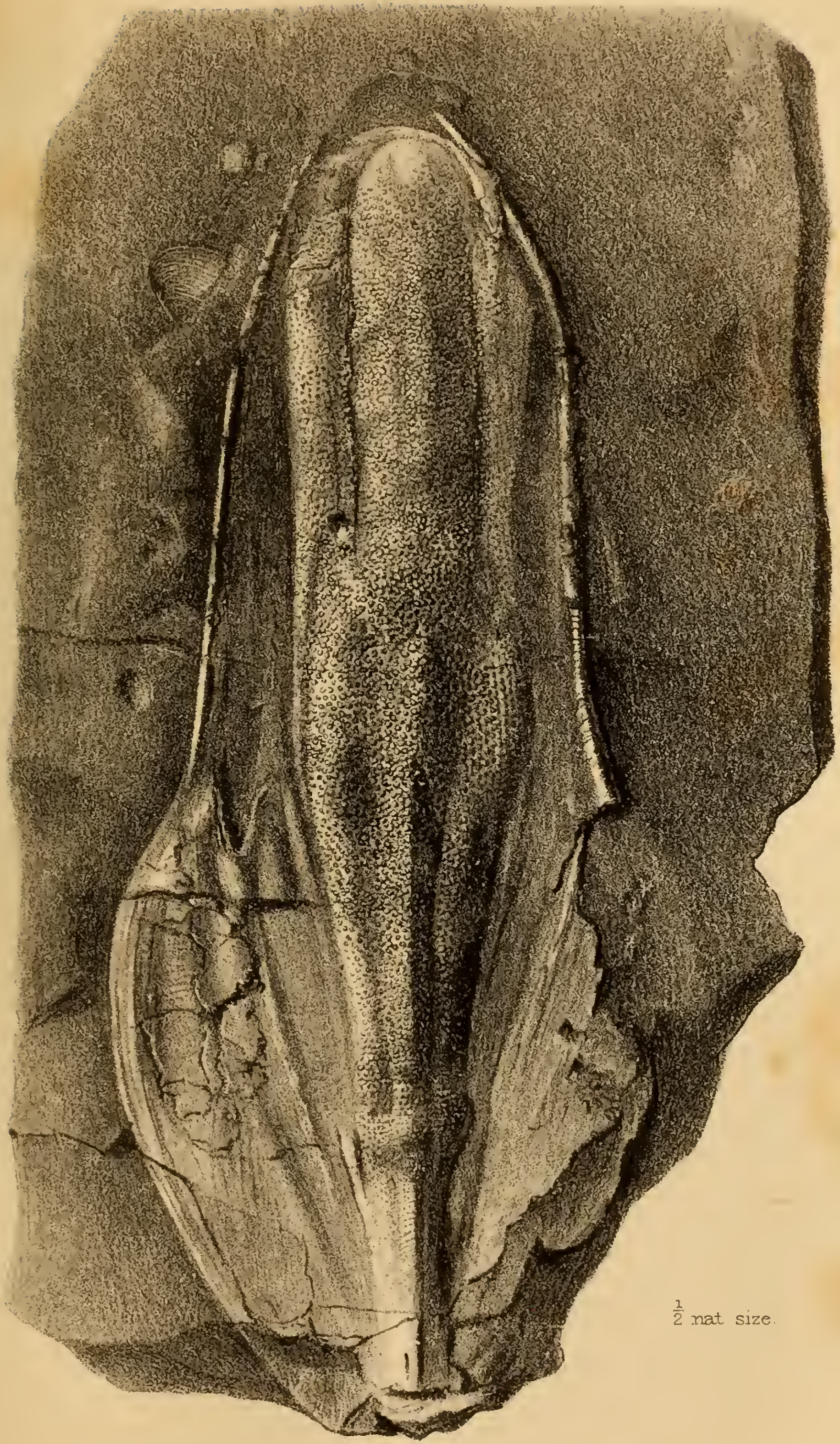
3. *Notice of a* NEW SPECIES *of an* EXTINCT GENUS *of* DIBRANCHIATE CEPHALOPOD (*Coccoteuthis latipinnis*) *from the* UPPER OOLITIC SHALES *at* KIMMERIDGE. By Prof. OWEN, F.R.S., F.G.S. &c.

[Plate VII.]

THE subject of the present notice is the internal shell, 'sepium' or cuttle-bone of a large Dibranchiate Cephalopod, combining some of the characters of that of the Cuttle (*Sepia*) with that of the Squid (*Loligo*, *Sepioteuthis*, &c.). The specimen was discovered by W. R. Brodie, Esq., at low-water-mark, in the shales at Kimmeridge, in a layer of which it lies imbedded, with the dorsal surface exposed. It is 1 foot in length, although the hinder pointed end is broken away, and $5\frac{1}{2}$ inches in breadth at its broadest part, about one-third from the hinder end; proportions which indicate the entire animal yielding it to have been about a yard in length from the end of the outstretched arms (see Pl. VII.). The sepium is slightly convex along the middle of the dorsal surface, which is the one exposed, and this convexity is beset with hard calcareous granules; the largest, occupying the middle of the convexity, are about half a line in diameter, and gradually diminish in size to the anterior border, and to within two inches and a half of the fractured posterior end. The substance of the plate which sustains these granules is calcified, but the calcareous layer is very thin, about one-third of a line, and it coats a black internal horny layer, which extends to the lateral margins, where the calcified outer layer gradually changes into a horny one. This albuminous or horny part of the body is much more extensive than in the Cuttle-bone, and differs more materially by being continued through the centre of the sepium. A little behind the rounded anterior border of the sepium, where the finely granular calcified layer is broadest, the horny marginal plate becomes half an inch in breadth, gradually increasing for nearly two-thirds the extent of the shell to a breadth of one inch and a half, when the margin suddenly expands and sweeps, with a convex curve, backwards to the hinder end of the shell. These posterior expansions have doubtless penetrated corresponding expansions of the mantle, forming the hinder fins of the Cephalopod; a part of the exposed shale, which was in contact with the under or ventral surface of one of these expansions, shows transverse fibrous markings indicative of former muscular attachments of the part in question. The anterior border of the shell is broad and rounded; the posterior end appears to have terminated more acutely, but this characteristic part of the shell is unfortunately wanting.

There is an indication at a fractured part near the middle line of



COCCOTEUTHIS LATIPINNIS (Owen).
Kimmeridge Clay.

[illegible] Ford & West Imp

the shell that it was slightly convex there along the ventral aspect; but, though it has been subject to compression, the solid resisting calcified part was evidently much thinner than in the cuttle-bones, or sepia-shells, of the present seas; and the distinct horny layers continued through the substance of the shell form a modification of structure not known in any existing Cephalopod with a calcified internal shell.

From the *Kelæno* of Munster (*Acanthoteuthis* of Wagner), the genus indicated by this shell differs in having the lateral expansions; from the *Teudopsis* of Deslongchamps and *Acanthoteuthis* of D'Orbigny it differs in the well-defined and restricted extent of those expansions; from the *Ommastrephes* and *Conoteuthis* of D'Orbigny it differs in the absence of the strong median crest or keel. The nearest resemblance which I have found in previously described or figured fossil remains of the Dibranchiate Cephalopods is in that specimen which forms the subject of Taf. ix. Heft vii. of Münster's "Beiträge zur Petrefacten-künde;" of which plate no description or notice occurs in the text or on the plate itself, in the copy of the work in the Geological Society's Library. I am indebted to the Referees of the present notice for the following information respecting fig. 1. t. ix. Münst. Beitr. vii. Heft. "It is the *Loligo antiqua* of Münster, according to Hœninghausen and D'Orbigny, and the *Sepia prisca* of Kœnig's 'Icones.' Bronn refers it to the *Sepia hastiformis*, Rüppell, Solenh. 9. t. 3. f, 2; but that species may be different. D'Orbigny figures two species of '*Coccoteuthis*.' But from all these Mr. Brodie's fossil is probably distinct." [Feb. 22, 1855.] The present example from the Kimmeridge shales appears to be a distinct species; it is broader in proportion to its length.

To facilitate future references and comparisons of the rare indications of the higher organised naked Cephalopods in our oolitic series, I propose to name the specimen here described *Coccoteuthis** *latipinnis*, in reference to the well-marked granulated surface of the calcified part of the sepium, and to the breadth of the pallial fins. Its essential generic character is the extent of the calcified part of the shell combined with the horny part. It indicates a genus or subgenus with very interesting intermediate or osculant characters between the Cuttles (*Sepiadæ*) and Squids (*Teuthidæ* or *Loliginidæ*) of the present time; and it illustrates in the highest class of Mollusca that adherence to a more general type, which I have had occasion to point out in the fossils of many other classes of animals from the Secondary formations.

A second specimen, somewhat larger and nearly as well preserved, has been obtained from the same locality by Mr. Groves of Wareham.—R. O. April, 1855.

* From κόκκος, a berry, and τευθὶς, a squid or calamary.

4. *On the* Tertiary Formations *of the* North *of* Germany; *with special reference to those of* Hesse Cassel *and its neighbourhood.* By W. J. Hamilton, Esq., Pres. G.S.

Contents.

Introduction.

The observations contained in the following pages are intended as supplementary to those which I laid before the Society on the 22nd February last*. The subject is one of growing interest, and is, I am happy to say, attracting the attention of the geologists of the north of Germany and of Vienna. We have therefore every reason to hope that, from their combined exertions, many years will not elapse before we shall possess a complete table of the chronological history of the marine tertiary beds of Germany. Under these circumstances, and considering the comparatively limited extent of my additional observations, made last autumn, I should have deemed it premature to bring them on this occasion under the notice of the Society, had I not been desirous of availing myself of this opportunity to correct an error into which I was unconsciously led in my former communication, in which I have attributed an opinion to a distinguished German geologist which he never entertained, and which is at variance with what he has already published on the subject. I trust that my friend Dr. Sandberger will accept this explanation as sufficient reparation for the error which I have committed.

At page 292 of the 10th volume of our Journal, in alluding to the tertiary deposits of Westeregeln near Magdeburg, I have stated, apparently on the authority of Dr. Sandberger, that its exact relations to the beds of the Mayence basin have been made out, and that it overlies the Brown-coal formation of the Westerwald, which is itself the uppermost of the two Brown-coal formations of the Mayence basin. It is needless now to inquire how I was led to make this statement, or to explain what now appears to me to have been the cause of having been misled. It is enough to state that Dr. Sandberger's opinion, which he has published in his last work† on the Mayence basin, is that the Westeregeln or Magdeburg sands, which are stated by Dr. Beyrich and others‡ to be older than the Septaria-clay of Berlin, &c., are of the same age as the Weinheim sands, and consequently much older than either of the Brown-coal formations of the Mayence basin. I believe it is the opinion of other German

* Quart. Journ. Geol. Soc. vol. x. p. 254 *et seq.*

† Untersuchungen über das Mainzer Tertiär Becken, von D. F. Sandberger. Wiesbaden, 1853, p. 79.

‡ See Zeitschrift der Deutschen Geologisch. Gesellschaft, 1851, vol. iii. p. 216.

geologists that these Westeregeln sands are still older; but we shall return to this point hereafter. I will here merely observe that the only correct part of the statement above quoted is that the Marine-sands of Westeregeln *overlie* a Brown-coal formation, consequently a Brown-coal of a much older date than those of the Wetterau or the Westerwald.

I propose in the following remarks to call the attention of the Society principally to the following points:—

1. Tertiary geology of the neighbourhood of Hesse Cassel.
2. Remarks on the tertiary beds of Westeregeln.
3. Concluding remarks on the chronological connection of some of the tertiary formations of the north of Germany.

I. Tertiary Beds of Hesse Cassel.

The tertiary marine formations of Hesse Cassel have been long ago described by German writers, and a tolerably correct list of the fossils contained in them was published by Philippi in his work* on the Tertiary Fossils of the North of Germany.

Much, however, remained to be done in working out their true position, and in ascertaining their relative position to the Brown-coal formations of the district, and to the other tertiary marine beds of the north of Germany. The numerous volcanic outbursts and basaltic knolls which have penetrated the entire district, extending from the Vogelsberg and the Rhön Gebirge to the northwards far beyond Cassel, constitute one of the most peculiar features of the country, not only modifying the physical character of the region, but indicating the former existence of elastic forces which have affected the whole of the underlying sedimentary deposits. These basaltic rocks are sometimes found spreading themselves out in vast tabular masses over the underlying Brown-coal beds, to which they form a kind of capping, as is seen in the Habichts Wald near Cassel, the Hirschberg, and the Meissner. In most cases, however, the basalt occurs in dykes or in isolated knolls, spread over the face of the country from Frankfort on the Maine to Cassel, and even beyond to the neighbourhood of Göttingen and Carlshafen on the Weser.

The following Sections observed in the vicinity of Cassel will best explain the manner of the occurrence of these tertiary beds:—

1. *Sections at Habichts Wald and Wilhelmshöhe.*

Although, generally speaking, the Bunter Sandstein and the Muschelkalk form the basis on which the tertiary beds have been here deposited, it is the Muschelkalk alone which forms the basis of the tertiaries of the Habichts Wald. A ridge of Muschelkalk extends in the direct line of strike from E. to W., from Cassel to the north of Wilhelmshöhe, constituting a low range of hills. The beds dip due S. about 6° or 8°; while the Bunter Sandstein which occurs further N. loses itself conformably under the Muschelkalk. This ridge is

* Beiträge zur Kenntniss der tertiär Versteinerungen des nordwestlichen Deutschlands. Cassel, 1844.

traversed at right angles to the strike and almost vertical cleavage-planes by a powerful dyke of basalt, which is exposed near the town. Another dyke is seen in the Ahne Thal on the Habichts Wald, from which lateral injections of tabular horizontal beds of basalt have been forced into the Muschelkalk.

Over the Muschelkalk occur in ascending order:—1. Alternating beds of sand and clay, sometimes the one and sometimes the other, resting immediately on the secondary rocks. In one of these lower beds of sand are thin bands of sandstone, containing numerous vegetable impressions, amongst which those of *Taxus* and *Cypressus* have been made out.

2. A bed of clay, four or five feet thick, forming an underclay to the Brown-coal: this clay (blauer Letten) is generally of a dark bluish colour.

3. Brown Coal: these beds are here from 30 to 40 feet thick, and are extensively worked to supply the neighbourhood with fuel. In some places the Coal-beds crop out on the surface, and the coal is worked in open cuttings. In general character it is compact and earthy, of a uniform texture, and without any trace of vegetable organisms. Occasionally it acquires a brighter lustre, and is more easily broken, and is then called Glance-coal. This generally occurs in the neighbourhood of the basalt.

4. A bed of clay, about 4 feet in thickness; generally similar to that below the Brown-coal.

5. Marly yellowish sand, containing marine shells. The only section of this bed which I saw was in the Ahne Thal, where it occurs in a deep ravine; here the beds have been much disturbed by the protrusion of the igneous rocks. It is not well exhibited. The shells are chiefly small, and much broken. A list of them has been published by Dr. Philippi of Cassel in 1844*, from which it appears that at least 24 species are identical with those of the Mayence basin. There is no list of synonyms supplied by Philippi; such a list would probably give a greater number of identical species in the two formations.

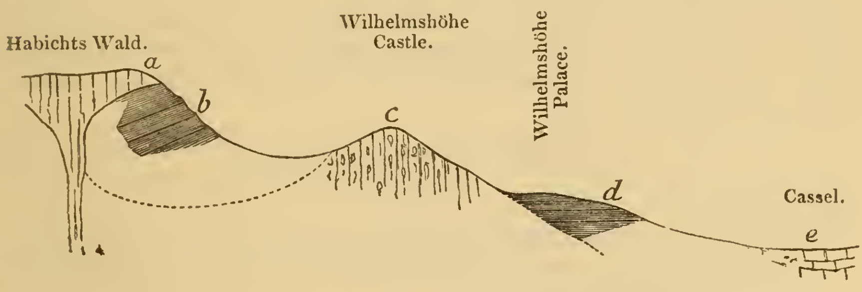
6. Loose incoherent sand, locally called Trieb- or drift-sand, from its tendency to drift into the shafts, and other works of the coal-pits. It constitutes the greatest difficulty of the workmen in driving their adits and galleries, and has occasioned the abandonment of more than one working. Large blocks of quartzose sandstone occasionally occur in this sand, some of which are said to contain marine shells, others are full of casts of the stems of plants.

These beds have all a slight inclination, varying more or less in different places, towards the centre of the basaltic hill which constitutes the summit of the Habichts Wald. (See fig. 1.) The Brown-coal dips under the basaltic mass which forms the plateau of the top of the hill. This phænomenon of the Brown-coals dipping under the basalt, which I have observed in other places, will be alluded to again hereafter.

* Philippi, Beiträge, &c.

It appears from the above detailed section that the marine deposit is comparatively small in this Cassel region. One thin bed only occurs containing marine remains, with the exception of a few isolated shells said to be found in the sandstone-blocks lower down the hill in the sand below the Wilhelmshöhe. The greatest number of the shells, and the best preserved specimens, described by Philippi, were obtained many years ago, while laying out the grounds near the palace at the foot of Wilhelmshöhe towards Cassel, *d*, in fig. 1. The beds were here nearly 300 feet below their position in the Habichts Wald, the latter having been probably elevated in consequence of the protrusion of the basaltic conglomerate which intervenes, and on which the fantastic ruins of Wilhelmshöhe are built.

Fig. 1.



a. Basalt.
b. Brown-coal beds.
c. Trachytic and basaltic conglomerate.
d. Tertiary beds.
e. Muschelkalk.

2. *Section of tertiary beds near Ober Kaufungen.*

In the small oblong plain irregularly extending between Nieder Kaufungen and Ober Kaufungen, about five or six miles E.S.E. from Cassel, is another extensive tertiary formation, in which are considerable deposits of brown-coal and blue-clay, overlaid, as in the Habichts Wald section, by a marine sand, of no great thickness, but full of remains (more or less broken) of marine mollusca.

The following section, in ascending order, was seen near the village of Ober Kaufungen. The tertiary beds here rest on the Bunter Sandstein, which constitutes the basis of the surrounding country. The Bunter Sandstein beds fall in suddenly under the tertiary beds, and these also, near the point of junction, fall in towards the Bunter Sandstein.

1. Stiff blue clay, containing numerous nodules of iron-pyrites.
2. Loose incoherent sand.
3. Brown-coal, 8 or 10 feet thick, occasionally separated into several seams by intervening beds of sand or clay.
4. Bituminous shale, from which alum was formerly obtained.
5. Various beds of marls and clay.
6. Fine white sand, with occasional bands or layers of hard sandstone, grit, or quartzite.
7. Mottled clays.

The whole thickness of these beds is upwards of 100 feet, but I could not obtain very exact measurements. A short distance to the S.W., a yellow clay with calcareous nodules occurs near the summit of the hill, which, although containing no organic remains, is supposed by the miners and local geologists to be identical with the beds near Cassel in which the marine mollusca have been found. Its true relation to the Brown-coal, however, has not yet been satisfactorily made out.

Other extensive coal-beds are worked on the other side of the valley, E.N.E. from Ober Kaufungen. Here the various seams of brown-coal are seen alternating with beds of sand and clay. In the sandstone-bed which underlies the principal seam of brown-coal are found the same vegetable impressions as those already described as occurring in the sandstone under the brown-coal of the Habichts Wald. They are chiefly *Taxus, Cypressus,* and other plants likely to grow in vast subtropical lagoons, not unlike those now found in the vast swamps of Louisiana. The uppermost beds consist of hard quartziferous sands, which are sometimes broken up and cover the surface with huge irregular blocks.

Approaching the district where the principal coal-works are carried on, we were enabled to make out the following section, in ascending order.

1. Brown-coal, occasionally containing erect stems of trees, broken off where the overlying beds commence, thus proving them to have grown *in situ*.
2. Blue clay, with numerous Septaria.
3. Thin band of limestone.
4. Blue clay, with marine shells; those we found consisted principally of—

Nucula margaritacea.
—— Lyellii? (Deshayesiana?).
Astarte.
Cytherea.
Cyprina.
Pectunculus.
Solen.
Tornatella (resembling *T. simulata*).
Rostellaria (with a broad-winged lip).
Turritella.

We found specimens of all these in a very short time.

5. Thin bed of highly fossiliferous sand, containing numerous fragments of bivalves—*Pecten* (resembling *P. pictus*), *Turritella,* &c.; closely resembling that on the Habichts Wald, near Cassel.

In one locality this sand contains numerous ferruginous concretions with the same fossil remains.

6. A thick bed of loose unfossiliferous sand, 30 feet.
7. Forming the top or capping of the hill, on the north side of the valley, is a thick bed of hard compact sandstone, now broken up into large irregular fragments.

On this north side of the valley, the rock underlying the tertiary deposits is Muschelkalk, almost horizontal. A small basaltic hill rises near the centre of this valley-plain. It has not yet been ascertained whether the brown-coal extends over the whole of this basin, but as it has been bored for and found in several directions, the probability is that it will be found throughout the whole district here laid down as tertiary in Prof. Schwarzenberg's map*.

A short distance further westward, near the village of Nieder Kaufungen, a very interesting section has been lately exposed, giving an almost complete epitome of the whole tertiary series, resting immediately upon Muschelkalk, as follows, in ascending order :—

1. Muschelkalk.
2. Thin beds of clay, resting on the Muschelkalk.
3. A thin seam of coal ; not very good.
4. Sands, which at a distance of 50 or 100 yards are found to contain abundantly the same fossils as those found in bed No. 5 of the former section.

We have therefore here apparently the edge or coast-line of the basin containing the shallow lagoon in which the coal was formed, and which, on the irruption of the sea, was covered up by a marine deposit containing the organic remains of a marine fauna.

3. *Sections at the Hirschberg.*

In the same direction from Cassel, viz. E.S.E., but seven or eight miles beyond Kaufungen, are the extensive Brown-coal works of the Hirschberg, and still further on, the more extensive and better known works of the Meissner. I had no opportunity of visiting the latter, but the circumstances under which the Brown-coal occurs there are nearly, if not exactly, similar to those observed at the Hirschberg. In both cases a basaltic plateau forms the summit of the isolated hills, that of the Meissner being the more extensive and more elevated of the two. The Brown-coal beds, which with their associated beds of marls and clays rest upon the ridge of Muschelkalk to the north (which is as it were a prolongation of that near Kaufungen), dip in both cases at an angle varying from 10° to 25° towards the centre of the hill, and partly even under the basalt.

At Ringkühlen, near the N.E. foot of the Hirschberg, Prof. Schwarzenberg of Cassel is principal proprietor of extensive chemical works. These were originally established for the purpose of obtaining alum from the bituminous shales, which are interstratified with the Brown-coal, and were obtained in open workings. The works are now reorganized on account of the facility of procuring fuel. The sulphur which is the basis of most of the operations, is imported from Sicily. Saltpetre is also imported. Amongst the numerous chemical productions of the works, the following appeared to be the most important, sulphuric acid, muriatic acid, chloride of lime, soda, and Glauber-salt.

The general section of the formation here contains four or five good working seams of coal, some of which are 30 or 40 feet thick. These beds are overlaid by basalt, which rising up apparently through the

* Geognostische Karte von Kurhessen und den angrenzenden Ländern zwischen Taunus-, Harz- und Weser-Gebirge, u. s. w., von Adolph Schwarzenberg und Heinrich Reusse, 1853.

centre of the hill, has spread itself out as a covering on the summit (see fig. 2). In the upper beds of coal specimens of Stengelkohl, or columnar coal, are sometimes found, evidently the result of igneous action; further from the point of contact with the basalt, retinite-asphalt also occurs, and in the same beds is found the Glance-coal, more resembling the Newcastle coal, with a bright shining conchoidal fracture, and below that again is the ordinary brown-coal, with its earthy structure. The following section, in descending order, was given me by Prof. Schwarzenberg:—

1. Basaltic boulders, from the summit of the Hirschberg.
2. Soil.
3. Yellow clay; 120 feet.
4. Brown-coal beds; 2 feet.
5. Bituminous clay; 6 feet.
6. Brown-coal; 36 feet.
7. Quartzose sands, or bottom sandstone; 78 feet.
8. Sand and sandy clay; 33 feet.
9. Brown-coal; 3 feet.
10. Inferior coal, called Schnapp-Erz, bituminous and containing iron-pyrites; 15 feet.
11. Bituminous shale (Leber-erz); 18 feet. It was from these beds that the alum was formerly obtained.
12. Brown-coal; 15 feet.

This last is separated from the Muschelkalk by intervening beds of clay, the thickness of which was not given. To the eastward of Ringkühlen, and still on the northern slopes of the Hirschberg towards Gross Almerode, thick beds of fire-clay, of extraordinary quality and tenacity, are developed in the section. This clay is extensively worked, the best being sent in its natural state to America, while that of inferior quality is absorbed in the neighbouring potters' village of Gross Almerode, in the manufacture of Dutch-pipes and chemical crucibles, which are sent to all parts of the world.

The following section, also given me by Prof. Schwarzenberg, occurs nearly halfway between Ringkühlen and Gross Almerode, in descending order:—

1. Yellow whitish sand.
2. Grey clay.
3. Brown-coal beds.
4. Freshwater beds of a sandy clay,—Polirschiefer.
5. Clay shales and marl.
6. Variegated mottled clays.
7. Calcareous nodules; 2 feet.
8. Calcareous clay shales, with petrifactions.
9. Grey clay.
10. Mottled clays.
11. Compact argillaceous sand; 2 feet.
12. Quick sand.
13. Fire or glass-furnace clay,—pipe-clay; 40 feet.
14. Brown-coal beds.

15. Grey saponaceous clay.
16. Brown-coal beds (thin).
17. Grey clay.
18. Muschelkalk.

The peculiar feature of this section is the occurrence of two thin beds containing freshwater shells above the second coal-bed. They are chiefly found in a fine, unctuous, nearly white clay, above the fire-clay, and consist principally of one, if not more species of *Paludina* or *Bithynia*, a small *Planorbis*, and one or two species of small bivalves belonging to the genus *Cyclas* or *Cyrena*. At least these were all which the rainy and muddy state of the weather allowed us to obtain.

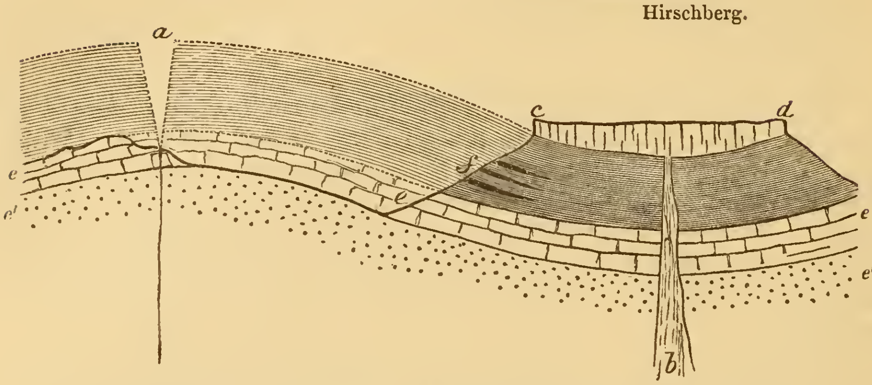
The whole Brown-coal formation of the Hirschberg, with its associated clays, and probably that of the Meissner, thus appears to have been a freshwater basin or lagoon, surrounded by Bunter Sandstein, with a ridge or reef of Muschelkalk passing through the centre.

Here also I was struck, as on the Habichts Wald, with the apparently anomalous fact of the coal-measures dipping towards and under the basaltic nucleus of the hill, although in both cases the basalt must be of a subsequent date, and in its elevation or protrusion might have been expected to give the coal-beds a contrary or quâquâversal inclination. From the numerous cases in which the same phænomenon occurs, I was anxious to ascertain a probable cause of this appearance: several explanations suggested themselves to me, but they would not stand the test of inquiry, until a hint from our former President, Mr. William Hopkins, our best authority in dynamical geology, suggested an explanation, which, if not the sole cause, must be admitted as one of the most likely partial causes of this appearance.

The Brown-coal beds of the north of Germany have evidently been subjected to a very considerable amount of alternate elevation and depression accompanied by lateral pressure. The consequence of this has been, where they have not been completely broken off, to cause a great amount of undulation in the beds themselves. Where this took place, the natural result would be to cause fissures or openings through the bed either from above or from below, accordingly as the bed has been raised upwards into a saddle, or depressed downwards into a trough. See fig. 2, p. 134.

In the accompanying diagram, fig. 2, if the undulation of the beds be caused by lateral pressure, a fissure would naturally take place at *b*, in the lower part of the strata, and at *a* in the upper part. When at a subsequent period the basaltic outburst took place, the fissure *b* at once afforded an easy outlet for the liquid matter which then filled up the hollow *c d*. This may have taken place when the whole region was under water. When the action of tidal waves or other atmospheric causes afterwards denuded the surrounding country, the basaltic capping protected the underlying beds, and, as the other portions have gradually wasted away as far as the line *c e*, there would remain only the hill with its basaltic capping, *c d*, and the Brown-coal beds cropping out at *f* on the slope *c e*, and dipping

Fig. 2.—*Ideal Section of the Hirschberg.*



a. Ideal fault and fracture. *e*. Muschelkalk. *e'*. Bunter sandstone.
b, c, d. Basalt. *f*. Tertiary beds and Brown-coal.

away under the basalt. And that is precisely the appearance which the Hirschberg now presents to us. It is a remarkable fact, in confirmation of this theory, that a small Brown-coal deposit was pointed out high up on the hills on the N. or N.E. side of the valley. I did not visit it, and its important bearing on this question did not then occur to me.

Another feature in both of these sections is also worthy of notice, as differing from other localities where the Brown-coal occurs, viz. the total absence of a marine fauna in the beds above the clay. In most of the other localities the marine bed is regularly superposed. From its absence here, we must conclude that this, as well as some of the other freshwater lagoons and swamps where the plants grew, from the decay of which the Brown-coal was formed, were situated at a so much higher level than the others, that they escaped being submerged when the irruption of the oceanic waters took place.

I cannot quit this neighbourhood of Gross Almerode without alluding to a remarkable hill of burnt clay, which occurs about half a mile to the south of the village. Here on the summit of a ridge is an isolated basaltic outburst between the Hirschberg and the Meissner, but nearer the latter. At no great distance from it is a vast mound or hillock of a burnt stone, which is neither more nor less than the beds of tertiary clays metamorphosed into Jasper or Thonjaspis. This jasper varies greatly, not only in colour, but in structure; in places having an earthy conchoidal structure, and in others, one almost vitreous. There is a great diversity of opinion among local geologists as to its origin, some referring it to a true geological cause, others considering it as recent, and occasioned by the burning of the bituminous shale or Leber-Erz.

Looking at the spot afterwards from a distance, its form was distinctly seen as rising above the surrounding ground, and resembling the crater of a volcano. I have little doubt myself that the metamorphism has been produced by geological causes, probably the escape of heated gases from below; this is rendered the more likely by the vicinity of the basaltic outburst. But whatever the causes of the burning may have been, there can be no doubt that the swelling out of the whole mass has been caused by the expansion of the clay on being converted into jasper. Moreover it contains numerous cavities, fissures, and cracks, and is split up in every direction, so as to occupy more space than before the change took place.

Another locality which we visited in the vicinity of Hesse Cassel, and where marine tertiary shells also occur, is a small hollow between Cassel and Münden, near the village of Landwehrhagen. Numerous clay-pits were formerly opened here, and fossils were abundant; but we only found a few broken fragments in the thrown out heaps. These were chiefly bivalves; we recognized three or four species, viz. a *Cardium*, *Cyprina*, *Cytherea*, and perhaps *Pectunculus*, enough to show the marine nature of the water in which the clay was deposited. This was overlaid by yellow marls, gradually passing upwards into fine yellow sand, but as far as we could see, quite unfossiliferous. This is exactly the same as occurs in the vicinity of Cassel, where the shelly marls and clays are overlaid by sandy beds. The same formation also occurs in the section near Kaufungen, where the clays with marine shells are overlaid by yellow sands; in the latter case, however, the sands are fossiliferous.

II. Tertiary Beds of Westeregeln near Magdeburg.

I have already alluded to and explained the error I was led into in a former communication respecting these deposits. I had intended visiting the locality during the past autumn, but was deterred from doing so, in consequence of having received information that the beds in question were no longer open or visible. I shall therefore only briefly state what I have learnt respecting their position. The fossils in question, a partial list of which is given in a former paper*, are found in a bed of fine greenish sand (Glauconite-Sand), of no very great thickness, irregularly covering up an extensive and valuable seam of Brown-coal, which is worked in the neighbourhood of Magdeburg and Westeregeln. In working the coal-beds, these sands are cleared away, and thus the fossils have been obtained. These sands, however, do not occur over that portion of the Brown-coal bed which is now being worked, and hence the impossibility of obtaining fossils; but it is probable that they will be again met with. The Brown-coal itself rests generally on a bed of blue clay, which lies immediately on Bunter-sandstein or Muschelkalk.

These Westeregeln sands appear, from all accounts, to be the oldest fossiliferous beds in Northern Germany. How far they extend has not yet been fully ascertained. The next overlying fossiliferous formation of Northern Germany is the Septaria-clay of Berlin, which now appears, from Prof. Beyrich's report, to have been found over a considerable tract of country, comprising the whole of Brandenburg and a large extent of territory to the west, inasmuch as the concretionary nodules of Sternberg contain the same fossils as the Septaria-

* See Quarterly Journal Geol. Soc. vol. x. p. 292.

clay, and must consequently be referred to the same age. It is also found in the neighbourhood of Stettin, Oldenburg, Lüneburg, and other places. Other tertiary beds also occur further north towards Hamburg, Schleswig Holstein, &c., which are, however, referred to a more recent period. They are alluded to by Prof. Beyrich in his work on the tertiary shells of the North of Germany. The only two beds to which I wish to call the attention of the Society at present are the Westeregeln or Magdeburg sands, and the Septaria-clay of Berlin. These two beds belong to one system, and are particularly interesting as being the beds which have been shown by the German geologists to have the greatest resemblance to those of Hesse Cassel and of Weinheim, as well as to those beds of Belgium with which the sands of Weinheim have been paralleled.

One feature in the Section of the Westeregeln or Magdeburg sands deserves particular attention, and it is the more remarkable inasmuch as it is in some respects at variance with what we know respecting the sands of Weinheim; while on the other hand it confirms some of the views which I have stated respecting that formation. The Marine sands of Westeregeln overlie the Brown-coal beds, thus showing the anterior existence of a freshwater or terrestrial tertiary period; whereas at Weinheim and in the Mayence basin the Marine tertiary sands repose at once, as far as our present information goes, on the underlying Carboniferous or Rothe-todte-liegende formation. It is true that these lowest beds of tertiary sand, when we approach the margin of the basin (where alone they are seen reposing on the red sandstones), are non-fossiliferous; and, being evidently derived from the disintegration of the older rocks, cannot be assumed as proving with absolute certainty the non-existence of older tertiary beds nearer the centre of the basin. All that we can say at present is, that none such have been discovered.

III. The Relative Age of the Tertiary Beds of Northern Germany.

There are three distinct localities to which I intend referring in the following observations, viz.: 1. The Mayence basin, and particularly the Marine sands of Weinheim. 2. The Marine beds of Hesse Cassel, Bünde, &c. 3. The sands of Westeregeln and of Magdeburg.

Philippi, in his notice of the tertiary fossils of the north-west of Germany*, gives the lists of fossils from three different localities belonging to the same epoch. 1. Cassel; 2. Freden and Diekholz; and 3. Luithorst. The results at which he has arrived are the same with respect to all these localities, viz. that the fossils in question have the greatest number of species identical with the Subapennine formation; and the next greatest number identical with living species. He has made no comparison between the German and the Belgian formations, nor had he any opportunity of comparing the Cassel

* Beiträge zur Kenntniss. Cassel, 1844.

beds either with those of Mayence to the south, or with those of Magdeburg and Westeregeln to the north, or rather N.E.

Dr. F. Sandberger, in his work already quoted on the geological position of the Mayence tertiary basin, has identified the Weinheim tertiaries with the Limburg beds of Belgium; and more particularly has he identified the Weinheim sands with the Middle Limburg beds, and the overlying Cyrena-marls with the Upper Limburg. Then, adopting Philippi's view respecting the age of the Cassel beds,—viz. that they belong to the Subapennine formation, Dr. Sandberger places them considerably above the Weinheim beds. And with regard to the formations of Northern Germany, he considers the sands of Magdeburg and Westeregeln as of the same age as the Weinheim sands; and the overlying Septaria-clay of Celle, Berlin, and Mecklenburg, as of the same age as the Cyrena-marls of the Mayence basin (*loc. cit.* p. 79).

Prof. Beyrich, in his last work on the fossils of the tertiary formations of the North of Germany, published in the Journal of the German Geological Society*, states that in his opinion the oldest North German tertiary formation, viz. that of the sands of Westeregeln and Magdeburg, belongs to the Lethen formation of Belgium, which is placed by Sir C. Lyell as the lowest member of the Middle Limburg series†, although Prof. Beyrich considers it as the lower Tongrian system, which properly belongs to the Lower Limburg series. The next youngest formation in North Germany, according to Prof. Beyrich, is the Septaria-clay of Brandenburg, Berlin, &c., which he identifies with the Belgian formations of Boom, Baesele, and other places south of Antwerp. These form, according to Dumont's classification, a part of the System of Rüpelmonde (*Système Rupélien*), constituting the Upper Limburg beds of Sir C. Lyell. Prof. Beyrich also observes that it is as yet uncertain whether there exist in Northern Germany any beds exactly corresponding with those which Dumont has placed between the Rüpelmonde and the Lethen beds,—in other words, with the Middle Limburg beds: this he considers an important point, inasmuch as this is the Belgian deposit which has the greatest analogy with the Mayence basin.

Having thus given the views of the German geologists who have principally occupied themselves with this question, I proceed to make a few observations on this question of relative age.

It is a somewhat remarkable circumstance, that the marine deposits in the three localities above alluded to have such a small horizontal and even vertical development, apparently belonging in each case to such a short geological period; and it has struck me as in the highest degree improbable that these three formations, situated at no considerable distance from each other, showing no evidence of superposition, and containing a certain number of organic remains in common, should be referred to three different periods. Beginning with the most southern formation, we have the Weinheim beds referred to the Middle Limburg; the next nearest beds, of Cassel, are

* Zeitschrift der Deutschen Geol. Gesellschaft, vol. v. p. 277.

† Quart. Journ. Geol. Soc. vol. viii. p. 307.

referred to the Subapennine formation (although here I am bound to say that Prof. Beyrich is distinctly of opinion that these beds have been placed too high by Philippi); and then we come to the sands of Magdeburg, which are referred to the Lower Limburg, or even to the Barton clay; while the overlying Septaria-clays are referred to the Rüpelmonde system. There can be no doubt that Philippi, in his endeavours to point out the errors of his predecessors in referring the marls and sands of Cassel to the Plastic clay and the Calcaire grossier respectively, greatly overshot his mark and placed these beds too high.

The following is the list of fossils which appear to be common to the Hesse Cassel and Weinheim beds. A more complete list of synonyms would undoubtedly have enabled me to extend it; but, even as it stands, it marks a great resemblance between the two formations.

List of Fossils common to the Hesse Cassel and Weinheim Tertiary Deposits.

Panopæa intermedia, *Sow.*	Pecten striatus, *Münst. & Goldf.*
Corbula striata, *Lam.*	Eulima subulata, *Risso.*
Cyprina rotundata, *Braun.*	Scalaria rudis, *Phil.*
Cardita scalaris, *Goldf.*	—— pusilla, *Phil.*
Cardium turgidum, *Brander.*	Cerithium lima, *Brug.*
Arca diluvii, *Lam.*	Tritonium argutum, *Brand.*
Pectunculus crassus, *Phil.*	Pleurotoma belgicum, *Goldf.*
Nucula margaritacea, *Lam.*	Cassidaria depressa, *v. Buch.*
—— placentina, *Lam.*	Cypræa inflata, *Lam.*
—— minuta, *Defr.*	Bulla concinna, *Wood.*
Modiola micans, *Braun.*	Lamna denticulata, *Ag.*
Pecten decussatus, *Münst. & Goldf.*	Notidanus primigenius, *Ag.*

At page 293 of my former communication* I have given a very imperfect list of the fossils found in the Glauconite-Sands of Westeregeln; imperfect, because it only contains the names of eighty-seven species, whereas I am informed that the total number of species found in that locality amounts to three or four times that number; and yet that imperfect list contains twenty-five species common to the Weinheim and Westeregeln formations.

The resemblance between the Hesse Cassel and the Westeregeln beds, however, is by no means so great. In the lists which I have had an opportunity of consulting I do not find more than five or six species common to the two formations.

I have already mentioned that, according to the views of Professor Beyrich, there are two distinct formations belonging to this period in the north of Germany, viz. the Sands of Westeregeln, and the Septaria-clay of Brandenburg, Berlin, &c. I am not aware that any evidence has yet been discovered of an intermediate bed of separation, or even of the distinct superposition of the Septaria-clay over the Sands of Westeregeln. The evidence of such distinction depends mainly on their fossil contents; but, even admitting the superposition, the change of sedimentary deposit in which the fossils occur, from a Glauconite-sand to a blue clay or marl containing Septaria,

* Quart. Journ. Geol. Soc. No. 39.

would by altering the conditions of life be sufficient to cause a considerable modification in the organic remains, without referring the beds to distinct epochs. I have also stated that Prof. Sandberger identifies the Westeregeln Sands with the Weinheim Sands, and the Septaria-clay of Brandenburg with the Lower Cyrena-marl of the Mayence basin. Now this Cyrena-marl contains a great admixture of brackish-water forms, while nothing of the kind is found in the Septaria-clay of the north of Germany. The change in the Mayence basin is a purely local one; and there is, therefore, no evidence of its being *contemporaneous* with the Septaria-clay. It is true the Cyrena-marl overlies the Weinheim Sands, as the Septaria-clay overlies the Westeregeln Sands; but that is no proof of identity of time, the changes in the two localities not being owing to the same causes; and Prof. Sandberger has himself shown, in the lists which he has published (*op. cit.* p. 67), that the Marine Fauna of the Cyrena-marl has the greatest affinity with that of the Middle Limburg formation, the very same Belgian bed with which he had already identified the Weinheim Sands. I am therefore disposed to look upon the whole marine fauna of the Mayence basin as referable to one period, viz. the Middle Limburg, locally modified in its upper portion by the introduction of vast bodies of fresh water, or by its gradual separation from oceanic influence, by which the waters became brackish, and its organic contents more and more modified, until at length all traces of marine or brackish-water fauna disappeared.

With regard to the Cassel marine beds, I consider them as forming a portion of the same marine deposit, and constituting a link in that connection which must have existed between the Mayence basin and the Northern Ocean. Here again we find two petrographically distinct beds, viz. blue clay or marl and shelly sands; but in this case the marls underlie the sands. In one locality, near Ober Kaufungen, Septaria are abundant in the blue clays; in others they are wanting. In this locality the overlying sands are full of marine shells, while near Landwehrhagen the sands which overlie the blue marl containing marine shells, are entirely devoid of organic remains. These are evidently mere local differences, such as may be observed on any coast at the present day.

It is also worthy of notice that the marine beds in the neighbourhood of Cassel are of no great thickness. This was no doubt owing to the earlier upheaval of the underlying secondary formations (preceding the volcanic outbursts), which were ultimately raised to an elevation of more than 1000 feet above the sea, north of Cassel. This upheaval cut off all communication with the northern Ocean, and confined the waters to the Mayence basin, thereby exposing them to the influence of the freshwater rivers, and producing that brackish-water condition which we have already noticed.

In the great district which forms the low undulating lands of the north of Germany, to the north of the Hartz and of the other mountain ranges which extend towards the Weser Bergland, and thence to the Haarstrang on the Ruhr, east of Cologne, the marine condition of things having probably begun earlier, as shown in the Westeregeln Sands, lasted somewhat longer, until this region (also undergoing the influence of the elevatory action, though in a smaller degree) was likewise raised above the level of the sea, and became covered with a low swampy vegetation, the decay of which produced the overlying brown-coal deposits of Brandenburg and Prussia.

I stated in my former paper (*loc. cit.* p. 288), that I could not admit the hypothesis of the Mayence basin having been an insulated inland salt lake without communication with the northern ocean. I endeavoured very imperfectly, not being acquainted with the geological features of the neighbourhood of Cassel and other places, to show that some communication with the Northern ocean, round the eastern flanks of the Taunus, must have existed, and that the subsequent closing up of this northern channel might have been brought about by the elevation of the Vogelsgebirge (erroneously stated Fichtelgebirge in my former paper, *l. c.* p. 294), or by other basaltic outbursts. A more accurate knowledge of the geology of Hesse Cassel convinces me of the great probability of this opinion. A line of volcanic outbursts, perforating the surface in a thousand spots, extends from the neighbourhood of Frankfort and of Hanau, considerably to the north of Cassel, elevating the stratified beds to a considerable height, and thus causing a complete barrier to the connection between the Northern Ocean and the waters of the Mayence basin. These tertiary deposits are now consequently found in some places at an elevation of 1000 feet above the sea, as near Dransfeld ; and, judging from the configuration of the country and the elevation of the Bunter Sandstein, they were probably raised to a still greater height, although almost entirely removed by subsequent denudation ; while in other places they are found at a much lower level. Indeed the same argument will apply on a large scale to these volcanic outbursts and to the elevation of the Bunter-Sandstein, north of Cassel, which I have already used respecting the outbursts of the basaltic plateau of the Hirschberg and the surrounding district (see fig. 2, p. 134).

We have here an instance on a large scale, and accompanied by the same results, of the phænomenon already alluded to respecting the position of the basaltic plateaux of the Hirschberg, Meissner, and other places. I showed how the occurrence of these basaltic rocks in their present positions was owing to the molten matter having been forced up through the crevices in the *troughs* of the undulations into which the secondary formations had been thrown. Now the Bunter-Sandstein, north of Cassel, rises to a considerable elevation, in some places as much as 1000 feet above the sea, whilst between Cassel and Frankfort its elevation is comparatively slight. We may therefore consider the portion to the north of Cassel as representing on a large scale the anticlinal, while that to the south represents the synclinal portion of a vast undulation. This is confirmed by the dip of the Bunter-Sandstein, north of Cassel, which is to the south, dipping under the Muschelkalk between Cassel and Wilhelmshöhe. When the basalts subsequently burst forth, they found a readier passage through the lower or synclinal portion, than through the anticlinal, and we consequently find the whole country between Frankfort-on-Main and Cassel studded with basaltic outbursts, whilst to the north they are comparatively scarce, and ultimately north of Göttingen and Münden cease altogether.

To repeat then briefly the epochs and phænomena above described, we find the first evidence of tertiary deposits in North Germany in the brown-coal and its associated underclays of Magdeburg. During the earlier tertiary periods, the whole of Germany appears to have been dry land. At the same time, or at the termination of this period, a vast swampy region, covered with a semitropical vegetation, stretched along the base of the mountains of Germany, from Silesia and the confines of Poland to near the Eocene Ocean, which occupied those portions of Holland and of Belgium where its fauna has been preserved. A gradual subsidence took place, possibly contemporaneous with the period when the accumulations of Flysch or Molasse were being deposited, also in a gradually sinking sea-bottom on the northern flanks of the Alps. This swampy vegetation was then submerged beneath the ocean, and was being converted into Brown-coal, while a marine fauna was introduced, and lived and perished in the waters above. This great change, I am inclined to think, marks the limits of the Eocene and Miocene periods, as far at least as this part of the earth's surface is concerned; for I have already admitted that we must not attempt to introduce such a strict procrustean rule as to assert that the limits of these periods (if we choose to adopt them) must be absolutely applied to the same epoch in all districts.

The oceanic waters, thus admitted over a portion of Northern Germany, penetrated between the mountains of the Hartz and the Weser Gebirge, round the eastern flanks of the Westerwald and the Taunus, and along that deflexion through which the Upper Rhine now flows, until they reached those portions of the southern or Alpine ocean in which the Flysch and Nagelflue, and perhaps the Older Molasse, were deposited.

During the period of this connection, the Marine-sands of Weinheim were deposited, until the subsequent oscillation of the land first cut off the communication with the Southern Ocean, and subsequently, by the elevation of the Muschelkalk and Bunter-Sandstein, in the north of Germany, raised a permanent barrier between the Mayence basin and the North German Ocean. This separation was subsequently confirmed by the numerous volcanic outbursts which have penetrated the whole surface of the country, from the banks of the Main near Frankfort, Hanau, and the Vogelsgebirg, northwards, to the region of Göttingen and Münden.

After this a period intervened, when in the northern plains of Germany, a swampy district, with a luxuriant vegetation, stretched along the mountain coast, covering up the marine formation of the Septaria clay, and giving rise to that upper Brown-coal formation which is now so extensively worked in Mark Brandenburg and the country about Frankfort on the Oder, extending to the frontiers of Silesia and of Posen. Thus those formations which we have endeavoured to identify with the Middle Limburg of Belgium are confined between the extensive Brown-coal deposits which (notwithstanding the ingenious hypothesis of a German author*, who attempts to show how these vast accumulations of vegetable matter were deposited in the sea) I am disposed to consider as formed on the spot where the plants originally grew, and consequently as a freshwater formation, raised perhaps only slightly above the level of the ocean, like the now existing cypress-swamps of Louisiana or the turf-mosses of more northern regions.

Brown-Coal Deposits.—I am thus led, before concluding these remarks, to add a few words respecting the various deposits of Brown-coal in the north of Germany, which are connected with the tertiary formations here alluded to. I am aware that there are many other deposits deserving notice, but this subject is too extensive to be fully considered at present. It is true that independently these Brown-coal deposits are not in themselves so conclusive as to geological epochs, in consequence of their not being necessarily so intimately connected with each other as is the case with true marine deposits. Still, when we can ascertain their age relatively to marine beds, we are enabled to come to some conclusion respecting their successive ages.

Brown-coal deposits occur in all the three distinct localities to which we have alluded in this paper, viz.—1. In the Mayence basin are two distinct deposits; first, between the true Marine-Sands of Weinheim and the overlying Cerithium and Littorinella limestones, and secondly, between the Littorinella limestone and the leaf-bearing sandstone. 2. In the Hesse Cassel deposit the great Brown-coal beds underlie the Marine Fauna. And 3. In the plains of the north of Germany there are again two distinct Brown-coal deposits; first, under the Westeregeln Sands near Magdeburg; and secondly, above the Septaria-clay of the Mark Brandenbnrg. Of these, the bed which underlies the Westeregeln Sands is unquestionably the oldest. That of Brandenburg may be contemporaneous with one of the Mayence basin deposits; but there is no direct evidence of the fact. We have thus Brown-coal deposits of at least three, if not four, distinct periods. That of Cassel is probably contemporaneous with that of Magdeburg.

The upper Brown-coal deposits of the Wetterau have been considered as of the same age as those of the upper Cyrena-marl. I am, however, disposed to think, from the observations of D. Ludwig of Nauheim, which I have only lately had an opportunity of perusing, that they must belong to a still younger period. They are described as occurring in hollows of decomposed basalt at Laubach, Salzhausen, and Berstadt, near the western limits of the great basaltic formations of the Vogelsberg. They rest upon or are imbedded in vast deposits of clay, derived from the decay, *in situ*, of the basalt itself, and are consequently posterior, not only to the basalt, but even to its decomposition, therein differing from the Brown-coal of the Westerwald, which has been elevated and broken up by the protrusion of the basaltic masses.

* Zeitschrift der Deutschen Geol. Gesellsch. vol. iii. p. 217.

I am aware how imperfectly these remarks have been thrown together, and how much still remains before the subject can be fully exhausted. I would willingly have deferred the communication until the German Geologists had completed their investigations, or I myself had had further opportunities of examining the country. I have already stated my reasons for the course I have pursued. At the same time I trust that I shall not have been altogether wrong in bringing this subject before the Society, if I have directed the attention of the Members to a country, the geology of which has not been often discussed in these rooms, and respecting which we have still much to learn.

January 17, 1855.

The following communication was read :—

On the Vertical *and* Meridional Lamination *of the* Primary Rocks. By Evan Hopkins, Esq., F.G.S.

[Abstract.]

The author described wide regions in several parts of the world as exhibiting in their geological structure the phænomena of successive vertical bands of schistose and crystalline rocks, parallel with each other, and having a meridional strike. This structural condition was illustrated by several extensive and highly finished sections, some of them traversing several hundred miles, made from the author's own observation in Panama, South America, Australia, and Ceylon. The section across the Andes*, for instance, exhibited parallel bands of quartzites, porphyry, mica-schists, greenstone, granite, gneiss, hornblende schists, trachyte, crystalline limestone, talcose schists, and clay-slates, occurring in variable succession, with a N. and S. strike, and with an almost uniform vertical dip. In plains and other places where the laminated structure has not been disturbed by local causes, the cleavage planes were shown to be more or less vertical; but sometimes in high ridges with precipitous flanks the bands and laminæ of rocks drop on both sides, from want of lateral support, thus giving the appearance of a radial or fan-shaped structure.

Here and there on the edges of these laminated rocks rest horizontal sedimentary deposits; and it was pointed out that many of these exhibited at the point of contact with the older rocks evidence of their undergoing the process of vertical cleavage or lamination; the lines of stratification becoming gradually obliterated. Even compact mud and soil lying on the edges of the schistose rocks have been observed by the author to be subject (under certain conditions) to cleavage and interlamination with calcareous and siliceous matter.

Mr. E. Hopkins maintained that in all parts of the world the old crystalline or "primary" rocks exhibit (with local exceptions, insig-

* See also Quart. Journ. Geol. Soc. vol. vi. p. 364, and Pl. 31.

nificant when compared with the whole) a uniform vertical cleavage or foliation, with a north and south direction; and that the rocks in those countries, like Australia, part of India, Siberia, South America, Central America, and California, which preserve this meridional uniformity, are productive of gold, platina, silver, and precious stones on the decomposed edges of the schists; whilst those regions which have been disturbed or bent from their normal position are more or less productive in masses of the ordinary minerals, and are comparatively barren of the precious products. In speaking of the meridional structure, Mr. Hopkins alludes to the N.E. variation of the cleavage-planes in the northern hemisphere, more especially in the United States and Europe; but, nevertheless, he believes that the general uniformity approximates more nearly to the true meridian than the magnetic meridian does.

The author observed also that, from his acquaintance during numerous mining operations with the deep-seated rock-masses of the Andes and elsewhere, he was convinced that the great base below was more or less granitic strongly saturated with mineral waters, and that it passed upwards by insensible gradations from a crystalline heterogeneous compound to a laminated rock (as gneiss), and still higher up to schists in vertical planes; the peculiar varieties of the higher rocks being dependent on the mineral character of the "parent rock" below; the schistose rocks forming, in short, the external terminations of the great universal crystalline base.

Mr. E. Hopkins referred to some important remarks on parallel lamination of nearly vertical rocks and on cleavage, made independently by Humboldt*, M'Culloch†, Sedgwick‡, and De la Beche§; and, leaving for further consideration the question as to how the lamination and cleavage of rocks were brought about, he concluded by recommending the study of the primary rocks, with their various transitions and foliations, to the special notice of geologists, as being of extreme interest, and likely to throw great light on several important points in geological science.

* "Sur le Gisement des Roches."

† "Geological Classification of Rocks."

‡ "Remarks on the Structure of large Mineral Masses," &c., Trans. Geol. Soc. 2 ser. vol. iii.

§ Geological Report on Cornwall and Devon.

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I. TRANSACTIONS AND JOURNALS.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

JANUARY 31, 1855.

The Rev. T. J. Prout, A.M., was elected a Fellow.

The following communications were read:—

1. *Additional Observations on the* SILURIAN *and* DEVONIAN ROCKS *near* CHRISTIANIA *in* NORWAY,—*on presenting* M. THEODOR KJERULF'S *new* GEOLOGICAL MAP *of the District.* By Sir RODERICK I. MURCHISON, V.P.G.S. &c. &c.

DURING an excursion to Norway and Sweden in the year 1844, I drew those conclusions respecting the order of the older sedimentary formations in the environs of Christiania, which, having first been enounced in the Quarterly Journal of this Society, were afterwards published in greater detail and with a more accurately finished section in the work entitled 'Russia and the Ural Mountains*.'

* See Quart. Journ. Geol. Soc. vol. i. p. 471. The *correct* section is given in Quart. Journ. Geol. Soc. vol. ii. Miscell. p. 71; *ibid.* vol. viii. p. 182; and 'Russia in Europe,' &c., vol. i. p. 13. Since the present notice was read, M. Kjerulf has sent to me the Memoir in German, which accompanies his map, entitled 'Das Christiania-Silurbecken, chemisch-geognostisch untersucht,' 4to. Christiania, 1855. In acknowledging this favour, I beg to state that this author does not seem to have been acquainted with my original communication on the subject; for the paper by Forchhammer, to which alone he refers, is in the Norsk language, and forms a part of the account of that Scandinavian Meeting of 1844 at which I gave

These views developed the existence of a vast trough or elongated basin of Silurian strata, the direction of which lengthwise is from S. and by W. to N. and by E., and which in the parallel of Christiania has a width of about thirty English miles. This trough was shown to consist of two low tracts, on either side of a high intervening plateau; each lower lateral tract being composed of a full series of all the Silurian strata (Lower and Upper); and the central higher ground, of Old Red Sandstone or Devonian strata.

This exposition of a symmetrical order, from the base of the stratum containing the oldest known remains through Lower and Upper Silurian rocks, and thence through about a thousand feet of overlying red sandstone, was naturally dwelt upon by me with great satisfaction: for, in exploring the remaining parts of Scandinavia where such palæozoic formations were present, no other district could be discovered in which so complete and continuous a succession was to be seen. The great Russian Empire exhibits no such clear Silurian base as this Norwegian trough presents; whilst even the symmetrical Silurian basin of Bohemia, so justly celebrated through the labours of M. Barrande, is inferior in one respect,—viz. in not exposing, like the Norwegian example, a great overlying mass unequivocally of Devonian age.

Although my explanation of this order, as first given at the Meeting of the Scandinavian Men of Science in June 1844, was warmly approved by my associates who were present (including Leopold von Buch, Berzelius, and Forchhammer), it met with an opponent in M. Keilhau, who, though he had published his 'Gæa Norvegica' and a map of Norway which is very praiseworthy for its mineral features, maintained ideas essentially distinct from my own respecting the consecutive order; and who still, as I understand, does not admit the metamorphism of some of the Silurian strata into crystalline slate (harte-schiefer)—a point I endeavoured to explain satisfactorily to this Society many years ago.

Under these circumstances, I have long wished to see some free Norwegian arise, who, looking fairly at nature, would say whether the order I had indicated was exact, or if not, who would correct it; and who would further test it by a close examination of the strata, and by laying down their outlines on a map.

Fortunately, I met with Mr. David Forbes, the brother of our universally beloved and respected former President, and, finding that he was frequently at Christiania, I urged him to produce before the Geological Society some fruits of his own observations on the rocks of Norway.

I also particularly requested him to obtain some data of detail

the first explanation of the true order of the region. In fact, whilst the memoir of M. Kjerulf contains much valuable new matter, particularly his descriptions and analyses of the igneous and metamorphic rocks, and also lucid diagrams explanatory of the physical relations of the strata, his chief sections (*ex. gr.* those of p. 51) are, as he himself states, analogous to that general transverse section which I offered to the Christiania Meeting of 1844, and which was repeated in the above-mentioned works, and lastly in my 'Siluria' of 1854, pp. 319, 320.—[R. I. M. May 23, 1855.]

respecting the Silurian formations of Christiania, and to procure a competent survey and admeasurement of them. Whilst Mr. D. Forbes will give you his own views on the crystalline rocks, I have to thank him for having obtained from his friend M. Theodor Kjerulf the map which is herewith exhibited. On it are delineated the boundaries of the Lower and Upper members of what M. Kjerulf terms the "Silurian Basin of Christiania," and of the overlying Devonian; the dips of the strata being generally noted. M. Kjerulf has also furnished some data to Mr. D. Forbes, among which the following are important:—

	Feet.
The Lower Silurian schists and limestones have a thickness of..	860
The Upper Silurian limestones and flagstones..............	150
Total thickness....	1010

In various publications, and specially in my last work 'Siluria,' I have adverted to the phænomenon, that, notwithstanding the thinness of the Scandinavian strata of this age, they exhibit as complete a "natural system" as in countries where they are expanded to many thousand feet of vertical dimensions. Thus, above the bottom beds (often only a few feet thick) of fucoid-sandstone resting upon gneiss or older granite, we meet with the so-called Alum-slates, recently illustrated by the publication of their fossils by Angelin, some of the forms of which were known long ago to Hisinger and the older Swedish naturalists. Whether at Andrarum or other places in Scania where I have examined it, or on the flanks of the Norwegian trough under consideration, this zone of schist has nowhere a greater thickness than from 60 to 80 feet, whilst its equivalent in Wales (the Lingula-flags) has a thickness of many thousand feet, as assigned to it by the British Government Surveyors, who place it as the bottom rock of the Silurian System. Still, notwithstanding this vast disproportion in dimensions, the thin shred of Scandinavia has afforded many more Trilobites of the genera *Paradoxides, Battus,* and *Olenus,* than the grand British mass. In consequence of its fauna, M. Barrande has recognized the Alum-slate of Scandinavia as being the exact representative of his primordial Silurian zone of Bohemia.

Then, in the succeeding few hundred feet of black schists, with occasional courses of limestone, which constitute the chief body of the Lower Silurian rocks, we have just the same profusion of typical fossils, whether they be *Asaphi, Illæni, Trinuclei,* or simple-plaited *Orthidæ,* as in the capacious mountain escarpments of Wales and Siluria!

In parts of Scandinavia, and particularly near Christiania, a limestone charged with the *Pentamerus oblongus* is, as in other parts of Europe (as well as in America), the band which separates the Lower from the Upper Silurian, and which, according to the predominance of fossils of the one or the other, may *locally* be classed with either group.

In Britain, however, the *Pentamerus oblongus* is unquestionably a Lower Silurian type, being found in the Llandeilo rocks as well as in the Upper Caradoc, and never in the Wenlock formation*.

But at whatever horizon the division be drawn (—a horizon which every far-travelled geologist knows must vary in different countries—), it is undeniable, that in Scandinavia, Russia, and Bohemia there is not the slightest trace of that local dislocation which has partially affected the British strata between the Lower and Upper Caradoc.

In Norway and other parts of Scandinavia, the overlying strata of shale, limestone, and sandstone which are laden with Upper Silurian forms are everywhere perfectly conformable to the Lower Silurian; and, even in the Bay of Christiania, the Wenlock limestone and shale charged with a profusion of Corals and Shells are seen to undulate upon and with underlying masses of the black Lower Silurian slates, in the horizontal space of a few hundred yards.

Feeble in vertical dimensions as the Upper Silurian is said to be by M. Kjerulf, his statement is quite in accordance with my own observations, which would not assign more than 80 or 90 feet to the limestone subdivision, and 70 or 80 to the flag-like sandy strata which, containing *Chonetes* (*Leptæna*) *lata* and other fossils, represent the Ludlow rocks, and pass up into the bottom-beds of the Old Red Sandstone, as seen on either side of the great plateau of Ringerigge exposed in my original section. Even in Gothland, that large island which is exclusively composed of Upper Silurian rocks, M. de Verneuil and myself could never recognize a greater united thickness than 200 or 300 feet, including a sandy representative of the Ludlow rocks, with some subordinate courses of an oolitic limestone. Yet, there also the fossils are very decisive of the age of the rocks, particularly those of the Wenlock limestone; whilst the meagre representative of the Ludlow rocks, whether seen at Mount Hoburg in Gothland or near Öfved-Kloster and the Lake Ring in Scania, where it is a purplish tilestone, is well marked by its *Orthonotæ*, *Cypricardiæ*, *Leptæna lata*, *Avicula retroflexa*, and *Cytherina* (*Leperditia*) *Balthica*†.

Having previously dwelt upon the great geological value of such data and comparisons in showing that the age of ancient deposits is never to be indicated by their thickness merely, I have naturally great satisfaction in seeing my views confirmed, as respects Norway, by an accurate local observer.

In addition to the indications on his map, M. Kjerulf has communicated to Mr. D. Forbes a few notes, both on the sedimentary rocks and on the eruptive and metamorphic rocks.

Thus, in speaking of the Devonian or Old Red Sandstone, which,

* M. Kjerulf classes the Pentamerus-limestone with the Upper Silurian, and is, I have no doubt, correct; for in Norway, as in Courland, the *Pentamerus oblongus* is almost always associated with a profusion of Wenlock species.—[R. I. M., May 23, 1855.]

† Quart. Journ. Geol. Soc. vol. iii. pp. 25, 34, &c.

he says, everywhere overlies the Upper Silurian, and to which he assigns a thickness of 900 feet, M. Kjerulf attributes the absence of fossils (none having been found in it) to a contemporaneous volcanic or igneous action, which caused a deposit of the tufaceous matter whereof the Lower Devonian is composed. The higher parts become more sandy; grains of quartz appearing, and finally a coarse red conglomerate.

Some peculiarities of the trap and porphyry districts are mentioned, and the cavities of the amygdaloid (mandelstein) are said to be often occupied with natrolite, green-earth, calc-spar, fluor-spar, striped chalcedony, quartz, prehnite, apophyllite, and sometimes with curious nodules of anthracite in calc-spar. Breccias appear in great force; one of these occurring between the Old Red Sandstone and the augite-porphyry, and another between the augitic and the felspathic porphyry. It is further stated, that there is no silicification of the slates or limestone in contact with granite or porphyry; the first being simply indurated, and the second converted into marble.

Some other structural phænomena are briefly touched upon, among which it is said that the veins proceeding from granite appear to be of augite-porphyry, and that the veins emitted from the syenite are of felspar-porphyry.

For my own part I have merely to state that, as far as I am acquainted with them, the observations of Mr. D. Forbes and M. Kjerulf are in unison with the opinions expressed by M. Forchhammer and myself, particularly in respect to the metamorphosed schists, sandstones, and limestones of Silurian age, and also in demonstrating that the chief outbursts of the igneous rocks of this region, and specially of the porphyries, were posterior to the deposit of the Old Red Sandstone.

In conclusion, let me say that, although I failed in leading Prof. Keilhau to agree with me respecting the order of succession from flanks to centre, or in the identity in age of his "harte schiefer" and my Lower Silurian, it was the simple inspection of his own geological map of the Christiania Territory which first led me to entertain views which I realized by personal surveys. By inspecting the map of Keilhau, the geologist will see, that the whole of that which is now called the "Silurian basin," as circumscribed by gneiss, has a major axis of 120 miles long from Langesund, on the S.S.W., to the Lake Miosen, on the N.N.E. He will further observe, that the northern and southern portions of this region, particularly the latter, have been occupied by vast masses of those eruptive rocks (whether grouped as granites or porphyries) which have been emitted subsequently to the formation of the Old Red Sandstone. Hence it is, that in the parallel of Christiania only is there to be seen a full and symmetrical development of all the Silurian strata; the eruptive rocks merely showing themselves in that district as dykes and bosses of protrusion, or partial superjacent sheets.

2. *On the* Causes *producing* Foliation *in* Rocks; *and on some observed cases of* Foliated Structure *in* Norway *and* Scotland. By David Forbes, Esq., F.G.S., A.I.C.E.

The study of the metamorphic and crystalline rocks has of late years attracted much attention, and the researches of Darwin, Sharpe, and others have brought forward many facts particularly interesting and important.

It will probably, however, be admitted, that, notwithstanding the labours of these geologists, great difference of opinion exists as to the formation and structure of these rocks, and that at present we are not in possession of sufficient data to enable us to place the question upon a firm basis. It is therefore of importance that as many observations as possible be laid before geologists working at this subject; and it is consequently hoped that the present communication may not prove unserviceable in advancing the inquiry.

The observations here brought forward have with a few exceptions been made during a residence of some years in Norway, where the foliated rocks play so important a part. The others are the result of some short excursions in Scotland made for the express purpose of comparison.

For a long period, and it may be said until late years, it was the generally received opinion that the lines of foliation in rocks were lines corresponding in direction or identical with the lines of stratification, and were produced by the alteration of these lines by metamorphic action. This view of the case can no longer be considered tenable, and the observations of many geologists have shown that foliation frequently takes place at a different angle to that of stratification.

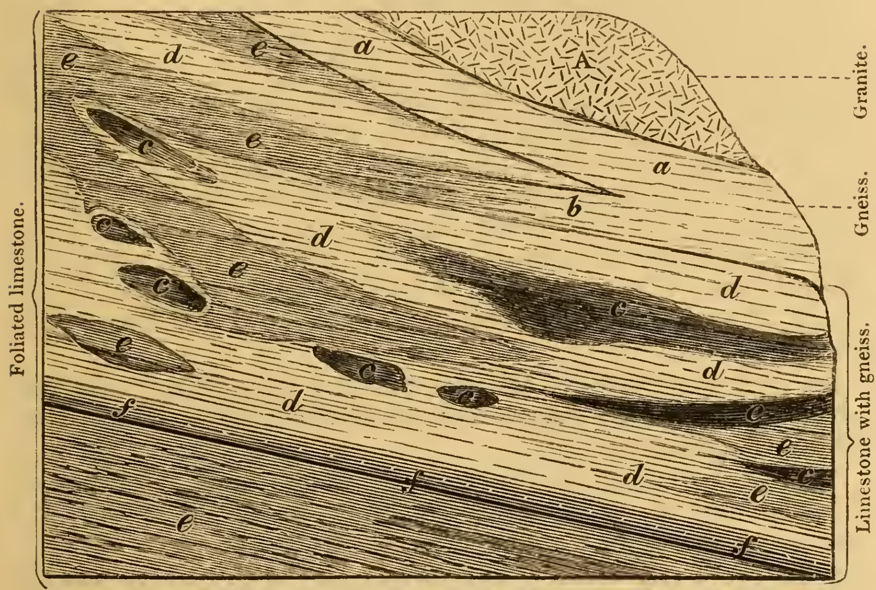
Darwin seems to consider this as almost invariably the case, and remarks that, even should they correspond in the strike, they would not correspond in the dip; and Ramsay, in his paper "on the Lower Palæozoics of North Wales," considers that there is no doubt that in many cases the foliation of the Anglesea rocks runs much across the dip. Many other observers might be quoted on this point; but, on the other hand, several geologists of high reputation seem to consider these cases as exceptional, and that in general the foliation is developed according to the lines of stratification.

(Case 1.)—As bearing on this point, I observed in the Highlands of Scotland, near Crianlorich, on the road to Tindrum, in Perthshire, regular beds of a blue limestone, resting upon a dark greenish-grey mica-schist, and dipping 32° N.E., with an inclination in the course of the strata of 24° S.E. This limestone was most completely foliated by the introduction of small plates of white mica, so that it often could hardly be distinguished by the eye from gneiss. Here the foliation in the limestone appeared perfectly identical with the planes of bedding, as shown by the coloured bands and large beds of the limestone. This was apparently also the case in the gneiss; but in the crust or stratum above the limestone on the surface of the ground the foliation was very twisted and irregular.

(Case 2.)—At Jægersborg, near Christiansand, in Norway, the foliation of a highly crystalline white limestone in schist was found to be parallel with the apparent lines of bedding (see fig. 1). It

Fig. 1.—*Section of foliated limestone and gneiss at Jægersborg, near Christiansand.* (See also page 173.)

Height of Section about 8 feet.



A. Granite.
a, *a*. Ordinary gneiss.
b. Quartzose gneiss.
c, *c*. Gneiss.
d, *d*. Crystalline white limestone.
e, *e*. Augitic limestone.
f, *f*. Micaceous limestone.

will frequently, however, be found very difficult to prove satisfactorily when the line of foliation coincides with that of bedding; as in many cases, and particularly in Norway, there are rarely any normal stratified beds in so close contact as to render the matter perfectly indisputable.

Keilhau seems, however, to consider the cases where the foliation does not agree with the stratification as exceptional, and mentions*, evidently with this impression, a case where he has observed in Thelemarken a thick bed of very characteristic gneiss situated amongst other crystalline strata in which the mica and gneiss structure, as a whole, was developed at right angles to the real planes of stratification.

It is possible also that the coincidence of foliation and stratification would be found much more frequently the case, were it not for the very general occurrence of the disturbing influence of a previously existing cleavage-structure,—or of a more or less inclined position of the beds during the time foliation occurred,—or, lastly, of the intrusion or approach of igneous rocks.

* Norske Mag. for Naturvidenskab, New Series, vol. i. p. 70.

Where cleavage is previously existing in rocks, it appears very reasonable to suppose that the folia would arrange themselves along the lines of cleavage, which may be regarded as so many cracks or vacuities extremely convenient for the development of crystalline matter. These spaces probably may be much more diffused than would appear at first sight. For we may suppose matter compressed so as to give it a cleavage-structure, and this pressure then removed or only relaxed: the elasticity of the mass itself (however small) would naturally cause a certain degree of relaxation throughout its entire body, giving it, in consequence, a general porous structure; the pores being of course elongated and flattened in the direction of the planes of cleavage, or at right angles to the compressing force. Afterwards, when the foliating forces, which cannot be other than chemical, come into action in a mass in this state, we may fairly expect that the lines of foliation will be identical with these lines;—which seems to be the reason that we so often find the lines of cleavage and foliation parallel. In case the chemical action here alluded to was so intense as to obliterate the cleavage-planes, then we have no guarantee that the lines of foliation will follow these planes.

In some cases possibly the cleavage may have taken place after foliation, and in some measure accommodated itself to these lines as offering the least resistance.

The superincumbent pressure, likewise, must be taken into account in considering the arrangement of foliation; as it appears likely that this would act against any vertical position of the crystals; and the elongated and flattened appearance generally seen in the crystalline minerals inducing foliation appears doubtless the result of this action.

Foliation and cleavage have both, I believe, been referred by some to electric or magnetic action; but I am afraid that it is too general to refer to these causes effects that we do not at first sight comprehend. If it be found, as I believe to be the case, that electricity traverses more easily in the direction of the cleavage-planes than across them, I think this argument has no further weight than as confirming the porous structure here supposed as consequent on the relaxation of a previously applied pressure; as it seems very probable that the resistance offered to the current in this direction would, in consequence, be less than across the grain,—and we know that most non-metallic mineral substances are very imperfect conductors, whereas space, or air rarefied by heat or exhaustion, are conductors, though not equal to the metals themselves.

Darwin and Sharpe (the latter in his paper on the Highlands) put forward the view that cleavage and foliation are identical,—that is, are parts of one and the same process, the former being but the first stage of the latter. To this I must object, and I believe that they are not only distinct phænomena, but that the causes producing them are also distinct; as in foliation we must have chemical action brought into operation, whilst in cleavage no such action is requisite, and the phænomena admit of a mechanical explanation.

We can only regard the truly cleaved rocks as mechanical aggregates; and the more foliated or crystalline such rocks become, the less perfectly do we find the cleavage-planes developed.

The microscopic researches of Sorby* and others have proved that in slates possessing the most perfect cleavage we have a mass composed of minute rounded grains of mica, decomposed felspar, quartz-sand, phosphate of iron, and other substances, all easily recognizable, and having all the characters of a waterworn deposit, apparently not in any way mineralogically different from the state they were in when originally deposited as a sediment. In fact they are nothing further than a consolidated mud, in which a lamellar structure has been induced by mechanical action; and the synthetical experiments of Sorby on this subject give the most conclusive evidence as to the mechanical nature of cleavage!

Admitting that cleavage and foliation were identical, how inconsistent with the parallel structure of cleaved rocks should we find the numerous cases of complicated and contorted foliated structure, which are so common, and where it is almost impossible to believe that these contortions have arisen from any twisting of the lines, either of stratification or cleavage, as the mechanical forces then brought into play would be so compound as hardly to be conceivable.

It must, nevertheless, be admitted, that the lines of foliation and the planes of cleavage do often agree and are parallel to one another; and several opportunities of confirming this have come under my observation.

(Case 3.)—In Espedalen, Norway, the foliation of the mica-schists and hornblende-gneiss is parallel to the cleavage of the clay-slates of the district, both running nearly E. and W., and dipping N. at various angles from 10° to 50°. The line of bedding cannot be determined, but seems probably to be in the line of cleavage.

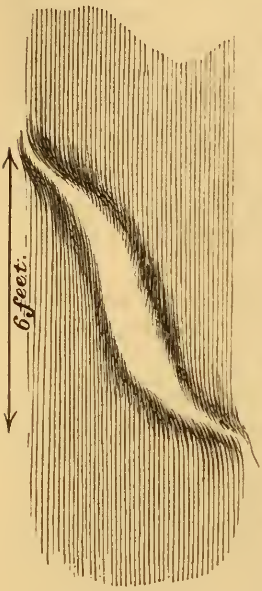
(Case 4.)—On the side of Loch Lomond, at Luss, I observed that the clay-slate there quarried has a cleavage-strike of N.E.–S.W., and dip of 70° S.; the stratification being uncertain. A little further north the mica-schist appeared (the points of contact were hidden by the soil), and the strike was found to be 65° N.E.–S.W., with a dip of 60° to S.; which may be regarded as nearly coinciding.

(Case 5.)—In the slate-quarries at Luss we have also instances of the cleavage-lines being bent by coming in contact with quartz-veins, just as described by Mr. Sharpe†; but I found that, where these veins occurred, not only were the ends of the cleavage-planes bent, but around the quartz-vein there was developed a distinct curved foliation, induced by a deep-green chlorite, with here and there a little mica. This foliation sometimes extends for a short distance into both the slate and the quartz, but appears quite independent of the cleavage, though with an evident relation to the curves of the veins themselves, which are very irregular. The quartz itself is

* Edin. Phil. Journal, July 1853.
† Quart. Journ. Geol. Soc. vol. v. p. 117.

sometimes foliated by the chlorite, so as to resemble a green mineral. The annexed diagram, fig. 2, will give an idea of these conditions.

Fig. 2.—*Quartz-vein in clay-slate at Luss, Loch Lomond, Scotland.*



In general in foliated rocks there is a totally altered structure, and we have many instances where they hardly possess any character in common with cleaved rocks.

Thus, even the parallelism of the lines cannot be considered invariable; we certainly have some cases where the foliation coincides with the bedding and not with the cleavage, and the property of splitting into laminæ in certain directions is often not possessed by foliated rocks at all, particularly if the foliating mineral be not itself of laminar structure.

We find certainly that in considerable districts of country the cleaved rocks are totally different from those in another district, just as one formation might be expected to differ from another; but it is doubtful if we ever find such abrupt and total changes as come in such rapid succession in the beds of foliated rocks.

(Case 6.)—In a quarry on the roadside about two miles from Crianlorich, in Perthshire, I found the strike N.W.–S.E., with dip 30° N.E.; the rock consisted of very thin beds which alternately presented the character of perfect and highly micaceous mica-schist and of extremely quartzy schist, so that it was not possible to call one single linear foot by the same name. Other cases more unusual will be noticed in the course of the communication.

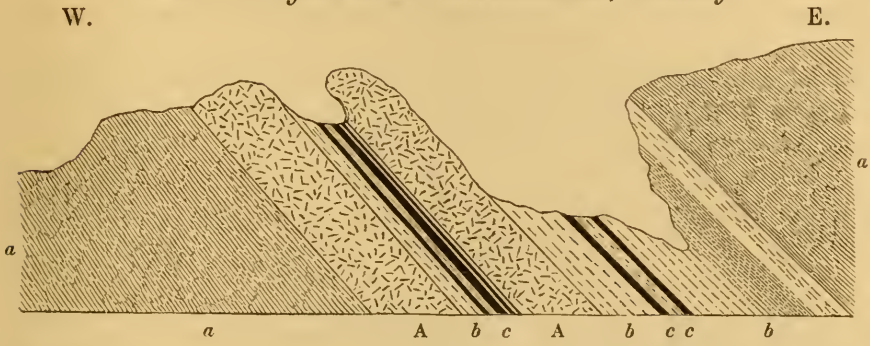
The production of foliated structure is not confined to the introduction of laminæ of one or two mineral substances, as mica, hornblende, chlorite, &c.; it may be produced by minerals widely different in chemical composition and mineralogical character, and the presence of which is only to be accounted for by the supposition that the constituent elements must have been at hand in the unmetamorphosed rocks, although in a different state of combination.

It is apparently also a necessary requisite in the production of foliated arrangement, that the minerals thus formed be of a different chemical constitution to those composing the mass of the rock itself.

I may here bring forward some instances of very distinct and determinate foliation produced by minerals not usually found under these circumstances.

(Case 7.)—On the heights immediately above Christiansand, in Norway, probably at a distance of two miles from the town, the section represented by fig. 3 was taken. The prevailing rock is here gneiss (*a a*), composed of black mica, white quartz, and white and red felspar, with sometimes specks of black oxide of iron. The strike of the foliation runs nearly N. and S., and the dip varies from

Fig. 3.—*Section of gneiss, limestone, and granite, at Stampekjærn, on the Heights above Christiansand, Norway.*



a, a. Gneiss.
b, b. Foliated, crystalline, pink limestone.
c, c. Bands of augitic gneiss in the limestone.
A, A. Granite (each band is about 10 ft. thick).

30° to 45° East. The strike inclines in course of the foliation about 10° towards S.

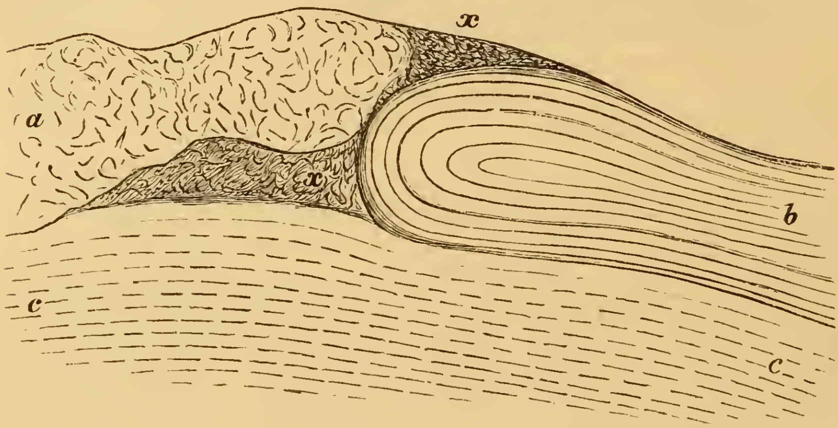
The section here represented is E. and W. nearly, or at right angles to the strike; and, coming from the east, we have first the gneiss, which sometimes is slightly granitic, but always preserves its regular foliated structure;—next we find a bed, about 14 feet thick, of coarsely crystalline pink limestone, in which a beautiful foliated arrangement is visible (as shown in the specimens now exhibited), by the presence of numerous small crystals of a green augitic mineral and white scapolite. Sometimes these minerals are so abundant as to present a very striking appearance, at other times we have only single lines of these crystals, with the intermediate limestone free from them; in all cases, however, both in this bed and throughout, they arrange themselves in distinct lines, which are invariably parallel to the lines of foliation of the gneiss itself. No tendency to split along these lines is present. Next we have some small beds (*c c*) of what may be termed gneiss, but in which the same augitic mineral appears to replace the mica, giving the mass a green appearance. The beds between this and the granite are of limestone, similar to the above, but of white colour and foliated in the same way.

The granite (A), which now shows itself and is about 10 feet thick, is composed of white felspar, quartz, and black mica, is coarse-grained, and follows the general line of the beds. On its sides, where it touches the limestone, it is in some places impregnated to a small depth, but very strongly, with the same green augite; and in cavities at the junction we find aggregations of garnets, scapolite, and augite, sometimes finely crystallized.

Beyond the granite we have beds of white limestone like the former and similarly interstratified, if we may use the term, with beds of augitic gneiss, until we again come to another and larger vein or bed of granite, of similar character to the former band, and under which we again find the regular gneiss, still preserving the unaltered line of foliation. In the different beds of limestone I did not observe any mica whatever.

(Case 8.)—On the other side of Christiansand, about five miles from the town, west of Torresdale River, we have very extensive beds of a white crystalline limestone, very similar to, and foliated like, the last-mentioned. A section is seen in fig. 4, and represents a quarry near the top of a mountain called Pusaasen.

Fig. 4.—*Section of gneiss and limestone at Pusaasen Mountain, near Christiansand, Norway.*



a. Granitic gneiss ; not distinctly foliated.
b. Quartzose, brownish, foliated gneiss.
c, c. White, crystalline, foliated limestone (about 15 feet exposed).
x, x. Indeterminable broken and weathered mass, filling joint.

The section is taken about parallel to the strike, or 40° N.W.–S.E. The strata incline towards the south, and dip at 15° S.W. At the top of the section on the north side we have a considerable mass of gneiss (*a*), without a grain (or nearly granite-gneiss), with no foliated arrangement apparent, very quartzy, and containing but very little mica. This abuts against a bed of very quartzy gneiss (*b*), where the lines of the foliation give the appearance of its having been doubled up. This gneiss contains numerous crystals of iron-pyrites in the lines of foliation, and by their oxidation it has acquired a rust-brown colour. Between these two gneiss rocks we have a joint filled up with a broken, decomposed, and weathered mass (*x*), of undistinguishable character; but below the whole is a large bed of white crystalline limestone, foliated by lines of augite-crystals, precisely as in the last case; the foliation is here parallel to the upper and lower surfaces, or the foliation, of the gneiss above it. About 15 feet of the limestone bed is uncovered; the lower 3 feet is coarser-grained than the upper 12 feet. At a few spots mica is seen present, foliating the limestone in a similar direction.

(Case 9.)—On the same side of the Torresdale River, and about two miles west of the last locality, can be seen an extremely interesting case, in which the lines of foliation are carried out quite independently of the nature of the minerals by which they are formed.

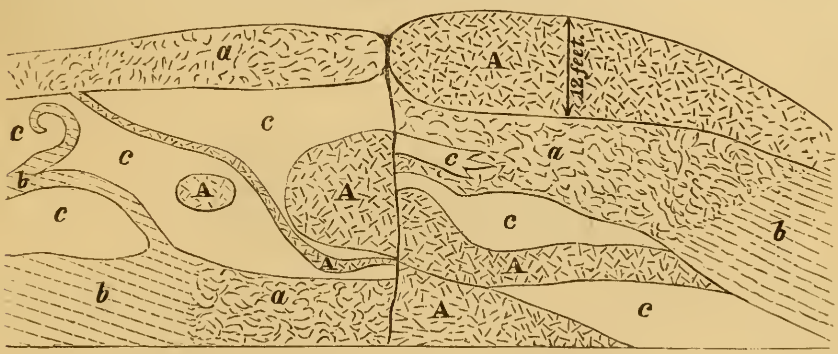
It will be understood by referring to fig. 1, p. 167, where we have an overlying granite (A), below this a bed of ordinary black micaceous gneiss (*a a*), sending forth a small arm (*b*), very quartzy and losing itself in the surrounding white, coarse-grained, crystalline limestone (*d*), of which a thickness of about 8 feet is uncovered and is here represented; in this we find several blackish detached patches of gneiss (*c*).

The line (*f f*) crossing the lower part of the section represents an apparent line of bedding, very regular, and showing itself the more strongly, from the foliation of a few inches on the upper side principally being much closer than throughout the rest of the mass. This line, as shown in the section, runs nearly E. and W., or at right angles to the strike, and inclines 20° from N. to S. The strike itself is within a few degrees of N. and S., and inclines 15° to E.

The portions of the limestone marked *e* in the section, fig. 1, are foliated by crystals of blackish-green to light-green augite and white scapolite; in the part marked *f f* the foliation is produced by the presence of laminæ of mica. Now when the lines of foliation are examined, which are well developed and distinct, it will be seen that these invariably run in one direction throughout the mass, no matter what minerals produce the foliation itself; also that this direction coincides with the line of apparent bedding.

Not many yards above, and at right angles to this, the section represented in fig. 5 was made, showing as much as was uncovered

Fig. 5.—*Section of granite, gneiss, and limestone at Jægersborg, near Christiansand, Norway.*



A. Granite. *b.* Ordinary gneiss.
a. Granitic gneiss. *c.* Foliated crystalline limestone.

by soil or debris. This presents a much-disturbed appearance; the central part appears to have been broken through by a fault, and we have on the east side, on the surface, granite (A); below this, gneiss (*a*), without grain, passing into regular gneiss (*b*), and then the limestone (*c c*) cut up by granite. On the other side, the granite is absent; and we have gneiss, similar to the former and without grain, at top, and then the limestone, in which rounded masses of granite are seen, as if protruding from large supplies behind. We also see a small vein of granite, not more than a few inches thick, losing itself in the grainless gneiss at top. We have lastly some gneiss showing itself in a very peculiar shape, and becoming grainless when near the granite. The general foliation of the limestone and gneiss seems to agree. The section, fig. 1, p. 167, would cut across this at the extreme right of the diagram where the distortion is least.

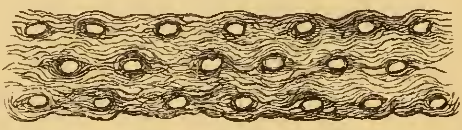
(Case 10.)—Besides the more regular beds of limestone here described, several apparently quite detached pieces (varying considerably in size) may be seen completely surrounded by the gneiss. Fig. 6 represents the shape of one of these detached masses*. The limestone

Fig. 6.—*Outline of one of the detached limestone-masses in gneiss at Jægersborg, near Christiansand.*

is precisely similar to the other, and is foliated by the same minerals as in the last case; and even here the lines of foliation in the gneiss appear to be carried out without disturbance through these limestone-masses.

(Case 11.)—A very interesting arrangement of the foliated structure, very similar to that of the garnets in mica-schist, was found by me at Lindflid, on the borders of Ongsteens lake, between Bratsberg and Nedeness Amt, in Norway, and apparently extending over a considerable area, probably of some square miles. The rock here is a species of talcy mica-schist, and contains innumerable nodules of dichroit, of a white or bluish-white colour, sometimes exhibiting the

Fig. 7.—*Mica-schist with nodules of Dichroit, Ongsteens Vand, Norway.*



peculiar and characteristic play of colours. These nodules are nearly of a size, about that of a walnut, and the foliation of the mica bends itself around them, producing a very peculiar appearance from the immense number of the nodules present and the extreme regularity of their disposition, which can be seen at a glance.

The whole would appear as the effect of some arranging force, in conjunction with the ordinary action of foliation.

The cases of foliation which I have hitherto brought forward have been all caused by the introduction of silicates, but in many cases I

* Scheerer also has some remarks on the occurrence of these masses of limestone at Christiansand, N. Mag. f. Naturv. vol. iv. part 2, p. 158.

have observed that the same phænomena have been caused by the appearance of totally different chemical compounds.

(Case 12.)—At Pusaasen, a little north of east of the locality described above, and illustrated by fig. 4, p. 172, we have a bed of limestone, apparently either the same, or one parallel to it, which lies on gneiss, and appears to run in the same direction as the former. Here I found that several feet of the lower part of this bed were foliated by the introduction of the mineral termed chondrodite (a fluosilicate of magnesia), which was arranged perfectly parallel to the micaceous foliation of the gneiss, as well as of that of the limestone. It may be also mentioned that the chondrodite here is associated with the black spinel, precisely as at Sparta in the United States.

I have also observed in Norway many cases of foliation where this structure has been induced by the presence of small laminæ or folia of oxide of iron, sometimes to the almost total exclusion of other foliating minerals. I have found this to be the case, on the small scale, in Nissedal, at Langoe, and at Dybsund Holm, near Krageroe. On a larger scale, it appeared at Rönningen, in Drangedal, where the gneiss was often very strongly foliated by scales of oxide of iron, and having a very characteristic red appearance. This foliation appeared not to disturb in any way that of the adjoining gneiss.

The foliation of rocks by means of oxide of iron is not peculiar, however, to Norway. From observations recently communicated to me by Lieut. Aytoun, Bengal Artillery, this is often the case in Hindostan. He states that at one of the small outliers of the Kupput-good range of mountains a very fine example of this may be seen. The rock is a siliceous talcy schist, and strikes N.N.W., dipping 50° E.; the beds thus foliated are from 60 to 80 feet thick, and extend for several miles. In some hand-specimens received from Mr. Aytoun there are portions of the talcy schist having the talc entirely replaced by scales of black magnetic oxide of iron, which also shows itself particularly well developed along the joints.

In the valley of the Mulpurba, about eight miles south of Belgaum, in the Deccan, Mr. Aytoun has observed many instances of mica-schist and clay-slate running 5° N.W., and dipping 80° E., in which small bands, from $\frac{1}{4}$ to $\frac{1}{2}$ inch thick, were foliated by oxide of iron, and many hand-specimens of which possessed a distinct polarity.

It is often the case in Norway that some strata or parts of strata, extending often for miles, present a peculiar foliated arrangement, due to the introduction or appearance of certain metallic compounds and the greater or less exclusion of the usual foliating silicates. Thus at Kongsberg, near Tvedestrand, in Drangedal, in Espedalen, and several other places I have found various sulphurets showing themselves; and at Modum and Snarum, also at Vena, near Askersund in Sweden, arseniurets show themselves under similar circumstances.

The details connected with these occurrences are particularly interesting, and important also in an economical point of view; but they cannot be brought within the limits of this communication: I trust, however, at a future period to bring some observations on the subject before the Society.

The cases already described show in some measure the wide range and extraordinary difference in mineralogical or chemical composition of the substances producing foliated structure; and I think it must be admitted that we have no such analogous phænomena characteristic of the cleaved rocks, and that these facts would be opposed to the view that cleavage and foliation were the effects of one action.

Mr. D. Sharpe, in his excellent paper "On the Foliation and Cleavage of the North of Scotland*," has brought forward another argument in support of the identity of these two phænomena, namely the arrangement of grand semicylindrical arches in which the lines of foliation and cleavage *together* form the defining boundaries.

My excursions in Scotland were too short to form even a faint idea of these arches. It seemed to be not improbable, however, that these lines, which appear so regular upon Mr. Sharpe's map, might be found continued into Norway, where I was better acquainted with the rock-structure. I could, however, make nothing of them, and must candidly confess that I relapsed into that state of despair described by Mr. Sharpe as "the first impression of an observer entering a district of gneiss or schist in search of order in the arrangement of their folia." The geological map of Norway now produced, and which is by Keilhau, has indicated on it a *résumé* of most observations of strike and dip made in that country prior to 1849, and probably more experienced observers than myself may be able to reduce these lines to a system. I am sorry that time has not permitted me to mark down on the map a great number of observations made by myself or collected from friends, since its publication.

In an attempt to generalize the lines of foliation in the district around Arendal and Krageroe in an examination of that tract made by Mr. Dahl and myself, and published last year in Norway†, we were unable to come to any more definite conclusion than that these lines generally varied from N.W. to E. and W., and were in the main parallel to the line of coast. The dip was found extremely variable at all angles, from 13° to 90°, S.E., S., up to S.W. Contorted arches are of constant occurrence in the gneiss districts in Norway, but they seem to be connected with local phænomena. Some are very interesting, and the arrangement shown in fig. 8 is one difficult of explanation.

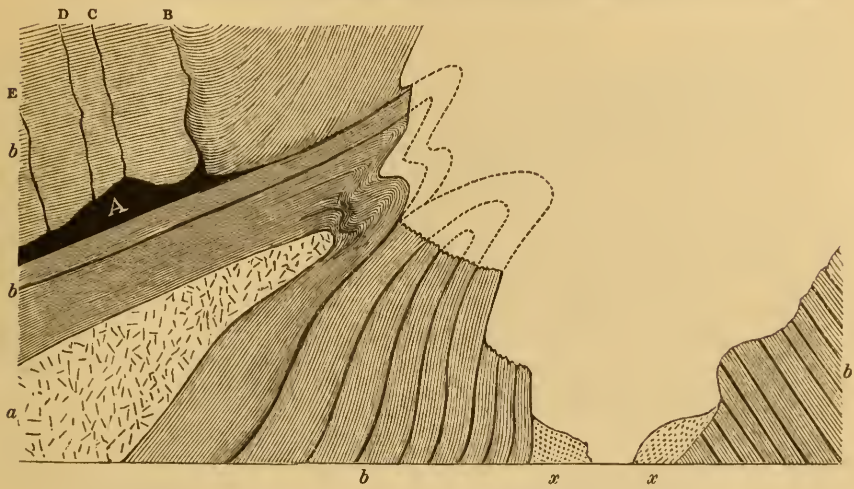
(Case 13.)—We have in fig. 8 a section of a ravine near Krageroe (the section being broken in the centre to admit of both sides being shown, otherwise impossible from the scale). The ravine at the bottom is probably not 50 feet across, and the precipice of the side is about 60 feet high. The angles dip in opposite directions on the respective sides of the ravine; on the one side, N.W. at various angles up to vertical; on the other, pretty constant at about 60° S.E. The dotted lines show what may be supposed to have been the continuation of the jagged edges of the strata, and are confirmed by the blocks of similar configuration lying loose in the ravine below.

The central boss *a* represents a mass something between granite

* Phil. Trans. R. Soc. London, 1852.

† See also Quart. Journ. Geol. Soc., No. 42, Part II. Miscell. p. 9, &c.

Fig. 8.—*Section at Lykkens Grube, near Krageroe, Norway.*



x. Alluvium. *a*. Granitic gneiss.
A. Granite; B, C, D, E, granite veins. *b*. Ordinary gneiss.

and gneiss, of undefined character; and above is seen a small vein of coarsely grained granite (B) containing numerous crystals of brown titanite. The contorted structure of the foliation here observed is, I think, due to the entrance of the granite-vein and the occurrence of the granitic gneiss, which seems in this case to be nothing more than gneiss into which granite has infiltrated from large masses of this rock, not seen in the section, but which are in the immediate neighbourhood.

Now as to the influence of the intrusion of the igneous rocks on foliation, it seems to me that the two are very intimately connected, and that, in many cases at least, foliated structure seems to arrange itself in planes connected with the configuration of the intruded or underlying igneous rocks.

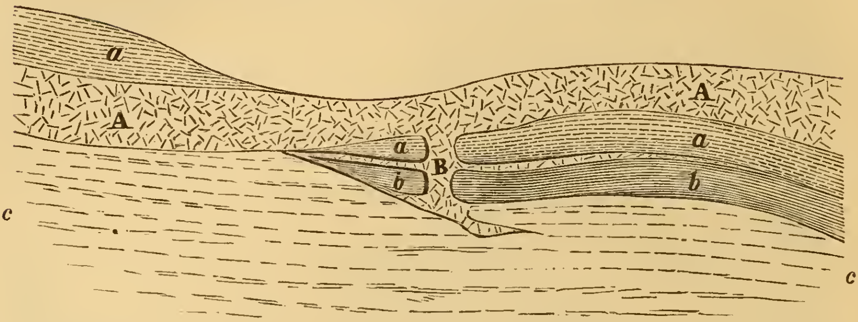
Mr. Sharpe admits that the occurrence of such rocks has a very disturbing influence on the regularity of his arches; but it may be fairly questioned whether such arches may not themselves be due to the appearance or approach of such igneous rocks.

Looking at Norway, we find no considerable tract of country exempt from the constant occurrence of such igneous rocks; and, as far as my experience goes, these rocks seem generally to have an apparent influence on the lines of foliation.

Fig. 3 (p. 171) gives a good illustration of this; as also fig. 1 (p. 167) and fig. 5 (p. 173).

(Case 14.)—Fig. 9 also represents a similar case at Pusaasen near Christiansand, where we have a granite-vein (A) about 3 feet thick, breaking through gneiss (*a*) into crystalline limestone (*c*) similar to that previously described, and foliated by augite, scapolite, and mica; below the small vein of granite (B), the gneiss (*b*) is more calcareous and augitic; but above, it is of the ordinary character, and does not contain carbonate of lime. The strike is E. and W., and the dip 25° to the South.

Fig. 9.—*Section at Pusaasen, Christiansand.*



a. Gneiss.
b. Calciferous and augitic gneiss.
c. Foliated crystalline limestone.

A. Granite vein (3 feet thick).
B. Smaller granite vein.

The foliation here, in the gneiss, in the augitic calcareous gneiss, and in the limestone, is parallel in each rock, and to the general run of the imbedded vein of granite.

On the coast near Krageroe we have also numberless instances of the foliation of the gneiss having the same direction as the veins of granite may have on an immense scale. Near Smedsbugten we have, for instance, no less than seven enormous veins, or rather beds, of granite visible on the side of the mountain arising abruptly from the sea, and all of which run N.N.E., dipping to the W. at an angle of about 40°. Between each of these are great beds of gneiss, the general foliation of which is parallel to the beds of granite, and the whole appears to be several hundred feet in height.

In the paper by Mr. Dahl and myself, previously quoted, other instances will be found.

It is frequently also the case, where veins of trap make their appearance, that the foliation is found parallel or greatly influenced.

On the side of the road about two miles from Inverarnon, in Perthshire, I observed a vein of grey porphyritic trap, containing specks of iron and copper pyrites, and running N.–S., with a dip of 20° W.

On both sides of the trap, the mica-schist, which was quartzy and contained black mica, had the same angle of foliation as the imbedded trap-vein.

This I found also to be the case about two miles further north from this, where a large vein of syenitic trap, running nearly horizontal, showed itself. Here, however, as small veins ramified from the main body of trap, the coincidence was not always so carried out as in the previous case.

Similar cases to these were found in Drangedal, at Vedfald, where two veins of mottled serpentine-trap made their appearance.

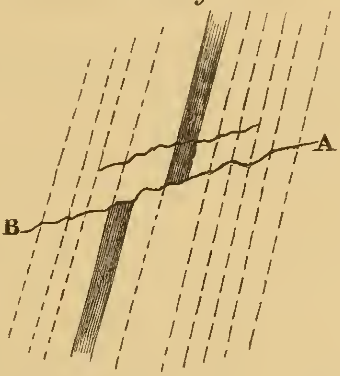
That the intrusion or approach of igneous rocks is always the cause of foliated structure cannot be insisted upon; and I am aware that many cases occur exhibiting appearances quite different from the abovementioned: still at the same time it is a circumstance worthy of consideration, as being in some cases the agent in causing as well as modifying foliated structure.

Whatever may be the cause of the arrangement of foliation in certain directions, I believe that most geologists agree in supposing that foliation itself is due to the action of heat, which has reduced the rock *in situ* to a fluid, or at least semifluid state, to which some add the action of gases and pressure.

On this point I would wish to make some remarks; and I may premise by stating, that to me foliation appears to be the result of chemical action in recombining the elements existing in amorphous sedimentary rocks, together with a simultaneous molecular movement of the products thus formed; also, that this action is effected by heat, but has taken place at temperatures lower than even necessary to change the external form of the masses, or to produce any semifusion or even softening.

As corroborative of this, I may refer to fig. 10, which Keilhau

Fig. 10.—*Section of the gneiss in the Island of Jomfruland, Norway.*



has also observed and made mention of*. It represents an appearance in the gneiss on the island of Jomfruland.

Here we have a vein of hornblendic character running across the gneiss, and disturbed by the fault AB, which throws it downwards.

On examining the lines of foliation, it will now be found that those lines which are most distinct are not at all affected by the fault, and continue throughout with the greatest regularity; so that it can hardly be doubted, that the foliation of the gneiss took place later than the formation and subsequent dislocation of the hornblende vein; and consequently we cannot suppose that the mass could have been in a fused or softened state at the time of foliation without the obliteration of these appearances. Again referring back to fig. 8, p. 177, it will be seen that the fault B, the origin of which apparently was previous to or simultaneous with the granite-vein, has altered the position of the foliation on the one side and bent it upwards. The faults C, D, and E do not effect this at all.

If, however, the rock had been in a semifused state when foliation took place, or when the granite-vein was injected, we should have

* Norske Magazin for Naturvidenskab, vol. iii. p. 175.

expected that the faults would have been obliterated, or that both sides would have been equally affected.

At the limestone quarry on the road to Crianlorich, previously described, p. 166, where the limestone is foliated, we have the foliation affected by faults and curved, and in one place a portion enclosed between two faults had the foliation curved on both sides in a nearly circular direction; so that there is here also reason to believe that the foliation took place subsequently to the faults, which otherwise would not have retained the sharp and defined angles here seen.

In submitting this opinion as to the temperature at which foliation took place, it can be objected, however, with reason, that in the present state of chemical science we have no right to assume that such chemical action and arrangement can take place in solid bodies without external change of form. Chemists will no doubt admit that in *homogeneous* bodies of one composition we may have a complete change of molecular arrangement without any change of form;—thus,

that a mass of bar-iron from being fibrous may become crystalline—

that sugar-candy may from an amorphous state become crystalline—

that large crystals of sulphur may change their structure, becoming an aggregate of small crystals belonging to a different crystalline system—

that the sandstone bed of a blast furnace or the bricks of kiln-walls may by the action of heat acquire a columnar or basaltic structure.

But in all these cases we have no chemical action, no production of other and totally distinct compounds as in foliated rocks,—we have only the results of a molecular arranging force*. It is necessary, therefore, before the view I have brought forward, with reference to the production of foliated rocks at comparatively low temperatures, can be securely established, that we have some data to prove that such action and changes can really take place. I endeavoured, therefore, to procure experimental proof of this with direct reference to the rocks, but met with many difficulties.

Thus, I often could not succeed in regulating the heat to sustain such temperatures as seemed necessary, and found that, the instant a pasty or semifluid state was induced, I could not obtain satisfactory results. The action of the air in oxidizing the iron present as protoxide to the state of peroxide also introduced a new element which would have been gladly dispensed with.

On taking, however, a rock like steatite, which we have in Norway in such quantities as to use it as a building-material,—and which is at once one of the most infusible of rocks, and nearly altogether free from iron,—I was not annoyed by the above difficulties, but found another obstacle in the way.

The results, however, on prolonged treatment of this rock, were so satisfactory as to be very encouraging as a beginning, and I found that a slightly foliated structure was evidently being induced. The

* See also Hausmann on Arsenikglas, &c., Quart. Journ. Geol. Soc. vol. vii. part 2, page 2.

pieces subjected to heat were, however, always more or less broken up and friable, evidently from the unequal expansion and contraction of the mass. To obviate this, it seemed necessary to have the auxiliary aid of pressure; and, in order at the same time to make experiments on a somewhat larger scale, I proceeded as follows.

Having some small blast-furnaces at disposition, I placed slabs or blocks of the rocks in question under the bottoms of them, which were composed of a stamped mixture of clay and charcoal-dust,—and which consequently protected them from the action of the air, whilst at the same time they were exposed to a certain amount of pressure from the slag and metal above them. This pressure varied as the sump was filled with slag or metal, or a mixture of both, and as the former was of average density 3, and the latter 5, and as the depth was about 3 feet, we might have a pressure of from 7 to 12 lbs. per inch. These experiments were made in Norway in a district where no great variety of rocks were obtainable, and as they occupied a very long time I can only here give the results of one or two, which, however, are so far satisfactory.

I exposed large slabs of an impure, rather micaceous clay-slate, about 4 inches thick, 6 feet long, and 4 feet broad, under these circumstances, to the action of heat continued for some months, but which never was so intense as to cause fusion or even softening, as the slabs, even if they had been broken up, retained their original outward form and sharp edges. From the pressure and the unequal distribution of the superincumbent weight, they were very frequently, if not always, broken up, and consequently had to be removed, so that generally some metal or slag is adherent to the pieces;—also it sometimes happened, when little cracks had arisen in the protecting lining of clay and charcoal, that the pieces would be found permeated to great distances with small veins of metallic matter, so fine as to render it astonishing how it could have occurred. In all cases, however, where a softening had taken place, the result was spoiled, and the foliated arrangement, which is otherwise so distinct, would be more or less obliterated or totally destroyed.

From the specimens now shown to the Society it will be seen that the original slate is unrecognizable, and that we have a rock of a white (probably feldspathic) ground, with specks of a black mineral arranged with a distinct foliated structure. The appearances here presented are strikingly like some of the rocks of the district, where syenite comes in contact with mica-slate.

The specimens, though not large, are, I think, quite characteristic.

Again, on repeating these experiments with soapstone, using blocks of this material (which is very abundant and is cut up with axes and saws), I formed the bottom of a furnace of cubes of this stone, 1 foot square, cemented by Stourbridge clay. After several months, under precisely similar circumstances, the blocks retained their external form and their sharp edges precisely as at first; even the axe-marks can be distinguished upon them.

On fracture, however, it is seen that in parts they have all the outward appearance of the chlorite found at Brevigstrand in Norway;

and here and there we observe small aggregations, evidently arising from foreign matters present in the original soapstone, which have separated themselves.

In repeating this experiment with a view to the economical use of soapstone for the bottom of furnaces, I found that the metal had broken through the protecting lining (which in this case was not so thick), and had gone right through the substance of the soapstone blocks, which had acted as a filter. The blocks themselves retained their form completely, and were perfect at the joints; but below them was found a large mass of metal which had percolated through them; and the blocks themselves were converted into heavy semi-metallic masses, much resembling in appearance the magnesian rocks impregnated with metallic ores found in the veins of this district. It was also easy to see that an arranging force had likewise come into play, as the sulphurets of the various metals previously existing in the *matte* as a homogeneous compound, were here separated and showed themselves distinctly crystalline.

Many other experiments of a similar character were made; but, as they were principally connected with the formation of minerals, they are not so immediately related to this subject.

The above facts are, however, I think, sufficiently conclusive to show that we may have an altered chemical, as well as molecular, arrangement at temperatures below that at which softening is produced.

That we may, however, sometimes have an arrangement analogous to foliated structure in rocks generally considered as of igneous origin, and which have been fluid, must be admitted. The structure of graphic granite illustrates this well; and Sedgwick mentions that the granite of St. Austell in Cornwall has a grain. Keilhau mentions*, that in a granitic rock at a place called Salmelic, in Norway, he found a parallel structure, sufficiently distinct to determine a strike and dip, induced by the presence of crystals of flesh-coloured orthoklase.

This arrangement cannot, however, I think, have anything in common with that found sometimes in volcanic rocks, and which is often seen in slags and glass, produced artificially, and which seem probably due to similar causes as those producing the ribboned structure of glacial ice. In the specimen of glass here produced we have an arrangement evidently due to this cause and to a subsequent crystallization superadded, in which the crystalline arrangement has followed the striæ of the glass, previously invisible. Some rocks certainly igneous may have been formed in a similar manner; but here, in the case of the glass, we do not have the chemical action as in the production of foliated rocks; since the glass is only to be regarded as a homogeneous body, modified by crystalline forces, according to pre-existing lines.

It will be found that many minerals apparently possess in themselves a certain independent arranging power. Minerals do not only

* Norske Mag. f. Naturv. vol. ii. p. 372.

show themselves in the same crystalline form, but have likewise a tendency to arrange themselves preferably in certain figures. Thus crystals of grossular from Brevig, in Norway, almost always occur as hexagonal rings of single crystals, the interior and surrounding mass being only the matrix. Crystals of augite from the Canary Islands were found to arrange themselves parallel to the long axis of the prism. Many other instances might be cited that are doubtless quite familiar.

I have now only to notice some points regarding the chemical composition of the foliated rocks, as compared with the other truly sedimentary beds.

This has by some been considered so different as to preclude the idea that foliated rocks have been formed from rocks similar to the present formations, without supposing that some ingredients must have been added to, or taken away from such.

Thus the amount of alkali has been supposed much greater. On examining the later analyses by Taylor of the carboniferous rocks, Hunt's analyses of the lower and upper Silurian rocks, and others, it will be seen that when we subtract the organic matter and other volatile substances, as carbonic acid, &c., we have then no greater difference than that usually found in different series of the foliated rocks. In fact, many of these contain but very little alkali.

Bischoff makes hornblende-schist to contain only 1·45 per cent. of potash and soda together, and the averages of two analyses of mica-slate give 6·67 per cent. of alkali; but, considering that the quartzy schist contains so much less, the average will probably not be more than we find in the fossiliferous strata. Thus Hunt found in the upper and lower Silurian beds of East Canada 5·05 and 5·59 per cent. of alkali respectively.

In the clayslates (azoic) of Norway, Kjerulf has found* between 5 and 6 per cent., and some of the slates analysed by Bischoff gave up to $8\frac{1}{2}$ per cent.; but whether fossiliferous or not, is not mentioned. I think, therefore, there is no necessity for supposing with Forchhammer that the alkali in the foliated rocks is derived from the vapours of potash and soda exhaled from the melted granite. This view is so extremely Plutonic, that I think it ought only to be accepted when we can find no more moderate doctrine. It seems to me more probable, that, if there really was a deficiency of alkali (which I doubt) in the strata before being metamorphosed, or rather foliated, in Norway (as Forchhammer especially alludes to the Norwegian rocks), we should rather seek to account for its subsequent presence by the supposition that these strata have been changed whilst submerged, and by the infiltration of sea-water and consequent decomposition of the salt by silica.

This is consistent also with the known upheaval of the land in Norway.

Keilhau has advanced the idea of a silicification of the limestones as they approach the crystalline rocks. I have analysed several;

* Norske Mag. f. Naturvid. vol. viii.

namely, from Stampekjærn, Jægersborg, and Pusaasen, near Christiansand, from Boedalen, in Gulbrandsdalen, and dolomite from several localities near Krageroe, as well as crystalline calc-spar veins near Arendal; but in none of these specimens have I found this the case; and no silica was present except that contained in the mechanically intermixed minerals. In fact, the limestone, on the contrary, seems generally purer than that found in fossiliferous strata; and this is accounted for by the tendency which the chemical action producing foliation has to separate and recombine all extraneous matters.

In one of these limestones and in several of the azoic rocks, I have found considerable per-centages of carbon present. This has also been found to be the case by Kjerulf, who has found as much as $4\frac{1}{2}$ per cent. of carbon in some of the clay-slates of Norway.

I have also observed the frequent occurrence of graphite (which may be looked upon as foliated carbon) in these rocks, often developed on the sides of the joints, as in Svadsum, Gusdal, Opdal, and other places.

Again, anthracite occurs in the gneiss, at Kongsberg, and near Arendal; at the point of junction with the gneiss at Narestoe I have found it in nodules in the granite. Phosphate of lime is also frequently present in the gneiss.

From these facts it would appear not unreasonable to question whether many of the metamorphic rocks of Norway may not originally have resulted from the alteration of fossiliferous strata, without at the same time at all deviating from Sir Roderick Murchison's views in his admirable exposition of the Norwegian Silurian system; as we may suppose that this very system may have covered considerable areas of the country, and by its destruction given rise to at least some part of the present metamorphic or crystalline rocks. In fact, Sir Roderick Murchison has described in his paper* a case where a portion of the Silurian system near Christiania has actually undergone a change into gneiss by contact with granite.

Without going further into detail as to the chemical relations of this part of the subject, I think that the observations and remarks which I have just laid before the Society would tend to strengthen the evidence in favour of the following views:—

1. That foliation and cleavage are two distinct processes not necessarily connected; and that those cases where they are parallel or identical generally result from previously induced cleavage-structure.

2. That foliated structure is the result of chemical action combined with a simultaneous arranging molecular force, developed at heats below the fusion or semi-fusion of the rock-masses; and that, when we find a similar structure induced in rocks which are known to have been previously in a fused state, this has been developed subsequently to the solidification of such rocks.

3. That the arrangement of foliation is often due to the presence or proximity of igneous rocks, and has a tendency to follow the direction

* Quart. Journ. Geol. Soc. vol. i.

of any lines present in the rocks, whether of cleavage, of stratification, or of striæ of fusion,—following preferably those lines offering least resistance; and lastly, that there are considerable reasons for supposing that the foliated rocks, even of Norway, may be chemically altered fossiliferous strata.

In conclusion, I have but to add, that, in laying these remarks and observations before the Society, I have hoped that they might not be altogether unworthy of notice, notwithstanding that they may in some points differ from the views already set forth by very eminent geologists.

FEBRUARY 16, 1855.

Annual General Meeting. [For Reports and Address, see the beginning of this Volume.]

FEBRUARY 21, 1855.

Edward Hull, Esq., A.B., was elected a Fellow.

The following communication was read:—

On the Occurrence of ANGULAR, SUBANGULAR, POLISHED, *and* STRIATED FRAGMENTS *and* BOULDERS *in the* PERMIAN BRECCIA *of* SHROPSHIRE, WORCESTERSHIRE, *&c.; and on the* PROBABLE EXISTENCE *of* GLACIERS *and* ICEBERGS *in the* PERMIAN EPOCH. By ANDREW C. RAMSAY, F.R.S., F.G.S.

Introduction.—The sedimentary strata which contain the fragments of striated and polished rocks to which I am about to call attention belong to the inferior portion of that which has been defined as the "Permian Group" by Sir Roderick Murchison, the true geological horizon of which in England was first explained by Professor Sedgwick, in his celebrated memoir, "On the geological relations and internal structure of the Magnesian Limestone and the lower portions of the New Red Sandstone series," &c. It is of the last-named division of this series that they probably form a part.

The speciality of the subject of this memoir scarcely requires me to enter upon points connected with descriptive geology further than may be needful to explain the true position of the Breccias alluded to; and the detailed sections subsequently given, having that object in view, should therefore be considered chiefly as explanatory of the general relations of the subdivisions of the Permian and Bunter strata to each other. It is, however, proper to state that the general position of the Permian rocks skirting the coal-fields of North Wales, Coalbrook Dale, and Staffordshire was first indicated in Sir Roderick Murchison's Map, published in 1839*. They are there coloured as Lower Red Sandstone with subordinate calcareous conglomerates; and their lower boundary he defined by the outcrop of the Coal, while the upper he shaded off into the New Red or Trias

* 'Silurian System.'

properly so called. The line of demarcation between the Permian and Bunter rocks has, however, lately been accurately defined by the Geological Survey, and while some supposed Permian areas have been expunged from the map, others, that up to this time have been considered of Triassic age, have been added to the Permian.

In the great work on the Silurian region, &c., the structure of the Permian rocks is also truly described near Alberbury, Enville, and in South Staffordshire, and the beds of calcareous conglomerate near Enville and the Lickey are mapped and clearly described*.

Respecting the Breccias (which are quite distinct from these conglomerates), up to this date different views have been taken by geologists from that advocated in this memoir, for most of the patches have been considered either as immediately connected with volcanic outbursts†, or else described as stratified trappoid conglomerates, containing a few fragments of stratified rocks, the whole being supposed to be derived from neighbouring igneous masses, or from metamorphosed strata now concealed‡. After a prolonged examination of every part of these breccias in Staffordshire and Worcestershire, and of every opening exposed, whether by nature or in quarries, and after many hundred specimens were broken and examined by myself and others on the Geological Survey, I have come to the conclusion that in every locality they are truly sedimentary and rudely stratified, and also that the fragments were rarely derived from neighbouring rocks, but generally had travelled from a distance. It is satisfactory to find, that as regards the stratified and lithological character of these fragments, I am borne out by so distinguished an authority as Dr. Buckland, who in 1819 most accurately described this breccia as it occurs in the Bromsgrove Lickey and Clent Hill range, stating its true sedimentary nature, and that it contains "pebbles that agree in substance with the quartz-rock of the Lower Lickey, mixed with pebbles of common white quartz, black and variegated jasper, flinty and chloritic slate, many varieties of porphyry, and of grey and variegated compact and granular sandstone§." Allowing for differences of nomenclature, it is easy to see that the character of many of the fragments is the same with some of those subsequently described in this memoir.

In the summer of 1852 I traced the boundaries of the Permian breccias that run between the Bromsgrove Lickey and the Clent Hills, having previously visited similar rocks on the flanks of the Abberley and Malvern range. Though much struck with the size and angularity of the fragments, and with the marly paste in which they are imbedded, I did not then venture to propose to myself the solution of these and other peculiarities, at which I have since arrived, viz. that they are chiefly formed of the moraine matter of glaciers, drifted and scattered in the Permian sea by the agency of icebergs.

* 'Silurian System,' p. 59. † *Ibid.* pp. 138, 139, 496, &c.

‡ Professor Phillips's "Geology of the Malvern Hills," &c., p. 162. See also Mr. Jukes's "Memoir on the South Staffordshire Coal-field."

§ Transactions of the Geological Society, 1st Series, vol. v. pt. 2. p. 507.

But when, in connexion with my duties on the Geological Survey, I began in 1854 to inspect these rocks near Enville, and afterwards revisited the equivalent strata in South Staffordshire, and on the Abberley and Malvern Hills, their true nature gradually dawned on me, and on the 18th of July I wrote to our late deeply lamented President, announcing what (if true) I considered a discovery of considerable value. Though I was unaware of the circumstance at the time, it appears that two authors had previously hinted at the possible agency of ice in two epochs,—palæozoic and secondary. In the 'History of the Isle of Man' (1848), p. 89, in describing the conglomerate of the Old Red Sandstone, Mr. Cumming compares it to "a consolidated ancient boulder-clay formation," and continues, "Was it so, that those strange trilobitic-looking fishes of that æra (the *Coccosteus, Pterichthys*, and *Cephalaspis*) had to endure the buffeting of icy waves and to struggle amidst the wreck of ice-floes and the crush of bergs? These are questions which we may perhaps venture to ask, but which we dare not hope to have solved till we know something more than at present we know of the history of the boulder-clay formation itself." It may be remarked as a curious coincidence, that, when in Worcestershire I arrived at the conclusion that the Permian breccias are also boulder-clays, my thoughts at once reverted to the more ancient Old Red conglomerates of Scotland, and I stated at the time to my colleague Mr. Howell that they might afterwards turn out to have had a similar origin.

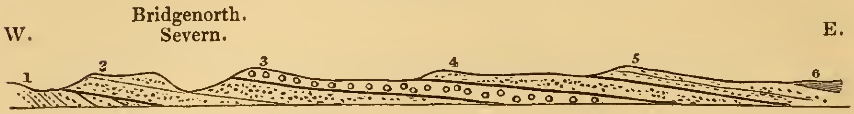
In a paper published in the Quarterly Journal of the Geological Society, February 1850, pp. 96 and 97, Mr. R. Godwin-Austen observes that "the great blocks of porphyry of the middle beds of the New Red series in the West of England, included in sands and marls indicating no great moving power, seem to require some such agent as that of floating ice to account for their position." In the following observations I hope to carry this subject considerably further, and to show, not only that there were icebergs of Permian date, but also partly to indicate the district whence the glaciers descended that gave these icebergs birth.

Geological Description of the principal localities of the Breccia; and its composition and character.—The Coal-fields of North and South Staffordshire, Tamworth, Coalbrook Dale, and the Forest of Wyre are partly bordered by Permian rocks which lie unconformably on the Coal-measures, and in most places once covered these fields, but have been partially removed by denudation. Patches of Permian strata also rest very unconformably on the Silurian rocks of the Abberley and Malvern Hills.

The Bunter or New Red Sandstone which forms the base of the Trias, has been divided by the Geological Survey into four subformations*, some of which are occasionally absent. The best and most complete typical sections of these rocks occur on the east side of Coalbrook Dale, or in the country between Bridgenorth and Pattingham. The section there is shown in fig. 1. p. 188.

* First made out and described by Mr. Hull.

Fig. 1.—*General Section of the four subdivisions of the Bunter Sandstone.*

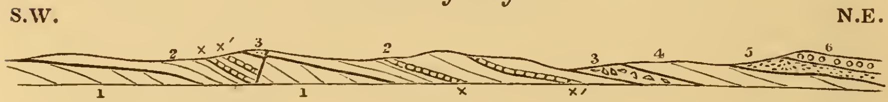


1. Permian sandstone and marl.
2. Lower, soft, brick-red, and variegated sandstone.
3. Coarse conglomerate or pebble beds; pebbles well-rounded.
4. Upper, brick-red, and variegated sandstone.
5. White and brown sandstone and red marl, resting on a calcareous conglomeratic base, succeeded by
6. New Red marl.

Some one of these four members lies generally quite unconformably on the Permian beds, unless where they chance to be faulted against each other.

In the Midland Counties and on the borders of Wales, the Permian section is different from that of Nottinghamshire and the north of England. The magnesian limestones are absent, and the rocks principally consist of alternations of deep red marl and brown and red sandstones, calcareous conglomerates and breccias, which are almost entirely unfossiliferous. The most complete section occurs south of Bridgenorth in the country between Enville and the Forest of Wyre. This ground, as coloured on the maps of the Geological Survey, was mapped by Mr. Aveline and Mr. Hull, the latter of whom supplied me with the following section.

Fig. 2.—*Section of the Permian rocks between Enville and the Forest of Wyre.*



Fault.

1. Coal-measures.

Permian.
- 2. Sandstone and red marls, containing two beds of calcareous conglomerate, marked × and ×′.
- 3. Coarse breccia.
- 4. Sandstone and red marls.

Bunter.
- 5. Lower brick-red or variegated sandstone.
- 6. Pebble-beds or conglomerate.

The general dip is easterly, and varies from 2° to 6°; and the breccia (No. 3) dips distinctly beneath the overlying marls and sandstones, No. 4. On the N.W., various members of the Bunter Sandstone abut on the Permian strata by means of a fault. The same takes place on the East, between Enville and Bewdley; but in the neighbourhood of Bobbington the inferior brick-red sandstone* rests directly on the higher Permian strata. Nearly the whole of this series is repeated by a North and South fault which intersects the country about two miles to the east of the Severn. It is a downthrow on the West, probably of from 300 to 400 feet. Though dili-

* No. 5 of the Bunter beds of the above diagram, fig. 2.

gently searched, no fossils have been discovered in these beds except the impression and part of the bark of the stem of a tree, about two yards long and a foot in diameter, which relics were found last summer by Mr. Hull and myself in the higher calcareous conglomerate (marked $\times'$ in fig. 2) near Four Ashes. The pebbles of these conglomerates are mostly well-waterworn, but some of them are subangular; they chiefly consist of numerous fragments of carboniferous limestone, mixed with pieces of chert, sandstone, quartz, quartz-rock, Silurian limestone of doubtful date, greenstone, felspathic trap, banded felspathic ash, red granite, red sandy marl, red sandstone, black slate, red jasper, and hornstone. These were collected at Gatacre Hall and the Four Ashes. The carboniferous limestone pebbles by far predominate; and few of the fragments of any kind exceed 3 or 4 inches in diameter. The nearest carboniferous limestone is that of the Titterstone Clee Hills, about twelve miles distant on the south-west. The Coalbrook Dale limestone contains chert, and is about fifteen miles off on the north-east; and in the same district occur igneous and quartz rocks not dissimilar to those found in the conglomerates. Some of the other pebbles may have come from the Welsh Border, near the Longmynd; but all of them may have been drifted by ordinary marine action.

The true Breccia is separated from the calcareous conglomerate by about 100 feet of brown calcareous sandstone and marl. The brecciated stones are imbedded in a deep-red hardened marly paste. They are mostly angular or subangular, with flattened sides and but slightly rounded edges. The pieces collected consist chiefly of fragments of micaceous schist, micaceous sandstone, quartz-rock, grey sandstone, chert, purple grit, green sandy slate (one of them polished and scratched), black slate, altered slate, greenstone, felstone, felspathic ash, and reddish syenite. The last is doubtful. A nodule of ironstone was also observed, and a few quartz-pebbles. None of them are larger than 6 or 8 inches in diameter. There are no rocks answering to the majority of these in the immediate neighbourhood; and with the exception of the chert, syenite, and ironstone-nodule, the rest lithologically resemble the Cambrian sandstones and slates of the Longmynd, and the Lower Silurian slates, quartz-rocks, and igneous rocks at and east of the Stiper Stones. The distance from the Enville Breccia to these parts of Shropshire and Montgomeryshire is from twenty to thirty miles in a straight line; and, if the inference be correct that any of the stones are derived from that district, they must have travelled at least that distance.

The South Staffordshire coal-field would be surrounded by Permian rocks, were it not that north of Cannock the pebble-beds (No. 3 of the Bunter Section, fig. 1, p. 188) overlap and rest directly on the coal-measures. On the east, between Beaudesert and Watling Street, the pebble-beds (3), white beds (5), and marl (6) are faulted against the coal-measures. In other places the Permian rocks abut against or rest on the carboniferous strata, except at Kingswinford and Oldswinford, where for a short space they are cut out by an increase of the boundary fault. The most complete section of the Permian beds

Fig. 3.—*Section of the Permian rocks of Clent Hill.*

1. Coal-measures.

Permian. { 2. Alternations of red marl and sandstone, with two calcareous bands.
3. Breccia, about 450 feet thick.

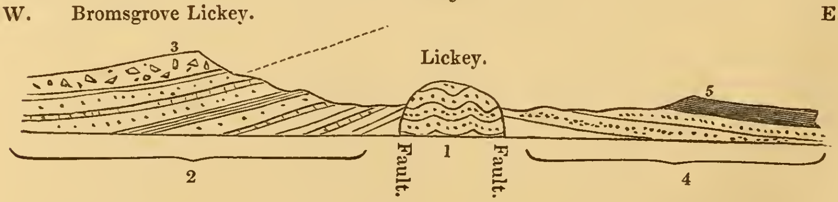
Bunter. { 4. Pebble-beds or conglomerate.
5. Upper brick-red and variegated sandstone.

in this area occurs at the south end of the coal-field, between the coal-measures and the summits of the Clent Hills and the Bromsgrove Lickey. The diagram (fig. 3) shows their arrangement.

The breccia here consists of pieces of various rocks imbedded in a hardened, red, marly paste. Like those near Enville, they are generally angular, or have their edges but slightly rounded. Their sides are often flattened, sometimes polished, and occasionally scratched. They rarely exceed a foot in diameter. On Clent Hill the fragments consist of felstone-porphyry, greenstone-porphyry, greenstone-amygdaloid, ribboned slate, black and green slate, red sandstone, quartz-conglomerate, and felspathic ash. In a section near Romsley, stones of the same nature were found, including altered sandstone, conglomeratic ash, banded felspathic ash, quartz-rock, variegated marl, quartz-pebbles, altered slate, ribboned slate, and blocks of a coarse conglomerate.

The igneous rocks of Staffordshire are very different from those in the breccia; and none of the other kinds quoted occur in that district, with the exception, perhaps, of the quartz-rock, which might be compared to that of the Lickey. There is, however, good reason why the quartz-rock of the breccia should not have been derived from the altered Caradoc of the Lickey. This ancient ridge is bounded by two faults, one being a downthrow on the east, and the other a downthrow on the west. On the east the white sandstone, and on the west the Permian rocks abut against it: see fig. 4. The continuous ridge of the Bromsgrove Lickey and the Clent Hills, crowned by the breccia, is higher than the Caradoc Hill; the Permian rocks

Fig. 4.—*Section of the Bunter, Permian, and Caradoc rocks of the Lickey.*



1. Altered Caradoc. 2. Permian marls and sandstone. 3. Breccia. 4. White beds (Bunter). 5. Red marl (Keuper).

forming a fine escarpment, the beds of which have a westerly dip. Were they prolonged from a quarter of a mile to a mile, the higher beds would cover the Caradoc sandstone; and, were it not for the fault, some of the marls and sandstones beneath the breccia would, if prolonged, also cover these altered Silurian strata. It may therefore be assumed that this old ridge was buried under lower Permian sediments before the breccia was accumulated, and therefore none of the brecciated fragments would be likely to be derived from these altered Caradoc sandstones. In this case, the nearest places to which we can refer the component fragments of the breccia are the Longmynd and the Silurian country east of the Stiper Stones. There we have numerous beds of green, grey, and purple grits, together with ribboned slates near Shelve and in other places, identical in structure and colour with those in the breccias, quartz-rock at the Stiper Stones, and all the varieties of greenstone and felspathic ash mentioned in the list. The next nearest places where such ashes occur, are Pembrokeshire and the remoter parts of North Wales; but, for other reasons besides proximity, it is safer to suppose they were derived from the Cambrian and Silurian regions between Church Stretton and Chirbury (Shropshire and Montgomeryshire), than from the more distant counties of Pembroke, Merioneth, and Caernarvon.

The summit of the hill called Frankley Beeches is crowned by an outlier of breccia; and it also forms a piece of ground about a mile and a half long a little to the west of Northfield, a good section of which occurs in the lane leading from Northfield to Bangham pit. The larger stones lie mostly towards the top. Many of them consist of Caradoc limestone (Upper Caradoc of some geologists), and calcareous sandstone and conglomerate, some of them attaining a diameter of about two feet. I submitted a collection of the fossiliferous pieces to Mr. Salter, who determined the following species:—

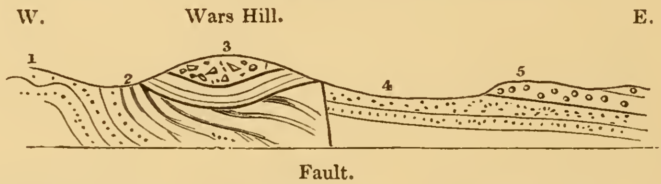
Strophomena compressa.
Orthis calligramma.
Atrypa reticularis (very common).
Spirifer trapezoidalis.
Leptæna depressa.
—— transversalis.
Rhynchonella semisulcata.
Pentamerus oblongus (rare and small).
—— undatus.
—— lens.
Mytilus mytilimeris.
Encrinurus punctatus.
Favosites alveolaris.
Petraia bina.
—— subduplicata.
Heliolites interstinctus.
Scalites (Trochus) lenticularis.
Euomphalus funatus, var. sculptus.
Goniophora cymbæformis.
Serpulites.

Besides the blocks containing these fossils, the breccia includes fragments of other calcareous sandstones, ribboned slate like that near Shelve, quartz-rock, porphyritic felspathic ash, felstone and greenstone, like that of the Lower Silurian rocks, purple conglomerates, similar to those of the Longmynd, and yellow sandstone and black chert, the latter like that of the carboniferous limestone.

The Upper Caradoc limestone and fragments of calcareous sandstone and conglomerate are peculiar. They do not resemble the Caradoc beds of Walsall, Builth, Malvern, May Hill, or the Lickey; but, both lithologically and zoologically, they are like the equivalent strata that rest unconformably on and once formed the beaches surrounding the Longmynd and adjacent Lower Silurian rocks, where, *in situ*, they contain green and purple slaty fragments and pieces of felspathic trap derived from the waste of that ancient Cambrian and Lower Silurian island. They may be identified by this circumstance, for in no other place with which we are acquainted does the Upper Caradoc assume this character; and Mr. Salter also gives the confirmatory opinion, that the assemblage of fossils nearly resembles some of the groupings in the parent rocks near Hope. It is therefore difficult to escape from the conclusion that the rocks generally must have travelled from that country across a space from forty-five to fifty miles.

Between the Forest of Wyre and the south end of the Malvern Hills several patches of the breccia occur at intervals, resting on the coal-measures and on the Silurian rocks of the Malvern and Abberley range*. The most northerly is that at Wars Hill, about two miles west of Kidderminster. It lies directly on the coal-measures; and on the east the Bunter pebble-beds and Lower brick-red Sandstone are faulted against it.

Fig. 5.—*Section of the Bunter and the Permian beds, with Breccia, at Wars Hill.*



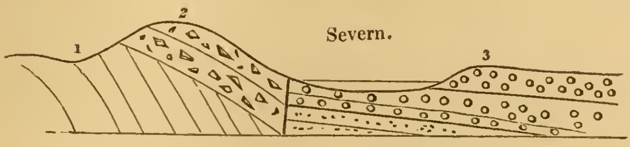
1. Old Red Sandstone. 2. Coal-measures. 3. Permian sandstone and marl, with breccia on top. 4. Lower brick-red sandstone, and 5. Pebble-beds (Bunter).

This breccia contains fragments of grey sandstone, very common, grey slate, ashy sandstone, highly felspathic sandstone, felspathic trap, and carboniferous limestone chert. The paste that binds them together is a bright-red marl. No very good sections are exposed; and the component stones of the breccia are apparently never larger than 8 or 10 inches in diameter. A calcareous conglomerate, identical in structure with that near Enville, underlies the Breccia, being separated from it by sandy and marly beds. The relative positions of the breccia and this conglomerate are therefore the same at Wars Hill and Enville, and there is no reason to doubt that, in general terms, they are equivalents. About three miles further south, a similar breccia occurs on Stagbury Hill, one mile and a half west of Stourport. This also rests on the coal-measures, and helps to form a connecting link between the Enville and the Abberley breccias, which lie indifferently on several of the older Palæozoic formations. On Stagbury Hill the mass dips east, at angles of about 50°, and the pebble-beds are faulted against it, their junction being, however, concealed by the alluvium of the Severn†.

* In consequence of the quantities of felspathic angular fragments which came out from beneath the sward, these patches were coloured as igneous rocks by Sir Roderick Murchison, who also informs me that no quarries were at that time opened on the hills.

† Notwithstanding the alluvium, there is no real obscurity about this fault, which has been traced.

Fig. 6.—*Section of Coal-measures, Permian, and Bunter at Stagbury Hill.*



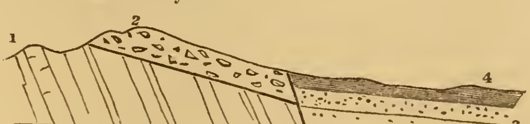
1. Coal-measures. 2. Permian breccia. 3. Pebble-beds (Bunter).

The brecciated fragments consist of felstone, felspathic ash, greenstone-porphyry with large crystals of felspar, greenstone, ribboned slate, grey and purple grit, like that of the Longmynd, coarse conglomerate, and red micaceous stones like pieces of the Old Red Sandstone. Excepting this last, the assemblage of rocks, and even their distinctive peculiarities (of ribboned slate, felspathic ash, &c.), are again characteristic of the Longmynd, and of the Lower Silurian series west of the Stiper Stones. The breccia is from twenty-seven to thirty-five miles distant from that country; and the largest mass observed in it may be about a foot in diameter.

A remarkable outlier of breccia forms Church Hill, about six miles west of Stagbury, nearly halfway between Stourport and the Titterstone Clee Hill. It is about three-quarters of a mile in diameter, and rests unconformably on the Coal-measures, serving as a mark to show that the breccia once extended many miles across the country to the west, and that it has been since removed by denudation. The included angular stones are fine altered sandstones, grey and purple grits, red conglomerate (sometimes in masses of 2 and 3 feet in diameter), greenstone and felspathic porphyries, felspathic ash, grey and green slate, variegated and red marls, red felspathic porphyry, arenaceous limestone, and altered black sandstone. The stones are unusually angular and broken, and the bright-red marly base is larger in quantity than in most of the other localities. Most of the stones possess the accustomed resemblance to the Cambrian rocks and Llandeilo flags with their included igneous masses in Shropshire and Montgomeryshire; and the limestones, by their fossils, belong undoubtedly to Caradoc of the Montgomeryshire type.

A few miles further south, this breccia again appears in two places on the Abberley and Woodbury Hills. Both of these patches rest unconformably on Upper Silurian shales and limestones; and

Fig. 7.—*Section at Woodbury Hill.*



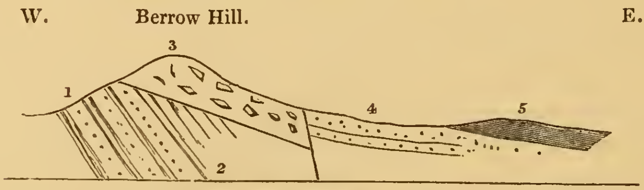
1. Upper Silurian shale and limestone. 2. Permian breccia. 3. Brown and white sandstone and marls (Upper part of Bunter). 4. Red marl (Keuper).

both, forming the highest crests of their respective ridges, dip towards the New Red Sandstone plain at Hundred House and Great Witley.

The Permian rock contains subangular fragments and larger boulder-like blocks of greenstone (very numerous), felstone, brecciated ashy conglomerate, greenstone-amygdaloid, felspathic ash and porphyry, purple grit, red conglomerate (with rounded pebbles), micaceous marl (Old Red?), green-banded slate, ribboned slate, and altered black and green slate. As in the other localities, the rock may be described as a rudely stratified breccia. At Abberley Hill, some of the masses are from 2 to 3 feet in diameter, and in one of the quarries near the base of Woodbury Hill I saw one half-rounded boulder-shaped fragment which measured 2 ft. 4 in. × 1 ft. 6 in. × 1 foot in diameter.

Following the Abberley and Malvern chain to the south, the Breccias again appear for about one mile and a half between Berrow Hill and the Teme, and also at Woodbury Rock, on the south side of that river, near Knightsford-bridge. On Berrow Hill they rest on a thin strip of Coal-measures; but a little further south they overlap this, and lie directly on the Old Red Sandstone. On the east, the upper part of the white sandstone is faulted against them.

Fig. 8.—*Section of Berrow Hill.*



1. Old Red Sandstone. 2. Coal-measures. 3. Permian breccia. 4. White sandstone (Bunter). 5. Red marl (Keuper).

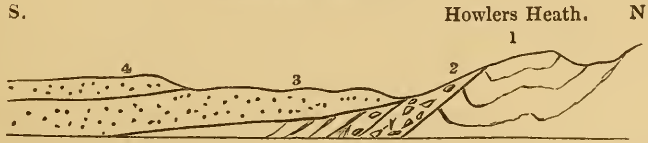
In this breccia we find greenstone, purplish-grey brecciated trap, felstone, felspathic porphyry, purple grit, and slate, grey and ribboned slate, brown sandstone, quartz-rock, red conglomerate, calcareous sandstone, limestone, and a few pieces of granite.

On Berrow Hill, the largest fragments observed were about a foot in diameter. At Woodbury Rock, purple grits form the great majority of the fragments, and many of the boulders are unusually large, one of them, of reddish conglomerate, attaining the size of 4 feet by 3, by 1½ deep. With the exception of some small pieces of granite, which may be derived from the Malvern Hills further south, the whole of the specimens again resemble the rocks of the Longmynd and the Shropshire and Montgomeryshire Silurian rocks west of the Stiper Stones.

A rock of similar structure to the rest of the breccias appears at Alfrick; but, as it seems more likely to be of Bunter than of Permian date, I shall pass it over for the present. It is bounded on the west by the same fault that ranges along the east side of the

Abberley and Malvern range, and from thence, with slight breaks, passes further south to the shores of the Severn*. At the south end of the Malvern Hills, between Bromsberrow and Howlers Heath, a strip of Permian breccia occurs, about a mile and a half in length, lying unconformably across the strike of the Upper and Lower Silurian rocks. A part of the same band, thrown further south by a fault, stretches for about three-quarters of a mile between Little London and Vineyard. It rests unconformably on the Upper Silurian rocks and the Old Red Sandstone, and both the strips are cut off at each end by faults, which throw the upper brick-red beds (No. 4 in fig. 1) of the Bunter Sandstone against them. They are each about an eighth of a mile in width, dipping southerly under the upper brick-red or variegated sandstone, at angles of about 25°.

Fig. 9.—*Section of the Bunter and Permian beds south of Howlers Heath.*



4. White and brown sandstone, with bands of marl (Bunter). 3. Upper brick-red sandstone (Bunter). 2. Permian breccia. 1. Silurian rocks.

Above No. 4 comes the New Red marls. Among numerous sub-angular fragments of the breccia were found pieces of quartz, quartz-rock, quartzose sandstone, purple grit, reddish conglomerate, greenish-grey grit, black and blue slate, ribboned slate, Silurian limestone, greenstone, felstone, felstone-porphyry, and granite like that of the Malvern Hills. Some of the other fragments, such as the black slate and limestone, alike resemble Malvern and Shelve rocks; but the majority have the character common to the Longmynd rocks, from which they are distant about forty-seven miles. They are generally of no great size, the largest observed rarely exceeding 6 or 8 inches in diameter.

The Breccias on one horizon; and extent of the area which they occupy.—I have now described these Breccias as occurring in ten localities, exclusive of small outliers, or mere minor separations of the same mass by local faults. Though occurring at intervals, there can be little doubt that they all belong to one Permian horizon. In the Enville country (fig. 2, p. 188) they are both overlaid and underlaid by marls and sandstones of true Permian type, the lower beds including two bands of calcareous conglomerate. These, as a whole, dip beneath the Upper New Red Sandstone to the east, and again rise from under it in the southern part of South Staffordshire, where, in consequence of unconformity, the higher Permian beds are overlapped by the Upper New Red Sandstone; and, the lower brick-red sandstone being absent, the pebble beds rest directly on the Breccias (fig. 3, p. 190). Between the Bromsgrove and Clent Hills and the

* Lately traced by Mr. Howell.

South Staffordshire Coal-field, the Permian section is, in general terms, the same as that of the Enville country; like it, including two highly calcareous bands. Around the South Staffordshire Coal-field, north of Northfield on the east, and Kingswinford on the west, the Permian strata exposed seem all to form portions of the series that lie below the Breccia.

Between Enville and Bewdley, the identity of the breccias is sufficiently apparent, two large strips being merely separated at the surface by means of a north and south fault. Between Bewdley and the south end of the Malvern Hills, they occur at six distinct intervals, resting on Coal-measures, Silurian rocks, and Old Red Sandstone; and in none of these places do we find the marls and sandstones that elsewhere rest upon and underlie them. The same may be said of the Church Hill outlier. This would seem to indicate that the breccias in places overlap the Lower Permian strata; and this may be easily accounted for, if we suppose that a tract of country of irregular outline was gradually depressed during the accumulation of the series, so that the original margins of the lower strata were by degrees overlapped, and the breccias deposited on still sinking land. There is, in truth, no good reason why these detached masses should be supposed of different dates; for structure and mode of occurrence alike point to their identity. If then the Staffordshire, Enville, Abberley, and Malvern breccias be all of one origin and date, either cropping out directly from underneath the Bunter Sandstone (except where faulted), or being associated with beds that do so, there is reason to believe that, along with the rest of the Permian strata, they may to a great extent underlie the greater part of the Bunter series between Malvern, Enville, and South Staffordshire; just as, by parity of reasoning, we conclude that the coal-fields of Staffordshire, Coalbrook Dale, the Forest of Wyre, and the thin strips on the flanks of the Abberley Range, near Martly, are also probably connected deep below the surface. The chances are in favour of this general continuity of Coal-measures; and, if they are not invariably united, it is probably because parts were removed by denudation before or during the deposition of the overlying formations. The same may be said of the Permian strata of which the Breccia forms a member; and, if they either are or were continuous at any time between outcrop and outcrop, they cover or covered an included area estimated at about 500 square miles. But at the south end of the Malverns they dip southerly, near Northfield at the south-east end of the South Staffordshire coal-field they dip easterly, and north of Enville they are cut off by a fault; so that to some extent they must—and for aught we know they may—extend beneath the New Red Sandstone over a much greater area.

Character of the stones in the Breccia; and whence derived.—The lithological nature of the imbedded fragments has already been described. Everywhere, in spite of exceptional fragments in the Malvern district, they seem to be derived from one set of rocks; they are all enclosed in the same red marly paste, and they are mostly angular or subangular. A well-rounded waterworn pebble is, in places, of rare occurrence. The surfaces of a great majority of the pebbles are much flattened, numbers are highly polished, and, when searched for, many of them are observed to be distinctly grooved and finely striated. The striæ in some are clear and sharp, and run parallel to or cross each other at various angles; while in others, though you see their remains, age and surface-decomposition have impaired their sharpness and roughened the original polish of the stone.

I have stated that (if lithological character be any guide) the fragments (with rare exceptional pieces) seem to have been derived from the conglomerates and green, grey, and purple Cambrian grits of the Longmynd, and from the Silurian quartz-rocks, slates, felstones, felspathic ashes, greenstones, and Upper Caradoc rocks of the country between the Longmynd and Chirbury*. The south end of the Malvern Hills is from forty to fifty miles, the Abberleys from twenty-five to thirty-five miles, Enville from twenty to thirty miles, and South Staffordshire from thirty-five to forty-five miles distant from that country. The question then arises, by what process were so many angular and subangular fragments transported so far; many of them being a foot, and some two, three, or even four feet in diameter; the whole in places forming a deposit of several hundred feet in thickness? Why also are they angular, and not well-rounded, like the pebbles of the great conglomerate-beds of the Bunter Sandstone; and why have they flattened sides, and often polished and striated surfaces?

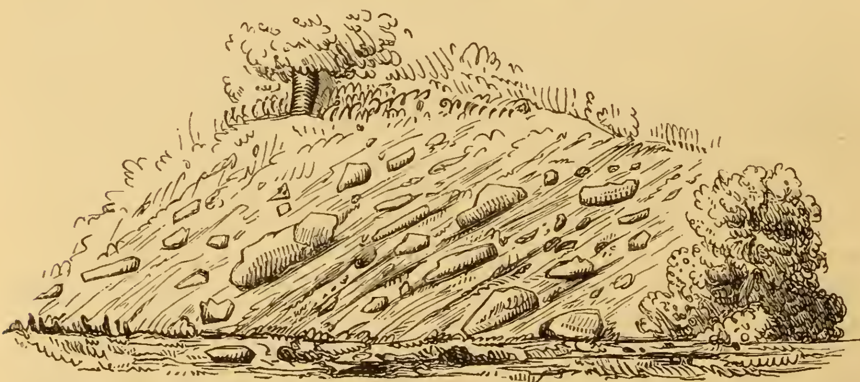
Fossils of the Permian : and Stratification of the Breccia.—There seems no special reason to doubt that the Permian beds of the midland counties are of marine origin, like the magnesian limestone series of Nottinghamshire, Yorkshire, and the North of England; although, except the remains of the tree near Enville, no native fossils have yet been discovered in them, either on the borders of Wales or on the east side of Coalbrook Dale, in Staffordshire, or on the flanks of the Malvern Hills. There are, however, identical deposits lying between Leamington and the neighbourhood of Tamworth, in which a few fossils were found. In this district these beds have heretofore been described as belonging to the Bunter Sandstone†, appearing as they do not far below the true New Red or Keuper marl. The error arose from the absence of the pebble-beds and the lower and upper brick-red sandstones of the Bunter Series (fig. 1, p. 188); and thus it happens that between Leamington and the country a little to the south of Tamworth, the white and brown sandstones, 5, fig. 1, p. 188 (that immediately underlie the New Red marl), rest directly on the Permian sandstones and marls, which were thus naturally mistaken for the lower parts of the Bunter strata. Having satisfied myself, on purely stratigraphical and lithological grounds, that these were true Permian strata, the truth of this surmise was further confirmed

* In part, the Shelve country.

† Memoir by Sir R. I. Murchison and Mr. Strickland, Transact. Geol. Soc. 2nd Ser., vol. v. p. 331.

in 1852, when I found fragments of *Lepidodendron* and *Calamites** in a quarry near Exhall. Encouraged by this discovery, these rocks were diligently searched for fossils during the completion of the geological lines by Mr. Howell, and in the same quarry a few casts of a shell were discovered by our collector Mr. Richard Gibbs, which Mr. Salter considers to be of Permian type and more allied to *Strophalosia* than to any other genus. The silicified trees found near Allesley and Meriden, and apparently several species of *Caulerpites* and *Breea* now in the Warwick Museum †, belong also to the same rocks (formerly supposed Bunter species); and, in addition to this, it is interesting to know that the beds near Kenilworth in which the *Labyrinthodon Bucklandi* was found by Dr. Lloyd ‡ belong to the same series. This reptile, previously considered of Bunter date, must therefore be transferred to the Permian period. Beds of calcareous conglomerate are associated with the strata in which all of these fossils were found, and are similar to those which underlie the breccia near Enville; and it is not improbable they may be general equivalents; in which case, trees, reptile, and marine shells are of earlier date than the great deposits of breccia. The Permian marls and sandstone near Enville, that overlie the breccias, are in no respect dissimilar from those that lie beneath; and the breccias themselves, whenever well exposed, are seen to possess a distinctly stratified structure. Not only do the stones generally lie on their flat sides, but sometimes there are long marly and sandy layers and beds in the midst of the mass.

Fig. 10.—*Stratified Permian Breccia.*



Glacial origin of the Breccia.—They were therefore deposited in water with considerable regularity, and, as we have seen, over a large area. It is altogether unlikely that the stones were poured into the sea by rivers in the manner in which some conglomerates are formed on steep coasts, where mountain-ridges nearly approach the shore, 1st, because the fragments, being derived almost exclusively from the Longmynd country, if the sea then washed its old shores, no

* Prof. E. Forbes considered it to be *Calamites Mougeotii*? Mr. Salter thinks it *Calamites Suckovii*, a Carboniferous species.

† *Caulerpites oblonga, C. triangularis, C. biangularis, Breea entassoides.* No *precise* locality is given for these specimens.

‡ Transactions of the British Association, 1849, Sections, p. 56.

river-currents passing out to sea could carry such large fragments from thirty to fifty miles beyond their mouths and scatter them promiscuously along an ordinary sea-bottom; and, 2ndly, if the rivers merely passed from the Longmynd across a lower land to the sea, transporting stones and blocks of various size, these would have been waterworn on their passage seaward after the manner of all far-transported river-gravels, whereas many of the stones are somewhat flat, like slabs, and most of them have their edges but little rounded. Neither could ordinary marine currents move and widely distribute fragments so large that some of them truly deserve the name of boulders; and, except in the case of earthquake-waves, which here and there produce an occasional debacle on a shore, I have no faith in violent currents of sea-water (such as have been sometimes assumed to result from imagined sudden great upheavals of land), washing across hundreds or thousands of square miles, and bearing along and scattering vast accumulations of debris far from the parent rocks. This is an assumption without proof. It is also unlikely, and I think impossible, that large debris of this kind could be distributed over so wide an area by the sifting process which Mr. Darwin has shown probably to take place on the east coast of South America, in consequence of movements communicated into deep water during long-continued heavy gales. Neither have they been moved along sea-shores, or subjected to breaker action, like the stones of the Chesil Bank, or of the conglomerate of the Upper New Red Sandstone, all the pebbles of which are true pebbles, spherical or oval, and smoothed by long attrition.

If, then, they were not distributed by any of these agents, there remains but one other means of transport and distribution—the agency of ice.

1st. There is in proof, the great size of many of the fragments,—the largest observed weighing (by a rough estimate) from a half to three-quarters of a ton.

2nd. Their forms. Rounded pebbles are exceedingly rare. They are angular or subangular, and have those flattened sides so peculiarly characteristic of many glacier-fragments in existing moraines, and also of many of the stones of the Pleistocene drifts, and the moraine matter of the Welsh, Highland, Irish, and Vosges glaciers.

3rd. Many of them are highly polished, and others are grooved and finely striated, like the stones of existing Alpine glaciers, and like those of the ancient glaciers of the Vosges, Wales, Ireland, and the Highlands of Scotland; or like many stones in the Pleistocene drift.

It has been said that in any breccia or conglomerate the stones may be scratched. In other ancient breccias I have never observed it; and I think that in the Permian fragments the experienced eye will have no difficulty in recognizing the peculiar characteristics of glacial scratching.

By way of contrast, I exhibit some of the pebbles of the upper new red conglomerate. This subformation has been traced over many hundreds of square miles, from Derby to the shores of the Mersey, and from thence to the neighbourhood of the Abberley Hills. Its component stones are often from 3 to 9 inches in diameter; but, unlike those in the breccias, they are all beautifully rounded; and, where they touch in the rock, they are not scratched, but indent each other at the points of contact; the indentations being, I believe, due to the fact, that, while these gravels were still incoherent (they may be dug out now with pickaxe and shovel) over great areas, the upper parts of the New Red series, the Lias, and perhaps other newer strata, were piled upon them, and the vertical pressure, consequent on this vast superincumbent pile, induced a lateral pressure in the loose-lying pebbles of the conglomerate; so that, being squeezed, not only downwards, but outwards, they ground on each other, and, partly by the aid of intervening grains of sand, circular indentations were formed, sometimes an inch in diameter. Occasional earthquake-waves would assist this process. These marks rarely occur in the Permian breccia; for, whereas in the case of the conglomerates we have sand mingled with the pebbles in the breccias, we find

4th. A hardened cementing mass of red marl, in which the stones are very thickly scattered, and which in some respects may be compared to a red boulder-clay, in so far that both contain angular flat-sided and striated stones and boulders brought from a distance.

I conceive, therefore, that the peculiar forms, polish, and markings of many of the stones indicate that these characteristics have been produced by the agency of ice of the nature of glaciers, for mere coast-ice would have picked up and drifted away numerous rounded pebbles from the beach, and not a great majority of angular flattened stones, such as form the breccias wherever they occur.

If this conclusion be correct, and if the parent rocks whence the stones were derived be properly identified, then it follows that the ancient territory of the Longmynd and the adjacent Lower Silurian rocks, having undergone many mutations, at length gave birth to the glaciers, which, flowing down some old system of valleys, reached the level of the sea, and, breaking off into bergs, floated away to the east and south-east, and deposited their freights of mud, stones, and boulders in the neighbouring Permian seas.

The few fragments of granite and syenite mingled with numerous Longmynd fragments in the Malvern area would not invalidate this conclusion, for what more likely than that the floating bergs should sometimes have stranded on or grazed along some of the higher Malvern hill-tops that, as islands, dotted the Permian Sea, and that they thus picked up a few fragments to be mingled and deposited with the foreign material wherever they chanced to melt?

It is in vain now to look for the terrestrial indications of these old glaciers on the hills and sides of the existing valleys. The country has passed through too many revolutions and denudations in later periods to permit their traces to remain. It may, however, be asked, what relation do the present levels of the Longmynd and of the breccias bear to each other?

The higher points of the Longmynd, Stiper Stones, and Corndon Hill attain a height of from 1500 to 1700 feet above the level of the sea. On the Clent Hills and Bromsgrove Lickey the breccias are from 800 to 900 feet above the sea-level; and on the Abberley and Malvern Ridge they are from 800 to 1000 feet high in their highest positions. In none of the other places where they occur do the breccias reach so great an elevation. There is, therefore, at present no disparity so great between the relative elevations of the Longmynd Range and the breccia as to induce a belief in the probability of icebergs breaking away from glaciers on that old shore and floating in the Permian seas; but it must be recollected that in Britain great disturbances of the strata have taken place since Permian times, and in various places alluded to in this memoir the Permian strata dip at all angles between 6° and 50°, so that their present relative elevations give but little clue to their ancient physical relations. A general tilting upwards of the country to the amount of 1° to the west would raise the Stiper Stones from 1000 to 2000 feet higher above Abberley Hill and Bromsgrove than they are at present; and 2° or 3° would double and treble this difference, and yet make no very sensible change in the relative slopes of the ground. Apart, however, from such speculations of mere tilting, there is one point which may possibly bear upon the subject more directly, although I am not inclined to attach too much value to the circumstance. A great fault lies between the Longmynd and the Breccias on the east. Beginning in the Upper Silurian rocks, near Gladestry in Radnorshire, it passes to the north-east by Presteign, Bucknall, Hopesay, and Church Stretton to Acton Burnell, and from thence to the Severn, where it splits and passes in two branches, one towards Uppington, the other to the west side of the Wrekin, throwing down the Bunter Sandstone on the west for the last ten miles of its course. It is also a downthrow of about 2000 feet on the west near Hopesay, and between Hopesay and Church Stretton it varies from 1500 to 2000 feet.

Affecting all the rocks from the Cambrian to the New Red Sandstone, this dislocation may possibly have had its throw increased at different epochs; but, assuming for the sake of argument that the main throw happened after the close of the Permian period, by annulling the fault, or in other words shifting up the Longmynd on the west to the amount of the throw, we obtain a configuration of the ground by which the relative levels of sea and land might have been greatly modified during the Permian epoch.

This naturally leads to another question. It will be remembered that the Caradoc limestone (immediately underlying the Wenlock or Pentamerus shale) rests directly and unconformably on the Longmynd rocks; and in a former memoir* I showed that, while the Caradoc and Upper Silurian beds were being deposited, the land consisting of the Longmynd and overlying Lower Silurian gradually sank and was encased in a thick coating of all the Upper Silurian rocks; and, seeing that it is partly surrounded by high-lying outliers of Old Red Sandstone, it is more than probable that this formation may have been added to the pile. The Wenlock and Ludlow rocks alone of this neighbourhood attain a thickness of 3000 feet. Now the Permian brecciated

* Quart. Journ. Geol. Soc. vol. iv. p. 296.

fragments being principally formed of Longmynd grits and of the Lower Silurian slates and igneous rocks east of the Stiper Stones, we get an approximation to the date of the denudation of those great masses of strata that once entombed the more ancient palæozoic rocks. In other words, they must, in part at least, have been stripped from the hills that they enveloped before or during the Permian period, otherwise the underlying rocks would not have been reached and degraded by the help of the glaciers.

Objections answered.—There is a common objection not yet exploded that may be raised to the view taken in this paper. I allude to the argument, that, the earth having gradually cooled, by radiation from its circumference, down to a late Secondary, or even Tertiary period, this radiation affected the entire climate of the world, and gave tropical characters to its fauna and flora far down in geologic time. To treat this subject in detail would lead to a discussion too lengthened and elaborate to be introduced as a subordinate part of a memoir the main object of which is simply to explain the origin of what seems to be an ancient boulder-clay; but, as the question of an ancient tropical uniformity of climate is still frequently asserted, it cannot in this place be altogether omitted.

Regarding the palæozoic faunas, many palæontologists are of opinion that there is no ground whatever for attributing to them a tropical character. This was certainly the opinion of our late lamented President, with whom I have often conversed on the subject. Further, the different assemblages of species in equivalent formations in various localities, even in Silurian times, would seem to indicate that the laws of distribution were the same then as now. Neither has it ever appeared to me that the style of reasoning is at all conclusive which asserts that the Secondary faunas were necessarily tropical because of the peculiarities of form. Of late tertiary date there was an age when elephants ranged every latitude from India to the confines of the Arctic Circle. Is there any reason why at an earlier period Ammonites, Belemnites, and great Saurians should not have done the same? What applies to animals may apply to many plants; and, if this be insufficient, we have in the arguments enforced by Sir Charles Lyell respecting different distributions of sea and land good cause for many variations of climate*.

* The greatest difficulty in the case seems to lie in the occurrence of Coal-measure plants in places beyond the Arctic Circle, in Bear Island and the Greenland shores, the loose cellular structure of which plants would seem to indicate that they could neither have been long withdrawn from the stimulus of light, nor yet have endured the long-continued action of frost. (Dr. Hooker, Memoirs of the Geol. Survey, vol. ii. part 2. p. 396.) The whole problem is in many ways obscure, and it is probably a mixed question, some of the elements of which we have not yet got hold of; but it may surely be assumed that the dogma of universal tropical climates dependent on central heat, so far from being proved, is daily losing ground. One argument may be adduced against it, which I think is deserving of attention.

The average melting-point of ordinary lavas is said to be something intermediate between those of silver and copper, or about 1934°. Assuming the increment of internal heat as we descend to average 1° for every 60 feet below the first 60 feet, In connection with this supposed universality of tropical climate, it has been objected that the nature of the Permian fauna and flora affords an argument against the possibility of glaciers existing in Permian times in this area, more especially as the Permian flora succeeds and nearly resembles the flora of the Coal-measures, supposed by many to have a tropical character. To this it may be replied—1st, That there is nothing in the Permian marine fauna essentially tropical, and of the habits of the one solitary *Labyrinthodon* we are altogether ignorant. 2nd, It was the opinion of Dr. Mantell, and has been confirmed by Dr. J. D. Hooker, that the Carboniferous flora indicates, not a tropical, but a moist, equable, and temperate climate*, possibly such as that of New Zealand; in which country, it will be remembered, there are glaciers at the present day in the southern island†. If indeed, after the early stage of growth, the beds of carbonaceous matter that formed coal accumulated in a manner at

the temperature of rocks would rise to the melting-point of lava at 113,100 feet beneath the surface, assuming for these latitudes a constant temperature of 50° at the depth of 60 feet. It does not, however, therefore follow, that they should melt at that depth, for this might be interfered with by pressure; but it may be assumed that under such circumstances the rocks might be considerably altered, if subjected to this high temperature for a great length of time. I attribute, for instance, in some cases, the metamorphism of shales or slates into gneiss to their approaching the sphere of such influences. Now (on the authority of Mr. W. Hopkins, Quart. Journ. Geol. Soc. vol. viii. p. 59), "the present effect of the internal heat is about one-twentieth of a degree" on the mean superficial temperature; but to affect the external climates of the globe 1° Fahr. (namely twenty times the present amount) "the descending rate of increase must have been twenty times as great as at present, about 20° Fahr. for every 60 feet; and, if the superficial temperature were thus raised about 10° Fahr., the temperature at the depth of 60 feet would, according to the same law, exceed 200° Fahr., and all but surface-springs would be springs of boiling-water. This physical state of our planet would scarcely, perhaps, be deemed consistent with the conditions of animal life at the more recent geological epochs." To this conclusion many geologists are steadily arriving; and for many years I have held that internal heat, at least since the formation of the oldest fossiliferous rocks, has not materially modified the climates of the world.

On the foregoing data an argument in favour of this view may be drawn from the rocks themselves. Let us suppose that the external climate was affected by internal heat only 1° Fahr., involving an increment of 20° Fahr. for every 60 feet of descent, then, instead of reaching the equivalent temperature of the surface-melting-point of lava at 113,100 feet beneath the surface, we should reach it at a depth of about 5700 feet; and, were the average surface-temperature increased 10°, we should reach it at a depth of about 580 feet. The thicknesses of many British formations have been determined by the Geological Survey. Thus in North Wales the Barmouth and Harlech grits are about 7000 feet thick without our reaching their base, and 25,000 feet of Lower Silurian strata are conformably superimposed on these, giving a total of 32,000 feet. But, as a rule, the rocks are not highly altered. The slates are cleaved and hardened; but it is only in a few places, where granite or other allied rocks have been intruded into them, that they become so changed as to deserve the title of metamorphic. I have elsewhere shown (Quart. Journ. Geol. Soc. vol. ix. p. 170), that the Welsh igneous bosses that effect this alteration were simply the nuclei or centres of the Lower Silurian volcanos; and in areas removed from these the rocks remain unmetamorphosed; which ought not to have been the case, had the rocks in general attained and long maintained the temperature of melting lava at a depth of only 5700 feet.

* Memoirs of the Geological Survey, vol. ix. part 2. p. 399.

† I derived this information from the late Dr. Mantell, who informed me that he had received descriptions of them from his son.

all analogous to the mode of formation of peat-mosses*, this of itself would form an argument against the tropical character of the carboniferous flora, for peat-moss only grows and largely increases in temperate and cold climates. If these arguments hold good for coal-measure plants, they are equally applicable to those of the Permian period, which are much fewer in number and consist principally of Ferns, *Calamites*, *Coniferæ*, and a few Sea-weeds. Even if the Carboniferous period could be proved to be altogether tropical, a glacial episode in Permian times would not be so remarkable, seeing that the unconformity of the Permian on the Carboniferous rocks is everywhere so great that there is evidently no passage or direct sequence in the strata, and probably between the close of the Carboniferous and the beginning of the Permian epoch a long period elapsed during which our Carboniferous rocks were upheaved above the waters.

In connexion with the nature of the ancient life of the fossiliferous Permian rocks of the North and East of England, a third argument remains, which has even more weight than the former two. The precise relation of the midland Permian beds to the true magnesian limestone series has not yet been completely demonstrated. The Alberbury rocks do not belong, as has been generally supposed, to the true magnesian limestone of Professor Sedgwick, but are formed of a breccia on the same horizon with and strongly resembling that of the Abberleys and South Staffordshire, except that, instead of trap and sandstone, the Abberley fragments are derived from the carboniferous limestone to the north-west. For various reasons I believe that the true magnesian limestone series is higher in the Permian scale than the rocks of the midland counties†, but the question is yet uncertain, the absolute proof being wanting. However this may be, why, considering the evidence adduced, might there not be a glacial episode, marked by a *consolidated* Boulder-clay, during Permian ages, just as we have had one in late Tertiary times, that may be said nearly to approach our own? If the newer Crag, and all the Pleistocene beds of the South and North of England, of Ireland, and Scotland, and the deposits now forming, were thrown far back in time, solidified, and highly disturbed, we should certainly, because of their fauna, include them all in one geological epoch. Uncertain subdivisions might be based on the presence of peculiar mammals, but the shells would be so nearly the same that all geologists would agree in referring them to one period, and possibly even Miocene beds might be included, but as a lower stage. Yet in the midst of this period, and indeed since our existing shells appeared, we have had in these latitudes a rigid arctic climate, with its glaciers, its great moraines, and floating bergs, scattering detritus from the Welsh, Irish, and Highland hills. The thickness of rocks affords no safe test of the time occupied in their accumulation, but sometimes it aids in the rude estimate, and, compared even to the

* See also Lyell's 'Elements,' 1851, p. 335.
† See 'Silurian System.'

midland part of the Permian strata, the Crag and Pleistocene beds are, as masses, sufficiently meagre.

There is one point of resemblance between these Permian breccias with their associated strata and the Pleistocene drift deposits worthy of note. In the latter fossils are much scattered, and in most of the beds of rare occurrence. They are still more scarce in that part of the Permian series with which the breccias are associated. I have thought, that, in like manner, this paucity of life may be connected in these latitudes with the glacial phænomena of the Permian and the Bunter periods, and I no sooner mentioned this to Professor E. Forbes than he suggested that it might also be connected with the great break in life that has taken place between Palæozoic and Secondary times. In connexion with this, in so far as it affects the Bunter rocks, I may state that near Wribbenhall in part of the pebble-beds (of Bunter date) there are breccias strikingly resembling those of Permian strata; and also near Astley, a little S.W. of Stourport, and probably at Alfrick, at the base of the white sandstones there is a recurrence of the same phænomenon. It is possible that these may have been reconstructed from the waste of the older Permian breccias; but when I examined them, I felt more disposed to attribute them to direct glacial action, and now incline to connect them with the passage quoted from Mr. Austen's Memoir, in which he attributes the transport of large blocks in the New Red Sandstone to glacial agency.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

POSTPONED PAPERS.

On the Correlation *of the* Eocene Tertiaries *of* England, France, *and* Belgium. By Joseph Prestwich, Jun., Esq., F.R.S., F.G.S.

[Read June 21, 1854*.]

[Plate VIII.]

Contents.

Part I.—Lower Beds,—the London Group†.

§ 1. *Known foreign Equivalents.*

In a former paper‡ I pointed out the distinctive palæontological and physical features of the London Clay and the Bracklesham Sands. Having on a previous occasion shown that there exists a close analogy

* For the other Communications read at this Evening Meeting, see Quart. Journ. Geol. Soc. vol. x. pp. 454 *et seq.*

† The correlative description of the upper groups is unavoidably deferred to a later period.—J. P.

‡ Quart. Journ. Geol. Soc. vol. x. p. 435.

between the latter deposit and the Calcaire grossier*—a conclusion confirmed and rendered more definite by subsequent observations—and having established the relation which the Tertiaries of London bear to those of Hampshire, the comparison between the main divisions of the London, Hampshire, and Paris groups becomes comparatively easy. At the same time, owing to the absence or obscurity of several intermediate links in the Hampshire group, the exact correlation of each varied member of the more distant groups of Paris and London would not be perfectly clear without the additional assistance of the Belgian Tertiaries, which, as they afford a type in many respects more closely allied than the Hampshire series to the Paris Tertiaries, serve to complete the chain of evidence. This comparison of the Belgian Tertiaries was, as far as the *Lower* divisions are concerned, not practicable until the clear and exact order of superposition established by M. Dumont†, chiefly upon very accurate physical evidence, and confirmed by the important palæontological evidence recently brought forward by Sir Charles Lyell‡, settled the true grouping of these strata§. The lists of fossils from the Lower tertiary beds of Belgium, previous to those drawn up by Sir Charles, and those more recently published by M. Omalius d'Halloy||, were either too erroneous or too incomplete to allow geologists to correlate satisfactorily, upon such grounds, this series with that of France and of England¶.

In this part of the paper I shall confine my observations to those Tertiary beds, which, commencing immediately above the Chalk, are in England limited above by the *Bracklesham Sands*, in France by the *Calcaire grossier*, and in Belgium by the *Système Bruxellien* of Dumont. My object will be to show the more exact correlation of the strata beneath that zone, and to claim for the London Tertiaries, as a group, a distinct and independent position under that of that Paris

* Quart. Journ. Geol. Soc. vol. iii. p. 378.

† Trans. of the Acad. Roy. de Bruxelles, vols. vi. xvi. xviii. 1839–1851.

‡ Quart. Journ. Geol. Soc. vol. viii. p. 277, 1852.

§ The Tertiary palæontology of Belgium had nevertheless received some very valuable contributions in several papers by M. De Koninck, and the larger monograph of M. Nyst; whilst the general geology had been partially illustrated by M. Galeotti and M. Omalius D'Halloy. Sketches of local sections and a few good general sections are much wanted, however, to facilitate the study of the Belgian tertiaries.

|| Abrégé de Géologie, 1853.

¶ One instance occurring at the onset—in the lowest Tertiary beds of Belgium—affected the bearing of the whole sequence; for, by some mistake, in previous works on Belgian Geology, amongst the fossils of the "Tufeau de Lincent," or "Landenien inférieur," a number of Calcaire grossier species, including the *Nummulites lævigatus*, had been introduced; this is now proved to be an error. M. D'Archiac, who has given two most excellent sketches of the relation of the Belgian strata with those of France, had very properly overruled this anomaly, and fixed, with his usual discrimination, the correlation of all the more important and leading middle divisions (Bull. Soc. Géol. de France, vol. x. p. 168, and Hist. des Prog. de la Géol. vol. ii. p. 500). Another step has also recently been made in correlating the higher beds by the evidence brought forward by M. Hébert proving the close relation of the fauna of the Limbourg beds with that of the Grès de Fontainbleau (Bull. Soc. Géol. de France, 2nd ser. vol. vi. p. 459).

group, of which latter the Calcaire grossier may be taken as the centre and the type*. (See Table.)

In France the Calcaire grossier forms so well-marked and definite an horizon, that no difference of opinion exists with reference to its range and characters. The Bracklesham Sands in this country, and the Système Bruxellien in Belgium, are the equivalents of this portion of the French series, and afford a base-line equally well-defined. Between this geological level and the Chalk the strata are very variable. Their relative position in the mass is, however, perfectly apparent; but yet there is in this portion of the French and English tertiary series one division only of which the exact synchronism stands recognized on sufficient combined physical and palæontological evidence, viz. that division formed by the lignites of the Soissonnais and the fluviatile beds of Woolwich and Lewisham†. In France and Belgium, the zone of the *Nummulites planulatus* in the upper part of the Soissonnais Sands and of the Ypresian series forms the only other well-established zoological horizon in these lower beds. On stratigraphical grounds the Ypresian Clay of Belgium had also been referred by M. Dumont to the London Clay.

§ 2. *Grouping of the Lower Tertiary strata in France, Belgium, and England.* (See Table.)

In the Paris district the strata beneath the Calcaire grossier have been variously grouped. By M. D'Archiac‡, in his very able classification of the French series, they have been all (with the exception of the Glauconie grossière) included in one group—that of his "Sables Inférieurs," or Lower Tertiary Sands—consisting of six members, which in his latest work, the "Histoire des Progrès de la Géologie," (vol. ii. p. 598) stand as under, commencing with the uppermost division:—

Group of the "Sables Inférieurs" (D'Archiac).

1er Étage. Glaises et sables glauconieux (Clays and glauconiferous sands).
2 „ Lits coquilliers (Shell beds).
3 „ Sables divers ou Glauconie moyenne (Varied Sands or middle Glauconite).
4 „ Grès, poudingues, et sables coquilliers (Sandstones, puddingstones, and shelly sands).
5 „ Glaises sableuses, Bancs d'Huîtres, etc., marnes lacustres, lignite, argile plastique (Sandy clays, oyster beds, lacustrine marls, lignite, *plastic clay*).
6 „ Glauconie inférieure, Calcaire lacustre inférieur, poudingues et argiles du sud-est du bassin (Lower Glauconite, lower lacustrine limestone, conglomerates and clays of the south-east of the basin).

This series is only fully exhibited in the more northern part of the Paris tertiary district. This, however, is the area with which, as it is the nearest to England, we must first establish our relations.

* See also Sir Charles Lyell's and M. Dumont's tables in Quart. Journ. Geol. Soc. vol. viii. pp. 279 and 370, 1852.

† With which, as suggested by M. Dumont, the Upper Landenian is synchronous.

‡ 1839, Bull. Soc. Géol. vol. x. p. 172; 1840, Mém. Soc. Géol. de France, 2nd ser. vol. v. p. 263; 1848, Hist. des Prog. de la Géol. vol. ii. p. 598.

M. Graves* not only includes the "Sables glauconieux and Lits coquilliers" in this lowest group of Sables Inférieurs, but also the overlying "Glauconie grossière" (which M. D'Archiac places with the "Calcaire grossier"), making of this latter division, together with the 1st, 2nd, and 3rd of D'Archiac, one group; and forming a second of the divisions 4, 5, and 6 of D'Archiac. These he designates as the two "Groupes des Sables glauconieux."

M. Raulin†, on the contrary, takes the "Glauconie grossière" and the "Lits coquilliers" out of this group, and classes both as subordinate members of the Calcaire grossier.

M. Charles D'Orbigny, in his "Tableau Général," also makes two groups of these lower French Tertiaries,—1st. "Sables quartzeux glauconifères" (divisions 1, 2, and 3 of M. D'Archiac); 2nd. "Argile Plastique;" but in a work‡ more recently edited by him, these are further subdivided into—1st. An upper group, consisting of,—Glauconiferous sands; sands, sandstones, and pebble beds; lignites, plastic clay, and fossiliferous conglomerates. 2nd. A lower one of the lower lacustrine limestone and quartzose sands.

M. Alcide D'Orbigny, who considers that the variation of the fauna of all this period results only from variations in the depth and saltness of the waters, forms of these six divisions his "Étage Suessonien ou Nummulitique§",—his oldest Tertiary group.

In Belgium, M. Dumont divides the lower Tertiaries into his "Upper and Lower Ypresian," and "Upper and Lower Landenian" Systems; whilst Sir Charles Lyell, combining and modifying the classification of Dumont, Omalius D'Halloy, and D'Archiac, groups them into Lower Nummulitic beds, London clay, Plastic clay and sands, Glauconite and Tufeau of Lincent, and Marls and Glauconite of Heers.

In England I have placed the Lower Bagshot Sands at the base of the Bracklesham series; then, in descending order, the "London clay," the "Basement-bed of the London clay," the "Woolwich and Reading series," and the "Thanet Sands."

It is curious and instructive to observe how, in each country, the grouping of these lesser divisions of the Tertiary series has been based upon local conditions. This is probably right and necessary in establishing a local order of superposition, but it shows also how much local phænomena will modify, even at short distances, the apparent relations which exist in nearly allied and synchronous strata; for it is on some actual predominating feature in the several districts that the various groupings are based. Thus I have, from the recurrence of like lithological characters and in the absence of palæontological evidence, referred the Lower Bagshot Sands to a subordinate position with the Bracklesham series; whilst, both from organic remains and structure, the London clay is referred to a

* Essai sur la Topographie Géognostique du Département de l'Oise, 1847, p. 174; an excellent local work to which we shall have constantly to refer.

† "Patria," 1847, vol. i. p. 370.

‡ Manuel de Géologie, 1852, p. 86 and 171.

§ "Cours Élémentaire de Paléontologie et de Géologie," vol. ii. p. 704. and 713.

division apart, but nearly allied to the three underlying subdivisions of "the Lower London Tertiaries." In Belgium, on the contrary, M. Dumont, on physical evidence, unites into one group the sands and clays of Ypres; and forms a second group of the beds beneath, dividing it into the Upper and Lower Landenian; whilst Sir Charles Lyell, mainly on the evidence of the organic remains, places the Ypresian Sands at the base of his middle Eocene group; the Ypresian clays and the upper Landenian in his lower Eocene group; and the lower Landenian in a separate intermediate group between the Tertiaries and the Chalk. In France the constant recurrence of very similar mineral characters in all the strata beneath the Calcaire grossier has rendered the division of this part of the Tertiary series rather unsettled and difficult of exact determination. So much is this the case, that M. D'Archiac observes *, that "where the 'Lits coquilliers' are wanting, there is no mode of separating the third member of the 'Sables Inférieurs' from the first, and that at those places where the sandstones, or even the lignites, with their beds of clay and oysters do not exist, there is no distinction to be seen between these sands of the third division and the Glauconie inférieure." M. Graves also states †, that "as the division into series of the 'Sables glauconieux' is entirely artificial, when the fossils are wanting at the same time as the lignites and sandstones, all distinction ceases, and the beds of sand continue uninterruptedly from the Chalk to the Calcaire grossier, without the possibility of distinguishing any divisions."

It was this unbroken sequence which before caused me to hesitate in assigning to the London clay its exact parallel in the French series. From the close agreement of the Calcaire grossier with the Bracklesham sands, I felt no doubt of the infraposition of the London clay to the former deposit, whilst, from the agreement of the Woolwich fluviatile beds with the lignites of the Soissonnais, I was satisfied of its superposition to the latter deposit. But then in France the beds beneath the Calcaire grossier were in perfect sequence, and showed no break. Therefore, if we looked only to the limits afforded by these two undoubtedly good geological horizons, the London clay in England held exactly the place occupied in France by the "Lits coquilliers" and associated sands (Ét. 1, 2, 3, D'Arch.). But the fossils of the latter presented a far closer agreement with those of the Calcaire grossier than with those of the London clay, although the number of known species common to these beds and the London clay appeared at that time larger than that of any other member of the English series. Consequently, though I considered the London clay to be more closely connected with the Lits coquilliers than with the Calcaire grossier, with which it had previously been associated, I stated ‡, that "possibly the London Clay may have been formed during a period not represented, or only very partially so, in the French series;" and further remarked, that I was inclined "to consider that the London clay period immediately preceded that of the

* Hist. des Prog. de la Géol. vol. ii. p. 604. † Op. cit. p. 257.

‡ Quart. Journ. Geol. Soc. vol. iii. pp. 376–7, *note*.

'Lits coquilliers;'—that it synchronises with some of the older portions of the Sables inférieurs" (of M. D'Archiac):—a view in which I am now confirmed so far as regards the higher antiquity of the London Clay, but which deposit I however now consider not to be exactly represented by any synchronous strata in the Paris district.

This instance of the intercalation of a large and important deposit in England, where in France the sequence of the Lower Tertiaries is so well maintained that there is no appearance of any link missing, is a very remarkable one. Both M. D'Archiac and M. Graves have, as mentioned above, particularly noticed the perfect sequence of the beds from the chalk to the Calcaire grossier, and I can bear testimony to the same fact. Lithological structure and superposition seem to indicate a complete and perfect series, whilst it would appear that the organic remains have not been considered to present any sufficient differences to militate against this view. It would nevertheless seem that there is a very important interval between the "Lignites of the Soissonnais" and the "Lits coquilliers," and that, at so short a distance as from Kent to the Department of the Oise, there is introduced, wedge-shaped, between these two deposits, the large mass of the London clay with its multitude of original organic remains. Yet there is not only no evidence either of the great lapse of time, or of the important physical changes which such a formation indicates, but there is even no cause for suspicion of such a fact in the apparently complete and continuous series of the "Sables inférieurs" of the north of France.

§ 3. *Correlation of the several Divisions of the Lower Tertiaries.— The Thanet Sands, and Landenien inférieur.*

To prove the foregoing position I will now state my reasons for the correlation I propose to assign to each member of the Lower Tertiaries of England, France, and Belgium, commencing with the lowest, viz. the "Thanet Sands." This deposit ranges through that part of the North of France which geologically forms a portion of the Belgian Tertiary district. At the Artesian well of Calais it is, as far as I could judge from the few specimens preserved in the museum of that town, about 80 feet thick, or about the same as on the opposite coast of Kent. Between Watten and St. Omer the Lower Tertiary Sands crop out from beneath the London clay, and the Thanet Sands reappear with characters closely analogous to those which they present near Canterbury. During a hasty visit to that district, I found in some semi-indurated beds numerous impressions of shells, amongst which I recognised the *Thracia oblata*, the small *Corbula* common at Pegwell Bay, and traces of the same *Pholadomya*, *Panopæa*, and *Cyprina*.

In the neighbourhood of Lille, M. A. Meugy * describes a series of beds overlying the Chalk, and consisting of variable strata, from 15 to 105 feet thick, of dark grey or blackish sandy clay more or less glauconiferous, fine sands, and semi-indurated calcareous marls, with marine shells. These are precisely the characters the Thanet Sands

* Essai de Géologie pratique sur la Flandre Française, Lille 1852, pp. 117–126.

have assumed in East Kent; at Pegwell Bay, for example, many of the lower beds are unusually argillaceous, and of a dark grey colour—some are fossiliferous, others without a trace of a fossil. M. Meugy states that the strata in many places contain marine shells, but, with one exception (*Cyprina planata* [*Morrisii*?]), he gives the genera only, and not the species. Sir Charles Lyell, however, who has also examined part of this district, states that at Carvin near Lille the *Cyprina Morrisii* abounds and that imperfect casts of a *Turritella, Arca,* and *Corbula* occur*. Further, these beds are considered by M. Meugy as the continuation of the Lower Landenian series of Belgium.

In Belgium this character of these beds is but little modified; but the fossils have been better determined, and form a fauna closely agreeing with that of the Thanet Sands. I have found at Tournay and Mons, fossils which I have identified with those of East Kent, though they are not quite so numerous or varied. The occurrence, however, amongst these few of such species as the

Astarte tenera, *Mor.* (*A. inæquilatera*, Nyst.)	Pholadomya cuneata, *Sow.*
Cucullæa crassatina, *Lam.*	—— Koninckii, *Nyst.*
Panopæa granulata, *Mor.*	Cyprina Morrisii, *Sow.*

combined with the general resemblance in mineral characters, development, and superposition, confirms me in the belief that the same deposit occupies the same position at the base of the Tertiary series in both countries†. M. Dumont, from an examination of the lithological structure of the beds overlying the Chalk at Chiselhurst and Woolwich, had before come to the conclusion that these Lower Tertiary Sands are of the same age as those in Belgium—that they are the equivalents of the lower division of his Landenian system.

I have not been able satisfactorily to recognise the Thanet Sands in the Paris Tertiary district; but, from the frequent difficulty, even in this country, of distinguishing this division from the one next above it,—for the lithological characters of the two are often almost identical,—it would be impossible to say, in the absence of sufficient organic remains, whether some portion of the Glauconie inférieure of M. D'Archiac should not be referred to the Thanet Sands period. This Glauconite forms the base of the Tertiary series in the more northern portion of the Paris basin, and detached outliers of it are common on the chalk hills which separate the Paris and Belgian Tertiary areas. It rarely exceeds 20 to 30 feet in thickness. M. D'Archiac notices the constancy of its characters and the rarity of organic remains, the only fossils he has been able to detect being casts of some marine bivalves, referred to the *Cyprina scutellaria*, Desh., *Serpula,* casts of a species of Sponge (*Spongia nidus-avis,* D'Arch.), bones of *Emydes*

* Quart. Journ. Geol. Soc. vol. viii. p. 360.

† M. Omalius d'Halloy in his last work, with which I have but just become acquainted, gives a corrected list of these fossils amounting to 14 species. Of these, besides those quoted in the text, the *Nucula fragilis* also occurs in the Thanet Sands, the *Scalaria Dumontiana* of Nyst is probably the *S. Bowerbankii* of Morris, and the *Panopæa intermedia*, Sow., the *P. granulata*, Mor. The *Leda, Cytherea, Arca, Pinna,* and *Modiola* will also, I think, prove to be species common to both countries. The list of fossils from these beds is, however, yet far from complete.—J. P., Jun., April 1855.

and of the *Palæocion primævus*. M. D'Archiac himself* refers these beds to the Lower Landenian of Mons and Ciply, but their lithological structure will answer equally well for the lower part of the upper or next division, whilst their general structure and the character of the few fossils here named incline me to place them generally in a rather higher position. Still it is quite possible that some beds of the Thanet Sands may stretch as far south as some parts of the Department of the Aisne—further than the London Clay, but not so far as the next division of the Lower Tertiary Sands, with which, owing to the want of distinctive characters, they might naturally enough be associated. (See Pl. VIII., Diagram, str. *g* and *h*.)

§ 4. *The Woolwich Sands*† (*lower part of*), *and Sables de Bracheux.*

In parallellising another portion of the French series, well developed in parts of the departments of the Oise, Aisne, and Marne, a difference of opinion as to its exact position renders it necessary to go into this part of the inquiry separately and in greater detail. I allude to those occasionally fossiliferous sands, of which the well-known sections and fossils at Bracheux, Abbecourt, and Noailles, near Beauvais, have been taken as the type. The superposition of these beds is not at first sight very apparent‡. By M. D'Archiac they were originally considered sychronous with the Glauconie inférieure and to underlie the Lignites and Argile plastique, and that view is taken by M. Graves and M. Hébert. From the general absence of fossils, however, with the few exceptions named above, and some later observations showing that in some places a bed of sand with *Pectunculus, Nucula, Cardium*, &c., overlies the lignites, M. D'Archiac separates the Glauconie inférieure from the marine sands of Beauvais, leaving the former beneath the lignites, but placing the latter above them. The lower marine sands of the neighbourhood of Rheims and Laon have in consequence likewise been referred by M. D'Archiac to a position over the lignites; by M. Melleville the lignites are considered subordinate to the sands; and by M. Hébert the lignites are placed above these sands.

There is further at a few places in Champagne another deposit, local in its nature, but of much interest from the peculiar group of land and freshwater shells which it contains, viz. the calcareous marls, or concretionary travertin, of Rilly. At this spot these marls repose upon a mass of remarkably pure and white quartzose sands. The infraposition of these various beds to the lignites was proved by M. Charles d'Orbigny, but their exact geological relations were not shown. M. D'Archiac considers these sands to be the equivalents of his Glauconie inférieure, and therefore older than the marine sands of Beauvais. M. Hébert refers both the marls and the sands to a

* Considering the fossiliferous sands of Beauvais to belong to a higher part of the series.

† Or the Woolwich and Reading series.

‡ As, in the *massif* of the Tertiaries, these strata crop out usually at the base of steep slopes, they are generally covered by earth and debris, and therefore are rarely exposed in good or continuous sections.

period anterior to any other of the French Tertiaries, and consequently preceding the Glauconie inférieure. He regards them both as formed in a large freshwater lake, the deposits of which were, with the exception of a few isolated masses, swept away by an irruption of that sea in which the marine sands of Laon, Rheims, and Beauvais were accumulated, and by which sands they are now, as it were, incased. In a paper communicated last year to the Geological Society of France, I have endeavoured to show that, on the contrary, these sands of Rilly are independent of the marls which overlie them, that they contain marine shells, and that they are, in fact, but part of the marine sands of Rheims and Laon which stretch around them on the same level; the difference of mineral character, and the absence of shells, except as casts, being attributable to the infiltration of limpid fresh water, charged with carbonic acid, which deposited the overlying tufaceous marls or travertin*.

Although on the whole we have not in England so full and varied a development of organic remains in the Lower Tertiaries as prevails in France, there are nevertheless some phænomena, which I have had occasion to observe in the Lower London Tertiaries, which may tend to throw light upon these differences of opinion; and, taken together with the facts presented by the French series, may prove sufficient to establish the order of superposition and the correlation of the different beds.

In England next above the Thanet Sands we have the complicated series of Woolwich and Reading. In the Isle of Wight it consists almost entirely of pure tenacious mottled clays, which range to the neighbourhood of London; but, as they approach this centre, they become more and more interstratified with beds of sand and pebbles, until at last these latter entirely replace the clays. With very few exceptions the only fossil shell found westward of the vicinity of London is the *Ostrea Bellovacina,* which occurs at places at the base of the clays. In the neighbourhood of London, the Fluviatile beds of Woolwich distinctly set in in the midst of this deposit with the mottled clays both above and below them, and the whole mass becomes pervaded with a fluviatile and æstuarine fauna. Proceeding further eastward these mineral characters undergo a further change; the clays die out, and, with the exception of occasional pebbly bands, the strata pass into a mass of white and greenish quartzose sands; while at the same time the estuarine and fluviatile fauna gradually disappears and is replaced by a marine one. It is, however, not until we reach the N.E. of Kent that this change is effected; and even then the fossils are very rare, preserved as it were by accident, for the calcareous matter of the shells has almost always been dissolved out, and it is only in some few places, where siliceous casts have occupied the produced cavities, that evidence of this marine fauna exists†. (See Pl. VIII., Diagram, str. *a*, *e*, and *f*.)

* Bull. Soc. Géol. de France, 2nd Ser., vol. x. p. 300. M. Hébert has since replied to these observations, and maintains his original views. He has also noted some new localities, Bull. vol. x. p. 436.

† For particulars of the changes in the structure and organic remains of this series, see Quart. Journ. Geol. Soc., vol. x. p. 75–170.

It is more particularly in the lower part of this division, or that portion of it characterized by the *Ostrea Bellovacina* (Reading and London), that this development of marine forms occurs. Fortunately the fossils, though few, are characteristic, and sufficient to establish a very marked analogy with the fauna of the sands of Bracheux. It is to this part of the Lower London Tertiaries that I would also refer the lower marine sands of Laon, Rheims, and the sands underlying the travertin of Rilly. In the first place the general relation of these beds of sand to the lignites and fluviatile beds is everywhere the same both in England and France. In East Kent they form, as before said, the lower part of the group which passes at Woolwich under the clays with *Cyrena, Melanopsis, Paludina,* &c.; and it is precisely in the same position that they occur in the Beauvais and Champagne districts, for there also they clearly underlie beds of fluviatile clays and lignites. Neither is there any discordance in the mineral characters. In East Kent the sands are quartzose, sometimes nearly white, and at others much mixed with green sand with a few flint pebbles. In the Beauvais district they also consist of a base of whitish quartzose sand, more or less mixed with grains of green sand, occasionally coloured in parts by the oxide of iron, and likewise containing some flint pebbles; they there merely exhibit in addition slight traces of carbonate of lime. As the sands range into Champagne, they become rather finer, the green particles fewer, and therefore the mass is often formed of a nearly pure white quartzose sand, especially where it has been subjected to the washing process which accompanied the deposition of the Rilly travertin, wherever that bed overlies the sands. In addition to these common mineral and palæontological features, there is a common physical feature maintained throughout their range, one of no importance separately, but of some value conjointly, viz. the presence of rounded and much-worn flint pebbles sometimes scantily scattered through these sands, at other times arranged in bands, chiefly at their base. (Diagram, str. *e, f, n.*)

The fossils are dispersed, as in the English series, in patches, and rarely form continuous or widely-extended bands. The lists of organic remains given by M. Graves* and M. Melleville† enable us now to compare the fauna of the Beauvais and Champagne sands‡ with that of the Woolwich Sands of East Kent. I should observe, however, that in this country these organic remains are far from being worked out so fully as in France, for, with the exception of the collection made by Mr. Layton and myself at Richborough, and by myself at Herne Bay and Oakwell, no fossil-examination of these beds has taken place; at the same time their limited development under marine conditions in England, and their peculiar mineral characters,

* *Op. cit.* p. 196.

† "Mémoire sur les Sables Tertiaires inférieurs du Bassin de Paris." (Annales des Sciences géologiques, vol. xi. 1845, p. 9–13.)

‡ M. Rondot also gives a list of some of the characteristic species ("Étude Géologique du Pays de Rheims," Ann. de l'Acad. de Reims, année 1842–43). M. Hébert makes a further addition to the Rheims fauna, and states that the number given in M. Melleville's list is far from being complete (Bull. Soc. Géol. 2nd Ser. vol. vi. p. 729–730).

almost preclude us from hoping to find in them a fauna equally abundant with that of the presumed synchronous series in France. In the neighbourhood of London, where however estuarine conditions prevail, the organic remains have been the object of earlier and more continuous research, and the lists of these fossils are therefore fuller and more satisfactory.

In East Kent the number of marine species hitherto determined from the Woolwich and Reading series amounts to fifteen. Limited as is this fauna, it is very characteristic. Seven of the species are likewise found in the lower sands of the neighbourhood of Beauvais and of Rheims. These are the,—

Cardium Plumsteadiense, *Sow.* (*C. semigranulosum*, Sow. of Graves.)
Corbula Regulbiensis, *Mor.* (*C. longirostris*, Desh. of Graves.)
Cucullæa crassatina, *Lam.*
Cyprina scutellaria, *Desh.*
Cytherea Bellovacina, *Desh.*
Pectunculus terebratularis, *Lam.* (*P. brevirostris*, & *P. Plumsteadiensis*, Sow.)
Teredina personata, *Desh.*

Of the other eight species, four (the *Cardium Laytoni*, *Glycimeris Rutupiensis*, *Sanguinolaria Edwardsii*, and *Ampullaria subdepressa*) being new, and but recently described, have not yet been compared with foreign specimens; the *Corbula Arnouldii?* occurs in the lignites near Rheims; the *Teredo antenautæ* may probably prove a variety of the *Teredina personata*; so that there are only two of the older-known described species (the *Thracia oblata* and *Cyprina Morrisii*) which have not yet been quoted in the French lists*.

The seven species common to the two countries are precisely those which are amongst the most characteristic fossils of the lower sands of the Beauvais district, as they are of the Woolwich Sands of East Kent.

As before mentioned, the Woolwich and Reading beds present, in their western area, an evidently continuous and unbroken series of like sands and mottled clays from top to bottom; but, as they range by the neighbourhood of London, the fluviatile and freshwater clays and lignites of Woolwich and Lewisham, set in in the midst of this series, dividing it into three divisions. The lower one consists of sands and pebbles; the middle, of clays; whilst in the upper one, sands again predominate. As they trend eastward, the central division thins out, and the upper and lower beds of sand blend and form an indivisible series. The lower division, with marine shells, of East Kent contains in West Kent a few æstuarine shells only; whereas the upper division, in the neighbourhood of Woolwich and Bromley, has a rich fluviatile and æstuarine fauna, with also some marine shells; but as the fresh and brackish water fossils are of identical species in the three divisions, I consider them, notwithstanding the occasional and exceptional presence of marine forms, as forming only one group. Taking now, therefore, the Woolwich series of West Kent in its entirety, we will first examine how far its

* Both, however, have been figured since the publication of M. Graves's and M. Melleville's lists.

organic remains agree with species found in the sands of Bracheux and Rheims, and afterwards consider the relation they bear to those of the "Lignites" of the Soissonnais.

The number of described species in the immediate district of Woolwich* is forty-two, of which the following nineteen are found also in the above-named sands in France.

Arca depressa, *Sow.* (*A. striatularis*, Mell. ?)
Cardium Plumsteadiense, *Sow.*
Corbula Regulbiensis, var. *β*, *Mor.*†
Cyrena cuneiformis, *Fér.*
—— intermedia, *Mell.*
Nucula fragilis, *Desh.*
Ostrea Bellovacina, *Desh.*
—— tenera, *Sow.* (*O. angusta*, Desh. ?)
Pectunculus terebratularis, *Lam.*
Teredina personata, *Desh.*
Buccinum fissuratum, *Desh.* ?
Calyptræa trochiformis, *Lam.*
Cerithium variabile, *Desh.*
Fusus latus, *Sow.* (*F. deceptus*, Desh. ?)
—— planicostatus, *Mell.* ?
Melania inquinata, *Def.*
Melanopsis buccinoides, *Desh.*
Neritina pisiformis, *Fér.* ?
—— vicina, *Mell.* ?

Of the other twenty-three species, fourteen are new; and, as there are still many undetermined species from the Bracheux and Rheims sands, it remains to be seen how many of these new forms may be identified upon a more thorough examination. Deducting these fourteen species, there is a remainder of nine, eight of which, although not occurring in the marine beds of Bracheux, exist nevertheless in those fluviatile and freshwater beds (lignite series of the Soissonnais) which I believe to be subordinate to these sands.

Viewing, therefore, the Woolwich and Reading fauna as a whole, and striking out the newly described species and the more freshwater forms which belong to the subordinate lignites, we have twenty-nine estuarine and marine species. Out of this number twenty-two are found in the sands of Bracheux and Rheims,—evidence which, allowing for variations produced by geographical distribution, I take as strongly conclusive of the correlation of these two groups in the Paris and London tertiary districts.

§ 5. *Middle beds of the Woolwich and Reading Series,—the Fluviatile Clays and Lignites; "Lignites du Soissonnais."*

Extending over a very small portion of the area of the Woolwich and Reading series, but more largely developed in France, are certain well-marked beds of clay with occasional lignites, characterized by a well-known freshwater and fluviatile fauna. These beds have been generally considered by continental geologists as distinct from the lower marine sands of Bracheux and Rheims; but if I am right in correlating these sands with the lower part of the Woolwich and Reading series, then, as we have in this country throughout the

* Those with "C" attached in my former paper. As that list can be readily referred to, I do not give it again here. See Quart. Journ. Geol. Soc. vol. x. p. 117; see also further on, p. 219.

† This species is, I believe, identical with the Bracheux *Corbula*, described as *C. longirostris*, Desh.,—a name at present restricted to the Fontainebleau species, from which the one from Bracheux is now known to differ. There is an undescribed *Dentalium* in the two deposits which also seems identical.

depth of that series common physical characters, common mineral structure, and common fossils, showing an intimate relation of conditions throughout the whole period, I cannot but consider that in France likewise, notwithstanding less blending of the several parts, the lignites of the Soissonnais and fluviatile clays are, with the mottled clays, subordinate to an equivalent but more largely developed mass of marine sands. Where the organisms of two groups of strata are so different as they necessarily must be in these marine sands and the overlying fluviatile clays, an apparent distinctiveness is produced by the difference of conditions, the reality of which can only be tested by a recurrence to like terms of comparison.

In this country we have seen that the marine sands pass horizontally into estuarine sands underlying the fluviatile clays; that estuarine and marine sands, with a group of shells identical with those descending into the clays and underlying sands, occur above these fluviatile clays; whilst the whole of these three subdivisions pass further westward into one undistinguishable series of unfossiliferous mottled clays and subordinate sands. Now, in examining closely the French series, somewhat similar phænomena are apparent. M. Graves has noticed in several places the occurrence of sands with marine shells over the lignites of the Soissonnais; and so marked is this feature at Varesne and St. Sauveur near Pont St. Maxence, that M. d'Archiac, looking at these beds as the equivalent of the marine sands at Bracheux, has on this evidence been inclined of late to place these latter above the lignites, contrary to the view he first took of their superposition, and which I believe to be the correct one*. The occurrence of 9 to 10 feet of sand, with marine shells, such as *Pectunculus terebratularis, Ostrea Bellovacina, Nucula, Cardium, Venericardia, Cerithium,* and also the *Cyrena cuneiformis,* in a similar position, has been noticed at several other places in the departments of the Somme, Oise, and Aisne†. Although the fossils of these beds have not been thoroughly examined, the notices given of them, and the few I have seen, lead me to believe that they are of the same species as those found in the Bracheux sands, and consequently that we have, in these beds overlying the fluviatile clays, a repetition of marine conditions such (but to a less extent) as prevailed before the intercalation of the subordinate clays; these latter appearing therefore, as in England, in the light of a temporary and local accumulation of river or lagune sediment spread over ground from which the sea had partially retired, but which at a later epoch it again invaded.

Wherever the fluviatile, estuarine, and marine conditions of this division of the Lower Tertiaries (4, 5, & 6 (part?), D'Archiac) are in full force, there the mottled clay (the true *argile plastique* of the French geologists) ceases altogether or in greater part. In the neighbourhood of Paris, the lignites and fluviatile beds form occasional bands ("fausses glaises") overlying the "Plastic Clay." This order of superposition—that the Plastic Clay forms the base of the

* 1839, Bull. vol. x. p. 172. See also further on, p. 245, for section at Coivrel.
† See Top. Géog. du Dép. de l'Oise, p. 234; section of the Lagny pit, p. 211, and mention of sandstone blocks at Louvetain, p. 224.

Tertiaries, and underlies the Lignites of the Soissonnais—has been considered definite. (See Pl. VIII., Diagram, str. *l, m, n, o.*)

But there seems to be some evidence in France, as in England, that the lignites alternate occasionally with the mottled clays, and that fluviatile clays with the *Cyrena*, &c. are sometimes found under beds of these clays, although the occurrence of such phænomena abroad is much less frequent and distinct than it is here. Nevertheless some such instances may be detected in the works of M. Buteux and of M. Graves, notwithstanding that the impression of the authors seems to be that the true "argile plastique" always underlies the lignite and fluviatile clays, and the evidence to the contrary is certainly scant. The former author, however, gives one distinct section at Marché-le-Pot, where four beds of variously coloured (mostly red, and with pebbles in one bed) plastic clay, together 9 to 15 feet thick, *overlie* 3 feet of Lignites with bands of other clays; the sections also at Mont Soufflard, Lihons, and Hallu show an apparent intermixing of lignites, mottled clays, and pebble beds, in one place (Hallu) overlying sands with *Cyrena* and *Cerithium* *.

M. Graves gives a section at Bonvillers, where 7 feet of well-marked mottled *red and purple* clay overlie clays with *Cyrena, Ostrea*, &c. and lignites. At Canly also, 9½ feet of *plastic clay* reposes on freshwater clays and lignites; and at Coivrel the shells seem sometimes to be imbedded in mottled clays †. (See also p. 245-7.)

With reference now to the organic remains of the fluviatile clays and lignites considered apart, the evidence of the synchronism of the French and English series has, as before mentioned, been often observed upon and appears well founded. In the London district, the group of shelly clays, sands, and pebble beds, with lignites, of Blackheath, Woolwich, New Cross, and Lewisham contain forty-two species of mollusks, the following eighteen of which are also found in the lignites of the Oise and the Soissonnais:—

Arca depressa, *Sow.*
*Cyrena cuneiformis, *Fér.*
—— tellinella, *Desh.*
Nucula fragilis, *Desh.*
*Ostrea Bellovacina, *Desh.*
—— tenera, *Sow.*
Pectunculus terebratularis, *Lam.*
Teredina personata, *Desh.*
Unio Deshayesii, *Wat.*
*Cerithium variabile, *Desh.*
*Melania inquinata, *Desh.*
*Melanopsis buccinoides, *Fér.*
—— ancillaroides, *Desh.*
Neritina consobrina, *Fér.*
—— globulus, *Defr.*
—— pisiformis, *Fér.*
Paludina lenta, *Sow.*
Planorbis lævigatus, *Desh.*

Those marked with an asterisk abound in both countries.

Of the remaining twenty-two, the following eight are met with in the Lower Sands of Bracheux or of Rheims:—

Cardium Plumsteadiense, *Sow.*
Corbula Regulbiensis, *Mor.*
Cyrena intermedia, *Mell.*
Buccinum fissuratum, *Desh.*
Calyptræa trochiformis, *Lam.*
Fusus latus, *Sow.*
—— planicostatus, *Mell.*
Neritina vicina, *Mell.* ?

* Géol. du Département de la Somme, pp. 49, 33, & 47.

† There are other indications in M. Graves's monograph, as well as in that of M. Buteux, which would lead me to believe that the term "argile plastique" might be more frequently applied to some of the overlying clays. *Op. cit.* pp. 250, 239, & 244. That the name is not applied, or that they are referred to drift or "remanied" beds, is not sufficient.

This shows a total of twenty-six out of the forty-two species of our English species as common in the lignites or in the lower sands of the French series. Of the other sixteen, ten are new and rare species, which have not yet been made the object of research and comparison in the French beds*.

Taking therefore the fact of the recurrence of marine fossils above similar to those beneath the lignites and fluviatile clays, and seeing the alternation of the mottled clays with the fossiliferous beds, I think that we should place them all in one group, identical as a whole, howsoever variable at places, in mineral and palæontological characters; and that even in all the subdivisions of this portion of the French and English series, there is a far closer correlation than could at first sight have been anticipated. As a whole, the total number of mollusks belonging to the Woolwich series, including the marine beds of East Kent, amounts to fifty-three species, thirty-four of which are common also to the lignites of the Soissonnais and associated fossiliferous sands.

In French Flanders and Belgium, all this series presents, as it were, a sort of neutral ground. Neither the great mass of the mottled clays nor the fluviatile shelly clays exist†, but the sands of East Kent and the north of France, in their unfossiliferous condition, prevail exclusively; the only organic remains mentioned by M. Dumont and M. Meugy (and they under the circumstances are not unimportant) being a few traces of lignite. Still the general character of these sands, and their superposition on the lower Landenian or the Thanet sands, leave but little doubt of their correlation with the Woolwich and Reading series. (See Pl. VIII., Diagram, str. *i*, *j*.)

§ 6. *The Pebble beds; Grès, Poudingues, and Sables* (*D'Archiac*).

We now come to a point where more obscurity prevails in the correlation of the French and English series. The sections of the Lower Tertiaries forming the connecting links between the Paris and London Tertiary districts are chiefly met with in mere isolated patches and detached outliers on the extensive chalk plains of Picardy. Consequently, as the series is very variable, and the sections are not continuous, great dissimilarity in the smaller details exists between the several sections, and the correlation of their various subdivisions is frequently far from apparent. Thus, on some of the hills in this extensively denuded district, there are large outlying masses of mottled

* The greater and more distinctive development in the Paris basin of both the marine and freshwater series has given to each a far larger fauna than we possess in this country; for, besides the species named above as common to the Lignites and Plastic Clay, there are twenty-seven other species not found here, whilst in the lower sands of Rheims and Bracheux there are also about eighty species unknown in the Woolwich and Reading Series. We can only compare, however, the known forms, and refer the greater profusion of life at that period in the French area to the more exclusive and fuller prevalence of marine and freshwater conditions respectively. Those species which are common to the two countries are, however, generally speaking, amongst the most characteristic in each.

† It is possible that some rudiments of these are to be traced. (For some sections of this series, see further on, p. 243.)

clays and lignites, or else large accumulations of flint-pebbles, whilst another not uncommon feature is the occurrence of great blocks of sandstone, often disturbed, but hardly removed out of place, and enveloped in a drift-clay. These blocks occasionally contain casts of *Pectunculus, Cardium, Cucullæa, Nucula, Venericardia, Cyrena, Cerithium** ; often also they enclose round flint-pebbles and pass into pudding-stones. (See Pl. VIII., Diagram, str. *k, l.*)

M. d'Archiac describes these beds, in the Department of the Aisne, as overlying the lignites, and M. Graves assigns to them the same position in the Oise; but the exact relation of the associated great shingle banks, without fossils, does not appear very distinct. Are they merely large lenticular masses intercalated in the fourth division of M. d'Archiac, and forming a zone parallel with the blocks of fossiliferous sandstone, as suggested by him; or are they, in accordance to M. Graves's opinion, subordinate at times to the Glauconie inférieure, and at others to the Lignites? There is no doubt that the lower sands of Beauvais, and the lignites and the sand above them, occasionally contain flint-pebbles, sometimes detached and sometimes in bands; these in fact seem to constitute one of the constant minor characters of this series both in France and England. It is, however, a question whether the great accumulations of flint-pebble shingle, such as occur on Mont Soufflard near Montdidier, at Galet, Siranmont, and other places on the confines of the Departments of the Oise and the Somme, and also in parts of the Aisne, do all belong to the same zone as that which includes the fossiliferous sands and sandstones;—whether rather these shingle beds do not belong to several zones. We have, in England, at the base of the Woolwich and Reading series occasionally large accumulations of flint-pebbles (as for instance at and near London), mixed with greensand, and sometimes associated with the *Ostrea Bellovacina*; at Watford, they form a thick bed in ochreous sand without fossils. Again, we have them mixed with the Mottled Clay itself in some well-sections beneath London† and at Lewisham; whilst the upper subdivision also of the Woolwich sands at Woolwich and at Sundridge Park is very pebbly. (See Pl. VIII., Diagram, str. *c, e.*)

So, in France, M. Graves mentions that the "Glauconie inférieure" is often pebbly; that at Bracheux a bed of pebbly greensand, $2\frac{1}{2}$ metres thick, underlies the fossiliferous sands; elsewhere there are some subordinate beds with pebbles amongst the mottled clays of the "argile plastique;" whilst in other places, the fossiliferous sands overlying the Lignites pass into pebble beds and conglomerates.

All this agrees perfectly well with the structure of the Woolwich and Reading series, but beyond this we have in England another shingle zone,—that of the Basement bed of the London Clay. This is frequently composed of great masses of pure shingle without traces of fossils, at other times of a slight layer of shingle passing up into a thin bed of fossiliferous sands. This irregular distribution I believe to have arisen from the change in the position of the sea which

* An exact list of the species is wanting.

† Quart. Journ. Geol. Soc. vol. x. p. 142.

took place at the commencement of the London Clay period, and whereby a large body of water, suddenly displaced and passing over the new-formed sea-bed, swept the banks of pebbles formed on the sea-shore and spread over the littoral zone during the Woolwich and Reading period, leaving them in some places merely as a thin layer, and at other places drifting them into thick heaps.

There are apparently in the French series some analogous conditions. There are many large accumulations of pure shingle; but nowhere have these been traced under any of the regular strata, as we can trace the shingle bed of Plumstead under the London Clay of Shooter's Hill. In those places where the fossiliferous sands overlying the Lignites are pebbly, the fossils are evidently such as belong to the Bracheux group, and I have not recognized in them any of the more ordinary and exclusive London Clay forms. Where the pebbly sands and sandstones are overlaid by other strata,—the "sables divers" of M. d'Archiac, and "Glauconie moyenne" of M. Graves,—another series of fossils commences; amongst these are the *Pectunculus depressus, Ostrea flabellula, Crassatella lamellosa, Cassidaria carinata,* and other shells not found in the lower sands, but belonging to the Calcaire grossier group. (See Table.)

Here then we have a divergence in the London and Paris series. I doubt whether any of the beds just described are the exact equivalents of the Basement bed of the London Clay; whether any of the great isolated masses of pebbles on the confines of the Paris district were then, as in England, swept into their present place from their previous position in the underlying sands and clays. The general appearances are certainly in favour of the existence of like conditions, at that period, in the two countries; but they are merely such physical conditions as might have resulted at any period by the movement of a body of water over the loose materials of the lower sands. In England, this followed close upon the former period of the Woolwich and Reading series; but it is a question whether in France the "Lignite and Argile Plastique" period was not followed by a period of dry land, and whether the partial destruction and reconstruction of the surface of some of the beds of that period did not take place later, viz. when the land was again submerged, and when consequently some portion of the pebbles and shingle derived from the lower beds were spread out at the base of the deposits of another period,—the one commencing with the Lits Coquilliers and Calcaire grossier. The probability of this position will be better understood after an examination of the overlying beds.

§ 7. *The relation of the lower members of the French series to the Sables Divers and Lits Coquilliers (D'Archiac), or the Glauconie Moyenne (Graves).*

In England the shingle beds are immediately succeeded by the London Clay, and in the northern part of the Paris basin by M. d'Archiac's fourth division, "Sables divers," which consists of light-yellow and greenish fine quartzose sands, attaining in places a thickness of 140 feet, but only occasionally containing a very few fossils.

At the top of these sands, and in close relation with them, M. d'Archiac places his fifth division or "Lits Coquilliers," usually about 20 feet thick, and abounding in well-preserved fossils. M. Graves unites these two divisions in his group of "Glauconie moyenne;" and M. Melleville forms of them his second stage of his "Sables inférieurs."

If I am right thus far in correlating the Woolwich and Reading series with the three lower divisions of the "Sables inférieurs" of M. d'Archiac, then these Sables divers and Lits Coquilliers, or the Glauconie moyenne of M. Graves, hold, so far as superposition goes, exactly the same position as the London Clay in England. The question then is, are or are not these deposits synchronous?

As before mentioned, the experienced geologists so often referred to cannot draw any decided and maintained divisional planes in any part of this lower series from the Calcaire grossier down to the Chalk. The strata seem throughout connected and continuous; but I apprehend, that as the whole series, with a few exceptions (of which the only important ones are the clay of the Lignites and Argile plastique), consists of sands, the absence of any marked divisional surfaces in materials so easily moveable and so yielding, and where the same texture and colour is repeated in the upper and lower beds, is not a proof of passage and uninterrupted continuity, or of the non-occurrence of contemporaneous physical changes. Thus I have shown that when the pebble bed is absent at the base of the Woolwich and Reading series, it is almost impossible to draw the line between these sands and the Thanet Sands; and in support of that fact, I further instanced the case where in a clear cliff-section* even a drift-loam passes down into the Woolwich sands in a manner so imperceptible that no line of demarcation can be drawn between them.

M. d'Archiac himself notices a fact of the very same nature in describing with M. de Verneuil some railway sections near Clermont. Speaking of a section where the Lower Tertiary sands and pebbles are overlaid by the drift and its pebbles, he observes†, "This section, although not an important one, is nevertheless valuable in showing what a degree of precision the careful examination of deposits allows us to arrive at in establishing real distinctions; for here there is a continuity and apparent connexion (*liaison*) between the oldest tertiary beds, the bed of diluvial pebbles, and the sandy alluvium which covers the whole." It is therefore, I conceive, quite possible that a very considerable break, so far as regards time, may occur in a series of loose sandy strata, and yet exhibit no physical evidence of the fact. But, in the absence of the well-marked divisional lines exhibited by more unyielding strata, organic remains afford evidence independent of such phænomena, and such evidence we here possess. I do not think that sufficient stress has been laid on the dissimilarity of the fauna of the sands of Beauvais and of that of the Lits Coquilliers. The comparatively small number of fossils in the former, combined with the characters above-named, has probably tended to keep them

* Quart. Journ. Geol. Soc. vol. x. p. 112.

† Bull. Soc. Géol. de France, 2 sér. vol. ii. p. 341.

in a subordinate position: but with regard to the "Lits Coquilliers," the fossils are most numerous and characteristic, and furnish us with an horizon perfectly to be depended upon.

The independent character of the fauna itself of the lower beds of sand was, however, pointed out by M. d'Archiac in 1839*, subsequently by M. Melleville in 1843†, and by M. Graves in 1847‡. The lists of fossils respectively found in the several districts which these authors described give the following results:—

	Total number of species in the Beauvais and Rheims Sands.	Species ranging into the Lits Coquilliers or beds above.	Number of species peculiar to the beds of Beauvais and Rheims.
D'Archiac ...	49	11§	38,—or 77 per cent.
Melleville ...	119	60	59,—or 50‖ per cent.
Graves.........	94	48	46,—or 49‖ per cent.

These results differ materially. This may arise partly from the circumstance that M. d'Archiac takes a general view of these beds in their whole range, and treats only of the fossils determined in 1839; that M. Melleville gives a joint list of the Rheims and Beauvais fauna, adding a number of new species from the neighbourhood of Rheims; whilst M. Graves's list is confined to the neighbourhood of Beauvais, and he describes no additional new species. If we separate from M. Melleville's list the Beauvais shells, which have since been more accurately determined by M. Graves, and confine ourselves to the list he furnishes of the mollusks of the Rheims sands only, the numbers will stand thus:—

Melleville......	43	11	32,—or 70 per cent.

M. Hébert¶ has since added 25 species to M. Melleville's list. Of these I infer that 10 are new species, or species peculiar to the Lower beds, whilst he names 8 species which have a higher range. Of the other 7 specimens he only gives the name of the genus.

As the fossils of these beds are generally so friable and often so indifferently preserved, while at the same time there yet evidently are many undescribed species, these lists are, no doubt, far from complete; and as also the determinations have been made chiefly upon comparisons with the better studied and far more perfect and

* Bull. Soc. Géol. France, vol. x. p. 174. As before-mentioned, M. d'Archiac has since considered that some of these beds may be higher in the series than he believed at that time; still they would underlie the "Lits Coquilliers," and our argument would not therefore be affected.

† Mém. sur les Sables Tert. Inférieurs, p. 78.

‡ Top. Géog. de l'Oise, p. 196.

§ M. d'Archiac makes the numbers 12 and 37 instead of 11 and 38; the *Pectunculus terebratularis*, however, which was then thought to be identical with the Grès de Fontainebleau species, has since been found to be different, and to be peculiar to these lower sands.

‖ The similarity of these results is more apparent than real, for in M. Melleville's enumeration of the Beauvais shells there are 21 Lits Coquilliers and Calcaire grossier species not found in M. Graves's later list. Against this there are 23 new species described for the first time by M. Melleville, and mostly peculiar to the Rheims district. There are also a few species given by M. Melleville as peculiar to the lower sands, which M. Graves gives also from the "Lits Coquilliers."

¶ Bull. Soc. Géol. France, 1849, 2nd ser. vol. vi. p. 730.

larger lists of the Calcaire grossier fossils, it is principally the new and peculiar species of these lower strata which remain to be described.

Further, to take the "Lignites" as subordinate to the "Glauconie inférieure." From M. Graves's list of the shells belonging to the Oise "Lignites," including those of the Aisne of M. d'Archiac, we obtain the following data*:—

	Total.	Range upwards.	Peculiar.
Fossils of the Lignites and associated clays ...	37	14	23
Adding to these three additional species found in the Rheims district†, and three new species recently described by M. Watelet from Soissons ...			6
			29,—or 78 per cent.

If we add these numbers to those before obtained of the fossils of the lower Sands of the Oise and Champagne, the following will be an approximate result of the distribution of the fauna of these strata,—those included in the three lowest divisions of M. d'Archiac:—

Total of species.	Species ranging upwards.	Species peculiar to the series.	Per-centage of peculiar species.
152	55	97	64

only 36 per cent. of the known species thus ranging up into the beds above these divisions. The independence of this fauna, although not appearing at present so great as I believe it will be ultimately found, is nevertheless important, and furnishes us with sufficient data for the subsequent argument.

The generally excellent state of preservation of the fossils of the Lits Coquilliers, their abundance, and the large proportion of described species‡ afford us much better means of judging of the fauna of that period. They have been made the subject of especial research by M. d'Archiac, M. Melleville, and M. Graves, in whose works we find large and carefully drawn up lists, and by whom the position of these beds in the geological series has been accurately determined; the only question about which there is, as before-mentioned, a difference of opinion amongst the French geologists, being as to whether this deposit should be grouped with the beds beneath or with those above it. The following table, showing the range and distribution of the Mollusks found in the Lits Coquilliers

* I do not include in this list the very remarkable land and freshwater shells of Rilly, as they form too exceptional a group to be used as a term of comparison. M. de Boissy has described and figured thirty-nine species, all peculiar to these beds (Mém. Soc. Géol. de France, 2 sér. vol. iii. p. 257, 1848). This deposit I consider subordinate to the Lignite series; M. Hébert places it lower, or under the marine sands of Rheims. In either case, however, it would belong to this lower eocene series.

† Soc. Hist. Arch. et Scient. de Soissons, 1851.

‡ M. Deshayes has described and figured the greater number of the fossils of Rétheuil, Pierrefonds, and Cuise-La-Motte in his valuable "Description des Coquilles fossiles des Environs de Paris." M. Melleville has, however, since described a considerable number of new species (*op. cit.*)

and Glauconie moyenne, is drawn up from the lists here referred to :—

	Total number of species.		Species ranging upwards*.
D'Archiac (*Aisne*)	188	......	108,—or 57 per cent.
Melleville (*Champagne*) ...	273	......	166,—or 61 per cent.
Graves (*Oise*)	318	......	162,—or 51 per cent.

Adding the twenty-nine new species since described by M. Watelet, and taking the mean of the above results, it would appear that about 50 per cent. of the shells of the Lits Coquilliers (D'Arch.) or Glauconie moyenne (Graves) lived on to the period of the Calcaire grossier, whilst of the same fauna only about 16 per cent. were living in the older tertiary seas.

On the foregoing evidence, therefore, I am inclined to agree with those French geologists who would associate the "Lits Coquilliers" with the "Calcaire grossier," rather than with the "Glauconie inférieure." At the same time it cannot be denied that the Lits Coquilliers and Sables divers form a very distinct and important subdivision of that well-marked and typical higher group†.

If we now turn to the London Clay, we find that so far as superposition goes, it is exactly on the same geological horizon as the Sables divers and Lits Coquilliers, but, instead of showing any close palæontological relations with this series, it exhibits almost entirely different affinities. It is true that there are some well-marked fossils common to both‡, and that the London Clay shows more ties with the Lits Coquilliers than with the Calcaire grossier, but still the difference is great; whilst at the same time its relations with the Glauconie inférieure seem almost equally distant. These deposits certainly present very different lithological characters, which might lead to considerable variation in the fauna, but hardly to the extent that here exists, or at least we must endeavour to ascertain whether

* The downward range of the species is omitted, as M. d'Archiac gives no list of the fossils of the Glauconie inférieure of the Aisne separately. In calculating the number of species which range upwards, I have taken into account both M. d'Archiac and M. Graves's lists of the Calcaire grossier fossils, as in each department some species confined to the lower beds in the one seem to range higher in the other. Taking only the Aisne, M. d'Archiac's lists show, including the unnamed species, but 71 identical species in the two deposits, while in the Oise M. Graves makes the number of common species 155.

† It is necessary to mention that this result is at variance with the opinion of M. Al. d'Orbigny, who considers these deposits to be far more distinct; so much so that he only allows eight species of shells to be common to the two. He admits that at the noted locality of Cuise-la-Motte there is a greater number of Calcaire grossier forms, but he attributes that fact to the circumstance of many of the fossils having been washed out of the older into the newer deposit, the lithological character of the beds favouring such a transference. I should attach more weight to this argument if the Calcaire grossier here contained species not found elsewhere, but it is the Lits Coquilliers which is here distinguished by the number of additional species. Cours élém. de Paléon. et de Géol. vol. ii. p. 713, 727, & 731.

‡ I have not been able to add many species to the eighteen I enumerated in 1847; after correcting a few errors in that list and adding some other species, there are now twenty-five.

there are other causes to account for the zoological differences. Of the 224 species of Mollusks of the London Clay, thirty-four are likewise found in the French series, where their distribution and range are as follows*.

	Glauconie Inférieure.	Lits Coquilliers.	Calcaire grossier.
Anomia tenuistriata, *Desh.*	—	—	—
Axinus (Cryptodon) angulatus, *Sow.* (*Héb.*)	—	..	..
Beloptera Levesquei, *D'Orb.*	..	—	..
Belosepia sepioidea, *Blainv.*	..	—	—
Buccinum semicostatum, *Desh.*	—	..	..
Calyptræa trochiformis, *Lam.*	—	—	—
Cardium Plumsteadiense, *Sow.*	—	..	..
Cassidaria carinata, *Lam.*	..	—	—
Corbula Regulbiensis, *Mor.*	—	—	..
Cytherea obliqua, *Desh.*	—	—	..
—— suberycinoides, *Desh.*	—	—	—
Fusus angusticostatus, *Mell.*?	..	—	..
—— bulbiformis, *Lam.*	—	—	—
Murex spinulosus, *Desh.*	..	—	..
Natica labellata, *Lam.*	—	—	—
—— patula, *Desh.*	..	—	..
—— sigaretina	—	—	—
Nautilus zic-zac, *Sow.*	..	—	..
Nucula margaritacea, *Lam.*	..	—	—
Ostrea cariosa, *Desh.* ?	..	..	—
—— Bellovacina, *Desh.*	—	..	..
Panopæa intermedia, *Sow.*	—	..	..
Pholadomya margaritacea, *Sow.*	..	—	..
Pectunculus terebratularis, *Desh.*	—	..	..
Pinna affinis, *Sow.*	..	—	—
Pleurotoma colon, *Sow.*	..	—	..
—— elegans, *Mell.*?	..	—	..
Pyrula tricostata, *Desh.*	—	—	..
Rostellaria macroptera, *Lam.*	..	—	—
Solarium canaliculatum, *Lam.*	..	..	—
Teredina personata, *Desh.*	—	—	..
Turritella imbricataria, *Lam.*	—	—	—
—— sulcifera, *Desh.*	..	..	Sables moyens.
Venericardia Suessonensis, *D'Arch.*	..	—	..
	17	25	14

* In this table I confine myself, as in the other parts of this inquiry, to the lists furnished by M. d'Archiac, M. Graves, and M. Melleville. It is possible that to the south of the districts described in their works the distribution and range of species may be somewhat different,—that species limited to one group in the more northern portions of the Paris basin may be found in other groups in the more southern parts of this basin. But no equally complete lists of the fossils of this latter area exist, and consequently, although we know the Calcaire grossier to be extremely rich in organic remains in the neighbourhood of Paris, we are unable to avail ourselves of any exceptional cases, which the fauna may there present, differing from that of the district which here serves us as the point of comparison with our English series. I do not, however, believe that this much affects our general results. In fact, although I have drawn up this and the other lists with as much care as possible, they will all no doubt require correction by those better acquainted with the local faunas than I am. Still, I think, the general conclusions will hold good.

Or, taking the total number of species in these three French deposits * respectively and jointly with those of the London Clay, as 376, 571, and 863, then the numbers common to them severally show the following per-centage† :—

London Clay, Glauconie Inférieure, and Lignites.	London Clay and Lits Coquilliers.	London Clay and Calcaire grossier.
4·5	4·4	1·6

The proportion of common species appears therefore in any case to be remarkably small, and, palæontologically, the London Clay shows nearly the same relation to the Lits Coquilliers that it does to the Glauconie Inférieure—one evidently closer than with the Calcaire grossier. It may be suggested that these conclusions do not accord with those other conclusions upon which the correlation of the Bracklesham Sands and the Calcaire grossier has been previously established, inasmuch as whilst we have here a per-centage of only 1·6 species common to the Calcaire grossier and the London Clay, I have on a former occasion shown that there are 9·4 species common to the two English deposits—a proportion greater even than that which holds between either the Glauconie Inférieure or the Lits Coquilliers and the London Clay, both of which, I conclude, will prove nearer equivalents.

To comprehend this anomaly, we must take each separate area on its own base, and determine the lapse of time by the successive changes there introduced; in each considering the progression of time as parallel and independent movements. These circumscribed centres may show great irregularities and hiatuses; the adjacent structures may at one time exhibit close relations with one another, whilst at intermediate and still synchronous periods, their aberration, arising in most cases from the independence of their zoological provinces, may be such as to produce dissimilarities greater than those which prevail between successive periods in each local centre itself. There are generally, however, at intervals, limits to these variations, which may serve to indicate the exceptional causes to which the latter are owing. These limits occur whenever two adjacent centres become so connected that like or nearly allied hydrographical conditions prevail over both areas at the same time so as to favour a community in the faunas. We are then furnished with a definite base-line to which we may safely refer all subordinate and intermediate changes.

We have every reason to believe that a close connexion of this nature existed at the Calcaire grossier period between those beds in France and the Bracklesham series in England‡. There are, it is true, not unimportant dissimilarities, but these are the permanent dissimilarities—those which belong to ordinary and constant geographical laws, and only modify without essentially impairing the zoological resemblances. They are dissimilarities which have grown

* In this I take the number of Calcaire grossier species given by M. Graves, his list being the largest and most complete.

† Looking at the French groups only, the numbers would be—

11·2	7·2	2·05

‡ Commencing with lower Bracklesham or Bagshot Sands, and attaining its full force at the time of the Glauconie Grossière and Lower Calcaire Grossier.

up on the area, and which result in some measure from those very intermediate geological aberrations to which allusion has been made, and which may give a sort of local stamp even to wide-spread deposits.

If, therefore, the Calcaire grossier and the Bracklesham sands are to be considered as synchronous, we may take them as furnishing a common geological horizon, to which, in each case, other and more independent local phænomena in the several areas may be referred. The point we have now to inquire into, is what proportion of the separate faunas of these two deposits is to be traced downwards in each respective centre. Taking a common measure, out of every 100 Mollusca living at the latest-named period, the following numbers approximately express the proportion living at the several earlier periods in each central area.

French area.			*English area.*
Calcaire Grossier	100	100	Bracklesham Sands.
Lits Coquilliers	29	......	......
......	......	15	London Clay.
Sables de Bracheux	5	6	Woolwich and Reading Series.

If, instead of taking this upper horizon, we take the lower one of the Woolwich and Reading Series in this country, and the Sables de Bracheux in France, excluding in both the freshwater and fluviatile fauna, the following are the results :—

Calcaire Grossier	30	31	Bracklesham Sands.
Lits Coquilliers	38	......	......
......	......	58	London Clay.
Sables de Bracheux	100	100	Woolwich and Reading Series.

Therefore, howsoever distant the relation between the Lits Coquilliers, the Bracheux Sands, and the London Clay may seem, when viewed with regard to space only, yet it becomes evident that, when viewed in relation to time within their own centres, these strata occupy certain definitely related and parallel planes; that on such deductions the London Clay holds a position intermediate between the Lits Coquilliers and the Bracheux Sands. This evidence by itself affords presumptive proof of each area having one fossiliferous zone peculiar to itself, and wanting in the other; of each having a link in the sequence which the other has not*. These calculations also afford a singular corroboration of the interval of time assigned upon other grounds to the top and bottom French and English zones in the above tables.

§ 8. *The London Clay; Système Ypresien Inférieur, or Glaise Ypresien; not represented in the Paris Tertiary district.*

In following the Lits Coquilliers and the London Clay as they respectively range, the one towards the London, and the other towards the Paris Tertiary district, there is no appearance of any sufficient change in mineral character that would tend to assimilate them to each other. The London Clay retains, with the slight exception mentioned further on, the same well-marked characters in the Isle of Wight and Hampshire as it does around London. It has not hitherto

* The unfossiliferous Lower Bagshot sands may probably occupy the 2nd English parallel.

been found anywhere in the Paris district, although it would appear to have extended across the Channel to the coast of Normandy. For last April, in company with several members of this Society, we examined the well-known cliff-section at the Lighthouse of Ailly near Dieppe, and the majority of our party came to the conclusion that the upper beds there belonged to the London Clay proper*. I had, on a former visit, suspected the presence of the true London Clay, but had found no organic remains to corroborate this opinion. On this occasion, however, we were fortunate enough to discover a few well-marked fossils, which, taken together with superposition and mineral character, leaves little doubt in my mind of the existence of the London Clay at that place.

The chalk here rises about 80 feet in the cliff and is overlaid by about 110 feet of Tertiary stata, the lower 60 of which belong to the Woolwich and Reading series perfectly well characterized and composed of sands, laminated clays, and pebble beds, with numerous fluviatile and freshwater shells, on the ordinary Woolwich type, forming a group very similar to that of the section at Castle Hill cliff, Newhaven (see Quart. Journ. Geol. Soc. vol. x. p. 83). Above these beds there is about 50 feet of laminated brown clay interstratified in its lower part with several thin layers of sand,—a lithological character of which we have occasionally some indications in the London Clay on the opposite coast, for at White Cliff Bay the London Clay also contains several subordinate beds of sand. This clay contains also some iron pyrites and small light brown calcareo-argillaceous concretions. At the base (which, by the by, is not very well defined) of this deposit I found a few fragments of the *Ditrupa plana* and teeth of *Lamnæ*, so characteristic of the base of the London Clay in the Isle of Wight and London district†. Mr. A. Tylor, further, was fortunate enough to find two small fossil crabs exactly in the condition in which they occur in the London Clay, and which appear identical with a species of *Zanthopsis* (probably a young specimen, the *Z. nodosa*) of Potter's Bar and other places near London. There is no appearance of any of the fossils of the "Lits Coquilliers." The London Clay cannot be traced further in the direction of Paris, as the chalk is

* The distinctiveness of these beds had not, however, escaped the practised eye of M. d'Archiac, who has, I find, stated, so far back as 1839, that "the London Clay formed the upper part of the cliff at the phare d'Ailly." He goes on to say, however, that these clays are "similar to those of the Barton Cliffs, but we have found neither fossils nor septaria." Bull. Soc. Géol. vol. x. p. 195, and Hist. des Prog. vol. ii. p. 499. At the time this was written, the Barton Clays were considered to be the type of the London Clay. Although these two deposits are now separated, this indication of M. d'Archiac is important, but has been generally overlooked, for other French geologists, both before and since, have referred all these beds to the sands and clays of the "Argile Plastique."

† M. Hébert is, however, of opinion that some similar fossils equally well mark a thin conglomerate bed at the base of the Calcaire grossier. The "*Dentalium strangulatum*" may certainly prove to be synonymous with the *Ditrupa plana*; but, if so, it ranges up to the "Sables moyens" and is no longer characteristic of a particular zone. The specific characters of the teeth of *Lamnæ* are also extremely problematical. To these two fossils alone I should attach no great weight. The prevalence of closely allied species might result from like conditions tending to the recurrence of analogous forms of life at distant periods of time.

denuded for many miles to the south-eastward of the hills of St. Marguerite; and at the next mass of the Lower Tertiaries, in the neighbourhood of Gisors and Chaumont, we could find no traces of that deposit.

If, however, instead of following in this direction towards Paris, we take a northerly direction through Cassel, Lille, and Tournay, we shall find every reason to believe that London Clay extends throughout the greater part of French Flanders and Belgium. I have before noticed the occurrence of this clay beneath Calais*. I have since seen it at the hills adjoining Watten, near St. Omer, where it rises 220 feet above the plain, with its ordinary aspect and mineral characters just as well marked as at the Norwood hills, or at Primrose Hill. Its thickness also at Watten cannot be less than 300 to 350 feet.

M. Dumont and Sir Charles Lyell have shown that the Ypresien Clay (London Clay) has a considerable range in Belgium. The observations of Sir Charles Lyell are particularly pertinent to this point, for he shows by a well-section at the Railway Station at the foot of Cassel Hill, where many of the beds of the Paris Tertiaries are well exhibited, that the London Clay, perfectly well characterized by its mineral character (which he resembles to that of Highgate) and with Septaria, is there more than 291 feet thick. If to this we add 118 feet for the elevation of the London Clay above the spot where the well was sunk, it will give a thickness of more than 400 feet to the London Clay in that district, proving it to have a development probably equal to that which it possesses in the neighbourhood of London. Further, Sir Charles mentions that it is only about 150 feet thick near Lille, showing, therefore, a gradual thinning-out as it ranges southward into France (see Pl. VIII. Sect. 2). No fossils†

* M. Meugy mentions (*op. cit.* p. 154) many other well-sections proving the same fact. One at Dunkirk was carried by boring through 118 feet of sands (called sea-sand), and then 266 feet into the London Clay; another at Hazebrouck reached the base of the London Clay (here covered only by a few feet of drift), at a depth of 328 feet. His work contains many other sections proving the importance of the Glaise Ypresien (London Clay) in French Flanders.

† This has been urged as a serious objection by some French geologists, who, however, have not hesitated to refer these clays to a large development of the clays of the "Argile Plastique,"—a correlation which would be attended not only by the same difficulty to which they here object, but would further want all the analogies which in the other case we possess. It must also not be forgotten that in England the London Clay is frequently non-fossiliferous; that even in cliff-sections, as for example at Sheppey or Herne Bay, it requires a careful search to discover any fossils in the clay itself. As the fossils also are more abundant in particular zones, it is necessary to attend daily during the sinking of a well, as large portions of the clay contain no fossils, whilst in other portions they may be plentiful. I doubt whether there have been opportunities to examine the London Clay in the north of France and Belgium with sufficient care.

Since writing this paper, I find that M. Meugy notices a single instance in which fossils were found in beds 55 feet thick, which he refers to the "Glaise Ypresien." He states that they were tolerably abundant, and consisted of species of *Turritella*, *Venericardia*, *Cardium*, *Lucina*, *Ostrea*, *Pleurotoma*, and the *Nummulites planulatus*, and in some underlying sands *Ostrea*, *Pecten*, and *Dentalium*. I should almost fear some mistake here. This is certainly not a group of fossils found in the London Clay in this country. The section, however, is not sufficiently definite to feel sure as to the position of the beds. *Op. cit.* p. 143.

have been described, although a few have been found in Belgium; but the mass, position, and mineral character of this bed of clay leave little doubt of its identity with the London Clay. To M. Dumont is due the merit of first having pointed out the analogy of his Système Ypresien with the London Clay proper.

§ 9. *Lower Bagshot Sands; Système Ypresien supérieur or Sables Ypresiens; Lits Coquilliers and Sables divers, or Glauconie moyenne.*

Having shown in a former part of this paper that the Lits Coquilliers are somewhat more nearly related to the "Calcaire grossier" than to the marine beds associated with and underlying the "Argile Plastique," whereas the London Clay proper shows, on the contrary, closer affinities with these latter beds, it remains to be ascertained whether we can in any way prove the superposition of the Lits Coquilliers and associated sands on the London Clay. I believe that this now admits of proof, and that in this country the Lower Bagshot Sands form the equivalent beds of the Glauconie moyenne.

The hill of Cassel, about thirty-five miles E.S.E. from Calais, rises to a height of 515 English feet above the sea, and affords some interesting sections of a large portion of the Belgian series. At about the middle of the hill are some calcareo-arenaceous beds, in which M. Elie de Beaumont many years since found the *Cerithium giganteum* and other shells which induced him to refer those beds to the zone of the "Calcaire grossier." The correctness of this parallelism has been generally admitted, and has been confirmed by the observations of M. d'Archiac*, who further proved that these beds were underlaid by fossiliferous sands which he referred to his "Lits Coquilliers," and tracing the same zone to Brussels, he showed that it was there characterized by that most abundant fossil of the French beds—the *Nummulites planulatus.*

These correlations have been since adopted and extended by M. Dumont and Sir Charles Lyell; the latter of whom further gives a measured section of the hill of Cassel†, which, with the list of organic remains he likewise furnishes, afford the exact data we require for comparing these beds with others in this country. We need not at present notice the upper part of the hill, which to the thickness of about 120 feet is composed of the sands of Diest, and of the Laeken beds with the *Nummulites variolarius.* Beneath these strata is the zone before-mentioned and referred to the "Calcaire grossier." But the change, both in mineral characters, importance, and the fauna, between the beds of this age at Cassel and in the Paris district is very great. Instead of the thick mass of soft earthy limestones with subordinate green sands ("Glauconie grossière") at their base, 100 to 150 feet thick, and containing a rich fauna of 600 to 800 named species, we have at Cassel a series of beds consisting essentially of mixed yellow and green sands more or less pure, and of very thin subordinate beds of sandstone usually with a calcareous cement.

* Bull. vol. x. pp. 183, 193, 1839; Hist. des Prog. vol. ii. pp. 497 & 500.
† *Op. cit.* p. 324.

According to the description of Sir Charles Lyell, I should estimate these beds not to be together less than 32, and not more than 50 feet thick *. He enumerates only thirty-seven named species of fossils; of these, thirty-one are found also in the "Calcaire grossier."

I should be inclined to consider these Cassel beds to represent both the "Calcaire grossier" and "Glauconie grossière," or rather, more especially as resulting from a development of the latter and a thinning of the former. At Brussels, the fauna of these beds is rather richer, Sir Charles mentioning forty-five named species †. He also makes the series about 100 feet thick. I should, however, be inclined, on the physical characters he describes, to place the lower 40 or even 70 feet with the next underlying series.

Sir Charles does not give an exact measurement of the lower beds at Cassel, but if we take the total thickness of the beds above described, it will give in round numbers from 140 to 160 feet. Now M. Meugy states that the "Glaise Ypresien" (London Clay) rises to a height at the base of the hill of 247 feet, which would leave 100 to 120 feet as the thickness of the siliceous sands which Sir Charles describes as underlying the zone of the *Nummulites lævigatus* and associated beds ‡.

In these lower sands, which are referred by M. Dumont and Sir Charles to the "Sables Ypresiens," the *Nummulites planulatus* has not been found; but it is met with in beds holding the same position between this spot and Courtray, whilst still further eastward this Foraminifer is abundant. The sands beneath this nummulitic zone M. d'Archiac refers to his "Sables divers §."

We have thus had established at the hill of Cassel, by M. Elie de Beaumont and M. d'Archiac, a succession of strata corresponding in all these central beds with those of the Soissonnais in the Paris district; whilst the later researches of M. Dumont and Sir Charles Lyell show that that series is underlaid by the London Clay. That the zone of the *Cerithium giganteum* and *Nummulites lævigatus* at Cassel represents the Calcaire grossier on one side, and on the other is correlated with the "Système Bruxellien" of Belgium, I take for granted upon the authority of these several eminent geologists. The identification, however, of the zones of the "Lits Coquilliers" and "Sables divers" is attended with more uncertainty; for, although a few fossils, position, and mineral structure all coincide in exhibiting a close analogy, yet it must be admitted that the evidence of organic remains is of itself not very strong. Of the Cassel fossils belonging to these beds, we have no positive list. It is possible, however, that the one given by Sir

* *Op. cit.* p. 324.

† M. Omalius d'Halloy quotes, on the authority of M. Nyst, 95 species of Molluscs from the "Sables Calcarifères de Bruxelles" (Système Bruxellien, Dumont), but I do not feel quite sure whether his division is exactly the same as that of Sir Charles Lyell,—whether it does not include the *N. planulatus* zone (*Abr. de Géol.* p. 579).

‡ Including the beds corresponding, according to M. Meugy, with the "Système Paniselien" of M. Dumont, this portion of the series would be 124 feet thick (*op. cit.* p. 168).

§ Bull. Soc. Géol. de Fr. vol. x. p. 182, 1839 (there termed "Sables inférieurs").

Charles Lyell at p. 331 may prove to belong to a bed of that age. In it eighteen named species are enumerated, fourteen of which certainly occur in the Calcaire grossier, but they are met with also in the Lits Coquilliers. One is peculiar to Belgium. Of the three remaining, the *Terebellum convolutum* occurs, it is true, in the Calcaire grossier, and not in the "Lits Coquilliers," but against that we have the *Panopæa intermedia*, which occurs only in the latter, and the *Vermicularia Bognoriensis?*, a London Clay species. The *Nummulites planulatus* does not, as before mentioned, occur here, but near Lille it abounds in these beds. In Belgium, this fossil is found in strata, of which the position beneath the zone of *Nummulites lævigatus* and at the top of the Sables Ypresiens is well determined. Sir Charles enumerates (p. 357 and 358) sixteen other named fossils, associated with the *N. planulatus* in the vicinity of Brussels. Of these, twelve occur in both series in the Paris basin, one is peculiar to Belgium, the *Turbinolia sulcata* is a Calcaire grossier species, and a *Cytherea* (*C. obliqua?*) and a *Natica* (*N. Hantoniensis?*) are found, which appertain as much or more to beds lower than the "Lits Coquilliers*." I presume also, from the observations of M. d'Archiac, that the general facies of the fauna must be essentially like that of the Lits Coquilliers; still it is clear that the leading evidence is the *Nummulites planulatus*, a Foraminifer which in the "Lits Coquilliers" generally, and in the Ypresian Sands occasionally, occurs in wonderful profusion, and yet appears in this part of Europe to have but this limited vertical range.

These lower Cassel sands may possibly admit, to a certain extent, of a subdivision into three parts; the upper one (Système Paniselien of Dumont) may correspond with the glauconiferous clays overlying the Lits Coquilliers in the Aisne; to this succeeds the fossiliferous band more exactly synchronous with the Lits Coquilliers, as distinguished by M. d'Archiac; and then the thick mass of unfossiliferous siliceous sands corresponding with the Sables divers. Or they might be all included in one division—that of the Glauconie moyenne of M. Graves.

There are two facts apparent in the Cassel and Belgian series, which are the poverty of the fauna compared with that of the synchronous deposits in the Paris basin, and the more purely siliceous condition of the strata.

If now we pass to the London Tertiary district, and take the first range of hills where the beds above the London Clay are well developed, viz. the Bagshot Hills, we shall find that they present some remarkable stratigraphical resemblances with the hill of Cassel. The Lower Bagshot sands are about 130 feet thick, and consist of light-coloured siliceous sands, with a few thin subordinate argillaceous beds, and a very few concretionary blocks of hard siliceous sandstone. In position and general basic structure they agree very closely both with the Cassel beds and the "Glauconie moyenne" of M. Graves (Ét. 1, 2, and 3 of M. d'Archiac). The main difference consists in the absence of intermixed green sands, of calcareous matter, and of solidified beds; all these, however, are subordinate features subject to great variation, even in the Paris district. The only superadded feature in

* The "*Cancer Leachii*" (?) is also quoted.

the London district is the greater importance of subordinate, very fine, laminated clays. The fossils also, which in the Paris district number 347, and which at Cassel have diminished to 18, are, with the exception of a few vegetable remains, entirely wanting in the London area. As, however, these are progressive changes, which harmonize perfectly well in all their parts, they rather strengthen than invalidate our position, for the dependence of all the collateral phænomena indicates a common origin, subject only to minor local superadditions. It is only in proportion as the amount of carbonate of lime in the sands diminishes and quartzose sands predominate, that the number of Mollusks decreases. In French Flanders we have intermediate palæontological and mineral conditions corresponding with the intermediate geographical position.

In this country I have traced the Lower Bagshot Sands as far eastward as the hills near Southend, in Essex; they also apparently exist in the Isle of Sheppey; this carries them about 60 miles from Bagshot and to within 100 miles of Cassel (see Sect. 1. Pl. VIII). These sands exhibit the same non-fossiliferous character in those districts as around Bagshot, but they are of no great thickness, and the upper portion, or that which is more fossiliferous in the Continent, is wanting.

Following the "Lower Bagshots" further westward, and again south-westward into Hampshire, they maintain nearly the same thickness and mineral characters. They are, I think, represented in White Cliff Bay by the Stratum No. 5 ("Section," Journ. Geol. Soc. vol. ii. pl. ix. p. 223), which overlies the London Clay, and consists of siliceous, and in parts clayey, sands, striped various shades of yellow, 98 feet thick. This mass may probably correspond with the "Sables divers," and possibly include the "Lits Coquilliers," although I do not think it unlikely that these latter may rather be represented by some portion of the overlying beds. In the Alum Bay section, it would be difficult to say how much of the series should be included in this division. I should commence with the bed 7, overlying the London Clay (3 to 6), and carry it probably up to No. 18 or 20 (*loc. cit.*). In that case, it would include the foliated clays of Stratum 17 with their beautiful group of plant-impressions. In some of these beds green sands again occur as a subordinate character.

At the base of the "Glauconie grossière" according to M. Graves, or at the top of the Sables Inférieurs according to M. d'Archiac, is a very variable bed of foliated clay with occasional lignite. This possibly may correspond with the lignite and foliated clay immediately beneath the green sands of Bagshot, and with some of the carbonaceous clays and lignites above the sands last described in the Isle of Wight. The Système Paniselien of M. Dumont may possibly also be placed on this level.

Not only, however, have we in the Bagshot district a series of beds, which in mineral character, superposition, and importance correspond in the main with the three upper divisions of the "Sables inférieurs" of M. d'Archiac, but we further find them overlaid by other beds corresponding with the "Glauconie grossière" or lower part of the "Calcaire grossier." Here again we must take into consideration, or rather admit in evidence of identity, the progressive changes apparent in this series as it ranges from south to north and north-west. In the neighbourhood of Paris, the "Glauconie grossière" is but very slightly developed; in the Oise and Aisne it becomes an important subdivision of the "Calcaire grossier," consisting of thick beds of partially consolidated calcareo-quartzose sands, more or less mixed with green sands, and with a slight conglomerate basement. The fossils are often numerous, and the same as those of the Calcaire grossier. At Cassel this zone consists, as before mentioned, of light-coloured siliceous sands, green sands, and calcareous bands irregularly mixed, and containing only a small number of fossils. Then passing to the Bagshot district, we find a single thick bed of nearly unmixed green sand with a few subordinate beds of fine foliated clay and quartzose sand, together about 30 feet thick. The calcareous bands are here entirely wanting. Fossils are very rare; they consist of the following named and characteristic species, which are sufficient to show, with the collateral evidence of mineral structure and superposition, the true relation of the group.

	Middle Bagshot Sands.	Système Bruxellien.	Calcaire Grossier and Glauconie Grossière.	Brack-lesham Sands, Hants.
Cardium semistriatum, *Desh.* ...	Chobham.	Cassel.	Oise.	*
Corbula gallica, *Lam.*	Chobham.	Cassel.	Oise.	*
—— plicata, *Edw.*	Shapley.	....	......	*
—— striata, *Desh.*	Shapley.	Brussels ?	Oise.	*
Nucula similis, *Sow*..............	Shapley.	Cassel.	Oise.	*
Nummulites lævigatus, *Brug*....	Chobham.	Cassel.	Oise.	*
Ostrea flabellula, *Lam*...........	Chobham.	Cassel.	Oise.	*
Pecten corneus, *Sow.* ?............	Shapley.	Brussels ?	......	*
Turritella sulcifera, *Lam.*	Goldsworth.	....	Aisne.	*
Venericardia acuticostata, *Lam.*	Goldsworth.	....	Oise.	*
—— elegans, *Desh*................	Shapley.	....	Oise.	*
—— planicosta, *Desh.* (*abundant*)	Chobham.	Cassel.	Oise.	*
Lamna elegans, *Agas*.............	Goldsworth.	Cassel.	Oise.	*
—— compressa, *Agas.* ?	Goldsworth.	....	Oise.	...
Carcharodon angustidens, *Agas.*	Goldsworth.	Brussels ?	Oise.	*
Pristis contortus, *Dix*.............	Goldsworth.	Brussels ?	......	*
Otodus obliquus, *Agas.*	Goldsworth.	Brussels.	Oise.	*
Myliobates striatus, *Agas.* ?	Goldsworth.	Brussels.	......	*
Ætobates irregularis, *Agas*.......	Goldsworth.	Brussels ?	......	*
Edaphodon Bucklandi, *Agas*....	Goldsworth.	Brussels.	......	*
—— leptognathus, *Agas*.........	Goldsworth.	....	......	*
—— eurygnathus, *Agas*..........	Goldsworth.	....	......	*

The Brussels species marked with ? are in Om. d'Halloy's lists of the fossils of the Sables calcarifères; see note †, p. 233.

With the exception of three species, peculiar to the English area, there are nineteen which occur likewise either in the Calcaire grossier zone of Cassel or in that of Brusssels; and 14 of these (including all these shells except one) species range into the Paris Tertiary district. The *Nummulites lævigatus, Venericardia planicosta, V. acuticosta,* and *Ostrea flabellula* abound in the Glauconie grossière and the lower beds of the Calcaire grossier, and it is on this level that I would place the central green sands and marls of Cassel (*h* and *i* of Lyell's section) and the green sands of Bagshot.

In consequence of this parallelism of these green sands of Bagshot with the Bracklesham series of Hampshire, I had on a former occasion (*op. cit.* p. 399) suggested that the lower unfossiliferous sands of the Bracklesham series and the Lower Bagshot sands might possibly be of the same age as part of the "Sables and Grès inférieurs," but that, in the absence of fossils, the evidence was not sufficiently positive*. The other course we have now followed through Flanders has, by the extension of many of the fossils of the "Lits Coquilliers," by the lithological structure and dimensions of the mass, and by the recognition of the London Clay, afforded the further evidence required.

These considerations induce me to place the Lower Bagshot Sands on the level, on the one hand, of the three upper divisions of the "Sables inférieurs" (but chiefly of the Sables divers) of M. d'Archiac, or the "Glauconie moyenne" of M. Graves; and, on the other hand, on that of the "Sables Ypresiens" and the Système Paniselien, and including possibly the lower part of the Brussels Sands†.

§ 10. *Conclusion.*

If the synchronism of the Bracklesham series with that of the "Calcaire grossier" be admitted, then the independence of the London Tertiaries with respect to the former deposit will apply with equal force to the latter. For I have lately shown‡ that the London series contains 485 species of organic remains (plants excluded), and that only eighty-eight or 18 per cent. of these pass upwards into (or through) the Bracklesham series; or taking the fossils of the two series together, there are only 9·4 per cent. common to both. There are altogether 397 species peculiar to the London group, and they form—the Fishes, Reptiles, Crustaceans, and Echinodermata especially—a very characteristic fauna. The distinctiveness of age and origin shown by the fauna is fully corroborated by the physical evidence.

The large proportion of species peculiar to the three lower divisions of M. d'Archiac also shows a well-maintained distinction between these beds and the Calcaire grossier; although in this case the fauna of the Lits Coquilliers serves as an intermediate link, and tends to lessen the apparent force of that difference. Nevertheless, these lowest French divisions are evidently in closer relation with our more distant London Tertiaries than with the overlying series in the Paris area.

I conceive, therefore, that we may take the "London Tertiaries" as a good natural group, constituting an important and independent division of the Eocene period perfectly well marked by its organic

* M. Dumont has since visited the Bagshot district, and without hesitation referred the Lower Bagshots to the Ypresien Sands. Quart. Journ. Geol. Soc. vol. viii. p. 370.

† I am inclined to place in this series (the equivalent of the "Glauconie moyenne") the 40 feet of siliceous sands without fossils, and possibly even the "Grès lustré" (strata *b* & *c*, *op. cit.* p. 334), included in the base of the Brussels group.

‡ Quart. Journ. Geol. Soc. vol. x. p. 435.

remains. In this country it is equally well distinguished by structure and physical characters; whereas the absence of distinctive physical phænomena in the equivalent series in France has tended to mask the palæontological distinctiveness which there also equally characterizes this group of strata.

The series next above the London Tertiary group I would term "the Paris Tertiary group," of which, in France, the centre in time is the Calcaire grossier, and in this country the Bracklesham Sands. Of the relations of the deposits of this period and the one next succeeding I purpose to treat in the next part of this paper. My reason for taking as the base of this Paris group the Lits Coquilliers and the Sables divers*, or rather the Glauconie moyenne of M. Graves, is founded chiefly on the palæontological evidence; notwithstanding that, in mineral characters and in the absence of any well-defined base-line, they seem as much, or even more in regular sequence with the underlying than with the overlying series†. In this country, on the contrary, there is no fossil fauna to distinguish the beds of this age (the Lower Bagshots), but in lithological characters and structure they form one consecutive series with the overlying beds of the Bracklesham sands and clays. No passage exists between the Bagshot Sands and the London Clay. It is true that there is no strongly marked line of separation—only occasionally is a band of pebbles spread over the surface of the London Clay. In Flanders and Belgium the division is again less marked. But although an eroded surface, a conglomerate bed, or a sudden alteration of mineral character form palpable and useful adjuncts indicative of distinct periods and of altered times, yet such corroborative evidence is by no means indispensable. When these phænomena occur, some geological changes are generally indicated, but it by no means follows that these phænomena must necessarily be attendant upon all such changes. If the movements of the earth's surface at that time took place at a distance,—or if the encroachment of the sea, after its retirement from the land during a long period, were gradual, and the materials drifted to form the newer beds were derived from the same source again as formerly,—then the peculiarity alone of the new fauna would form the test of its independence, as the physical distinctions would necessarily be in a great measure faint and obscure.

One cause possibly of the difference of the faunas of the Calcaire Grossier and Lits Coquilliers and of the London Tertiaries is the connexion apparently of the former with forms generally considered to belong to more southern and hotter climates, and of the latter with the forms usually inhabiting more northern seas. Commencing with the Thanet Sands, a sea open to the north extended probably over the south-east of England, Belgium, and the north of France; whilst, to the south of that area, dry land, including the greater part, if not the whole, of the Paris Tertiary district, prevailed and continued to prevail

* With possibly some portion of conglomerate beds.

† M. Raulin, however, seems to imply that the base-line between the Glauconie moyenne and the "Sables des Lignites" is generally well defined. Bull. Soc. Géol. 2nd ser. vol. viii. p. 461.

for some time. A subsequent extension of the sea to a short distance further south then led to the formation of the lower marine sands of Champagne, the Aisne, and the Oise, and the marine beds of the Woolwich series in East Kent; whilst the continuance of some small or slow changes in progress during this period caused, after a time, the littoral zone of this sea to be fringed with river or with lagune deposits, in which fresh- or brackish-water areas the lignites and their associated shell-beds were accumulated. A slight further subsidence again, however, led to the partial return, over these freshwater or fluviatile deposits, of the same sea with part of that fauna that the changes of level or silting up of bays had temporarily displaced. This last period appears to have been rather suddenly succeeded by an extensive rise of the Lower Tertiaries to the south, and a further depression to the north, or, I apprehend, more exactly to the S.S.E. and N.N.W.*, whereby in the former direction a large area was probably again converted into dry land, whilst, in the latter direction, the sea only became deeper and somewhat more extensive, covering the area now occupied by the London Clay. During this latter important period, the sea stretched over the south-east of England, some part of the north of Normandy, Flanders, and part of Belgium, as far east probably as Brussels, and thence apparently north-eastward in a course which yet requires tracing. That that sea was extensive is evident from the width and depth of the delta of the London Clay, which, with a maximum thickness of 480 feet, exhibits a transverse section in a straight line of not less than 200 miles,—conditions which also could hardly have obtained without a large river†, and therefore a large tract of adjacent dry land, unless possibly by the wear of a long line of coast.

The wider spread of the seas over the two countries is resumed at the period of the Lower Bagshot Sands. The change seems to have been a gentle one. The waters recommenced their deposition over the shingle and sands capping the Lignite and Plastic Clay series in the Paris district, and over the London Clay in England, and this change was apparently the result of some extensive subsidence to the south. For not only have the strata of this period a greater range southward, but a new fauna abounding in more southern forms is now introduced, and with it appears in extreme profusion the *Nummulites planulatus*, followed soon after by the several other species of this Foraminifer which so distinguish the middle portion of the Eocene or Paris group of strata of this part of Europe.

Many species of the shells which had passed from the Lower marine sands into the London Clay, or had migrated to some adjacent district, reappear in the "Lits Coquilliers"; but few of them had their existence prolonged to the period of the Calcaire grossier.

* And not, therefore, in any way connected with the rise of the Wealden and Pays de Bray, the final elevations of both of which tracts I believe to be subsequent to this period.

† The large quantity of organic remains derived from land, and at the same time the absence of freshwater shells, must surely indicate the proximity of a considerable tidal river. For this and many other reasons the debris seems to me to have been derived from such a source rather than from the wear of a coast.

A stronger break, physically, takes place between the "Lits Coquilliers" and the "Glauconie grossière" than is shown at the base of the "Lits Coquilliers;" but nevertheless, that break seems of less importance with reference to the animal life of the period, as so considerable a proportion of the species of the "Lits Coquilliers" are continued up into the Glauconie grossière and Calcaire grossier*.

We cannot expect to find in each country an exact identity in the fossils of these various geological zones. The difference is often important. In each centre there are a considerable number of species peculiar to it; and at the same time that there are usually a sufficient number to establish the correlation of the strata, there yet remain sufficient differences to show the variations produced by habitat, depth of water, temperature, &c., such as would exist over areas of like extent in the present day. These variations, while they afford matter for speculation as to what was the ancient distribution of land and water in these districts, yet leave resemblances sufficiently strong to enable us to engage in such speculations upon a sure and certain basis. They also show us that whilst it may not be safe to expect, upon any *à priori* reasoning, a repetition of a like order of palæontological succession in the two countries, we may nevertheless often successfully seek for that order by taking into consideration the limits within which the differences may, under any circumstances, be admitted to extend; and, having determined and eliminated the phænomena which may be considered aberrant, we may look for like terms of comparison where the conditions again become more general and common.

Fragmentary as our Tertiary deposits appear to be, I believe this to be in a great measure the effect of denudation and local peculiarities of structure, and that we shall eventually be able to connect many of them over large areas, and to show that they are for the most part merely the littoral and shallow water deposits of seas which probably had a wide and oceanic range.

* At the same time, although I group the Lower Bagshot Sands and their equivalents in the French series, with the Paris rather than with the London Tertiaries, in consequence of their apparently closer relationship, both palæontologically and lithologically, with the former than with the latter group, still that relationship is not so close but that those deposits may prove to be entitled to a separate grouping. For the zoological gap between the London Clay and the Bracklesham Sands and Calcaire grossier is such, there not being 10 per cent. of species in common, as to indicate a length of time of considerable importance. This period may be probably only in part represented by the Lower Bagshot Sands and Glauconie moyenne. The fauna of the "Lits Coquilliers" is, after all, very distinct, not only from that of the beds beneath them, but also, although to a less extent, from that of the Calcaire grossier above. In England, where mineral evidence alone assists us, it is difficult to separate the two groups; in Belgium, both in mineral character and in the few organic remains, there is still less apparent distinction, whilst in the Paris area, where organic remains become numerous, their individuality as forming a distinct fauna becomes far more marked. From the facts given by M. Alcide d'Orbigny, it seems probable that this deposit attains still greater importance and distinctiveness as it ranges southward. It is in this series that the great development of Nummulites takes place within the London and Paris areas. The under lying London Tertiaries are as much marked by the absence of these Foraminifera as the "Lits Coquilliers" are by their extraordinary abundance.

CORRELA'CALCAIRE GROSSIER,

France.

			HAMPSRTMENT OF THE AISNE. (*D'Archiac.*)	PARIS. (*Brongniart.*)
The Lower Part of the Paris Tertiary Group.		Zone	the Calcaire	Grossier.
		Lower Brackle	Glaises et Sables.	*Wanting.*
			Lits Coquilliers.	
			Sables divers.	
The London Tertiary Group.	Upper.	London Clay. (	*Wanting.*	*Wanting.*
		Rudimen	*Wanting?*	*Wanting.*
	Lower.	Woolwich ar Series. (M	Grès et Poudingues.	*Wanting?*
			gnites et Argile Plastique.	Argile Plastique.
			Glauconie inférieure.	*Rudimentary?*
		Wanti	*Wanting?*	*Wanting.*
			E R I	E S.

[*Quart. Journ. Geol. Soc.* vol. xi. *to face* p. 240.]

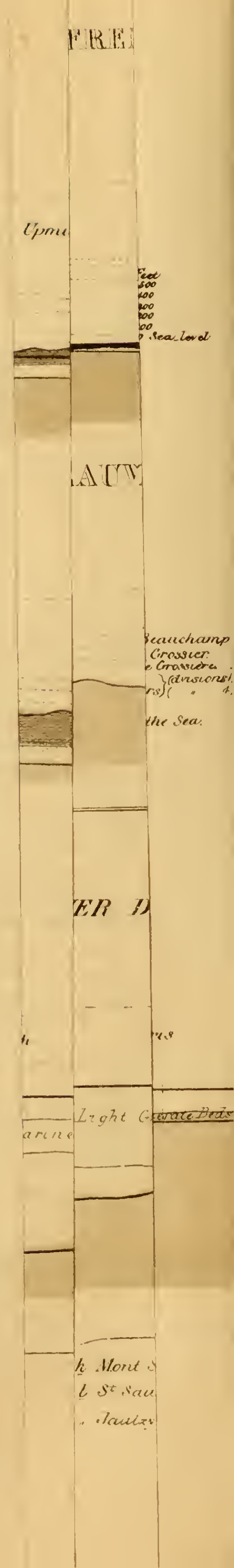
TABLE

SHOWING THE

CORRELATION OF THE TERTIARY STRATA LYING BENEATH THE ZONE OF THE CALCAIRE GROSSIER, IN ENGLAND, FRANCE, AND BELGIUM.

		England. HAMPSHIRE.	England. LONDON.		French Flanders and Belgium. (*Dumont.*)	France. DEPARTMENT OF THE AISNE. (*D'Archiac.*)	France. PARIS. (*Brongniart.*)
		Zone of the Middle Bracklesham Sands and of the Calcaire Grossier.					
The Lower Part of the Paris Tertiary Group.		Lower Bracklesham Sands.	Lower Bagshot Sands.		Système Paniselien.	Glaises et Sables.	*Wanting.*
					Système Ypresien supérieur.	Lits Coquilliers.	
						Sables divers.	
The London Tertiary Group.	Upper.	London Clay. (Bognor beds.)	London Clay.		Système Ypresien inférieur.	*Wanting.*	*Wanting.*
		Rudimentary.	Basement Bed of the London Clay.		?	*Wanting?*	*Wanting.*
	Lower.	Woolwich and Reading Series. (Mottled clays.)	Woolwich and Reading Series.	Upper.	Système Landenien supérieur.	Grès et Poudingues.	*Wanting?*
				Middle.		Lignites et Argile Plastique.	Argile Plastique.
				Lower.		Glauconie inférieure.	*Rudimentary?*
		Wanting.	Thanet Sands.		Système Landenien inférieur.	*Wanting?*	*Wanting.*
		CRETACEOUS SERIES.					

Pl VIII.


FRE
Upm
Feet
Sea level
AUV
Beauchamp
Crossier.
Grossière
divisions
the Sea.
ER D
Light
Beds
arine
Mont S
St Sau
Jaulz

EXPLANATION OF PLATE VIII.

Section 1 is drawn from the nearest points in England and in French Flanders, where all the series beneath the Calcaire grossier zone inclusive occur. The depth and position of the strata along this line are proved at the following points by local sections of railways, wells, and cliffs, which have already been described.

Goldsworth Hill, Chobham Place, Woking Com., Chobham Ridges	See Quart. Journ. Geol. Soc. vol. iii. pp. 382, 384.
Maryland Point, Stratford............	Ibid. vol. vi. p. 262.
Claremont, Mortlake, Kingston, Kensington, Paddington, Hornsey, Hoxton	Ibid. vol. x. pp. 96, 144–7.
Hampstead, Langdon Hill, Rayleigh, Southend, Herne Bay......	Ibid. vol. x. pp. 402–7.
Upminster	Proc. Geol. Soc. vol. iii. p. 132.
Herne Bay, Richborough	Quart. Journ. Geol. Soc. vol. viii. pp. 239, 251.
Chislet, between Herne Bay and Richborough	Ibid. vol. xi. p. 111.
Calais	'The Water-bearing Strata of London,' p. 208.
Cassel	Quart. Journ. Geol. Soc vol. viii. p. 324, and Essai sur la Fland. Franç., pp. 156–169.

The heights of the principal hills in this country I have determined roughly by the aneroid barometer; those in Flanders are taken from the French Ordnance-maps.

Section 2 is a continuation of Section 1 prolonged southward to that nearest portion of the Paris basin where a complete development of all the beds forming the "Sables inférieurs" of M. d'Archiac occurs in connection with the "Calcaire grossier" group. In this second section and part of the first, as I have not had leisure to visit all the French localities, several of the main geological features are derived from the local descriptions of Sir Charles Lyell and M. Meugy in Flanders, of M. Buteux in the Somme, and M. Graves in the Oise; whilst the general configuration of the country is taken approximately from the admirable French Ordnance-maps, which furnish us with levels both of hills and river-courses, that our otherwise excellent maps are entirely deficient in.

The following are the references to sections on this line:—

Bailleul, p. 153; Armentières, p. 152; Seclin, p. 107; Douai, p. 106; see also map and sections;—Meugy, "Essai de Géologie pratique sur la Flandre Française," 1852.

Mons-en-Pévèle;—Lyell, Quart. Journ. Geol. Soc. vol. viii. p. 359.

Davenescourt and Hangest, north of Montdidier, p. 45;—Buteux, "Esquisse Géologique du Département de la Somme," 1849.

Coivrel, pp. 184, 244; Agnetz, pp. 248, 370, 493; St. Felix, pp. 299, 372;—"Essai sur la Topographie Géognostique du Département de l'Oise."

The neighbourhood of Noailles is sketched chiefly from my own observations.

The paper of M. Elie de Beaumont in the 'Mémoires de la Société Géologique de France,' vol. i. p. 107, has aided me in the general features. The valuable geological maps of M. Elie de Beaumont and M. Dumont have also been of material assistance.

1, GENERAL SECTION FROM THE HILLS NEAR BAGSHOT TO CASSEL IN FRENCH FLANDERS.
DISTANCE 156 MILES.
Chobham Ridges
St George's Hill
Kingston
Hampstead & Highgate Hills
Valley of the Lea
Langdon Hill
Southend
Mouth of the Thames
Herne Bay
Richborough Castle
The English Channel
Calais
Watten Hills
Cassel
London Clay
Lower London Tertiaries
Chalk
2, GENERAL SECTION FROM CASSEL TO NOAILLES NEAR BEAUVAIS.
DISTANCE 125 MILES.
Cassel
Mons en Pévèle
Douai
Bapaume
Montdidier
Agnetz near Clermont
Noailles
Ypresian Sands
Ypresian Clay
Landenian Sands
Chalk
SECTIONS & DIAGRAM
ILLUSTRATIVE OF
THE CORRELATION OF THE LOWER TERTIARIES
OF
ENGLAND, FRANCE, & BELGIUM.
Middle Bagshot Sands | Système Bruxellien | Calcaire Grossier, Glauconie Grossière
Lower Bagshot Sands | Ypresian Sands | Sables Inférieurs, upper part
London Clay | Ypresian Clay
Lower London Tertiaries | Landenian Sands | Sables Inférieurs, lower part
Chalk
DIAGRAM OF THE LOWER LONDON TERTIARIES, THE SYSTÈME LANDENIEN, AND THE THREE LOWER DIVISIONS OF THE SABLES INFÉRIEURS OF M. D'ARCHIAC.
(GROUP Nº 1 OF THE ABOVE SECTIONS ENLARGED.)
Position of Chobham
London
Herne Bay
Richborough
Calais
Armentières
S.E. of Mons en Pévèle
Noailles
Thanet Sands
Middle Chalk
Lower Chalk
Woolwich & Reading Series
Thanet Sands.
Lower Landenian.
Upper Landenian.
Sables Inférieurs; div. 4, 5, & 6, D'Arch.

Not having sufficient data to give the dip of the Chalk throughout these sections, I have preferred leaving out the stratification altogether, and merely inserting the Chalk as a rock-mass under the Tertiaries (see below).

These lines of sections do not follow a straight line,—the variations of directions are indicated approximately. The horizontal scale is about 7 miles to the inch, and the vertical scale 2000 feet to the inch.

The numbers under the names of places denote the height of the spot in feet above the sea-level.

The black shading marks the depth of water in the Channel and the Thames.

The zones 6 and 7 are left blank, as their correlation is not treated of in this paper.

For the divisions of the Sables inférieurs of M. d'Archiac see p. 208; also Table.

All the Faults and minor disturbances are omitted in both sections.

Diagram. As the scale of the preceding sections does not admit of any detail in the structure of the lowest group of the Tertiaries—that between the Chalk and the London Clay—I have here given a theoretical restoration of these beds as presumed to have extended from London to Paris. It is, in fact, a magnified representation of zone No. 1 of both the Sections above, irrespective of the present configuration of the surface.

The vertical dotted lines denote the position of the proved and complete local sections on which the whole series is established, whilst the chief places at which each member of the series can best be studied is indicated by the names attached to the corresponding letters.

The distances are only approximately preserved in this diagram. The scale of depth is one inch to 200 feet.

The stratification of the Chalk is not given, for the same reason as mentioned with respect to the sections. I may state, however, that beneath the Tertiaries at Paris, the Chalk has been found to be 1400 feet thick; whilst at Lille the Tertiaries repose upon Chalk-strata only 217 feet thick and overlying the Carboniferous Limestone; at Calais, the Chalk beneath the Tertiaries again attains a thickness of 765 feet, reposing upon the Coal-measures; and at London of 645 feet, resting on the Upper Greensand and Gault.

For the evidence on which that portion of the Diagram which extends from Chobham to Richborough is founded, see my paper "On the Woolwich and Reading Series," in Quart. Journ. Geol. Soc. vol. x p. 75–170, and Plate.

At Calais, the well-section showed, under 85 feet of recent deposits and 20 feet of London clay, beds which I should group thus:—

	feet.	
Greenish sands with traces of shells	10	*Basement bed of the London Clay?*
Large flint-pebbles	$3\frac{1}{2}$	
Light-coloured green sands; traces of shells...	32	*Woolwich and Reading series.*
Very fine light-grey sands	17	*Thanet Sands.*
Clayey sands with traces of shells...............	8	
Compact sandy clay	11	
Hard brown clay with traces of shells...........	23	
Beds of clayey grey and greenish sands	19	
Bed of flints in clay..................................	$\frac{10}{12}$	
Chalk.		

As the specimens were much crushed by the auger, I could not determine any of the shells. Between Calais and Cassel I have no sections, except shallow surface-sections at Watten, where I recognised the London Clay.

At Armentières, under 37 feet of London Clay, M. Meugy describes* (*op. cit.* p. 152):—

	feet.	
"Blackish sand, rather compact	10	(*Basement bed?*) Upper Landenian. (*Woolwich & Reading series.*)
Loose green sand	34	
Plastic clay	2	
Greenish clayey sand	52	Lower Landenian. (*Thanet Sands.*)
Compact clay	10	
Hard and dry clay	36	
Chalk."		

A little beyond our line of section, and further to the east, a well-section at Tourcoing (p. 150) gave,—

	feet.	
"Clay	7½	
Shifting sand	36	
Blue clay	147½	Ypresian clay. *London Clay.*
Green sand	16	Upper Landenian. (*Woolwich & Reading series.*)
Seam of lignite	¼	
Green sand	44	
Clay mixed with sand	22	Lower Landenian. (*Thanet Sands.*)
Clay with seam of iron pyrites	3	
Clay mixed with sand—at base a hard stone (carbonate of iron?), 4 to 5 in. thick	33	
Black sandy clay—dry and with pebbles	57	
Chalk."		

At La Magdeleine near Lille (p. 148), under drift and 28 feet of London clay, there occurs,—

	feet.	
"Fine green sand	10	Upper Landenian.
Ditto with a seam of clay	2	
Argillaceous green sand, effervescing with acids	46	Lower Landenian.
Blackish grey clay, very compact	28	
Greyish argillaceous sand (effervesces)	11	
Chalk."		

At Orchies (p. 146), to the southward of Lille, under 18 feet of drift and 20 of London clay, there are,—

	feet.	
"Grey quick-sand	14	Upper Landenian.
Green sand	70	
Seam of clay and thin quick-sand	2	
Hard sand	25	Lower Landenian."
Clay	21	
Hard sand	6	
Clay and sand	5	

Near Faumont, between Lille and Douai, the section is as follows—

	feet.	
"Vegetable soil and clay	25	Ypresian clay.
Blackish quick-sand	7	Upper Landenian.
Green quick-sand with a seam of blue clay	67	
Green sand and hard clay	24	Lower Landenian."
Plastic clay	28	

M. Meugy further speaks of the upper glauconiferous sands (Upper Landenian?) which forms the small outliers south of Douai and of the River Scarpe. It is not clear from the text if he means that the Lower Sands are wanting; but in his sections he makes the outlier at Brunemont, near Douai, to consist of both Lower and Upper Landenian—

* In these descriptions, I merely give a literal translation of the original—my own additions are in *italics*.

the former, however, being reduced to one-third of the thickness he gives to it on the north of Douai. (Pl. VIII. Sect. 2.)

South of this district extends part of the great Chalk-plateau of Picardy, rising to an average height of 300 to 500 feet, and showing only at a few distant intervals small cappings of Tertiaries. Of this district we only possess a very general description. A little to the east, however, of this line of section, between St. Quentin and Peronne, M. Elie de Beaumont has given (*op. cit.* p. 112 and pl. 7. fig. 1) a section which is of considerable interest, inasmuch as it shows that, whereas at Mons-en-Pévèle the Lignite series is separated from the "Lits Coquilliers" and "Glauconie moyenne" by 150 feet of London clay, at the hill above Marteville, near St. Quentin, the London clay is apparently wanting, and the total thickness of the strata beneath the Glauconie moyenne is thus much reduced (see Pl. VIII. Sect. 2). The following is an abstract from the text (p. 113):—

	feet.
Sand with calcareous concretions, full of *Nummulites* and *Turritella*...	10 to 13
Greenish laminated clay, containing vegetable impressions and capped by a seam of imperfect lignite	26 to 32
Thin seams of red, yellow, and black clays, with indications of lignite:—a few decimetres.	
Quartzose sand with green grains, the lower part greener than the upper.	

The thickness of the last bed is not given, but from the general description, the section, and the height of the hill, and as at a short distance lower down the hill the Chalk crops out, I should suppose it not to exceed 20 to 30 feet. Now I presume these upper sands belong to the Glauconie moyenne (Graves), with the *Nummulites planulatus,* and that the clays, lignites, and greenish sands belong to the Upper Landenian or the Woolwich and Reading series.

The department of the Somme has been more fully described by M. Buteux, according to whom the Tertiary outliers set in again more continuously in the neighbourhood of Montdidier. He gives the following section on the chalk-hills between Davenescourt and Hangest:—

	feet.
"Grey sand and thin seams of sandstone	2
Reddish sand	6½
Greenish sand	9¾
Whitish sand	?"

It is on the confines of the Somme and the Oise that the remarkable thick pebble-beds, extending from east to west, and which M. Graves (p. 182) considers as indicating the boundaries of an old shore, occur. On Mont Soufflard, between Montdidier and Breteuil, these beds are largely developed. M. Buteux gives the following section of them:—

	feet.
"Round flint-pebbles enveloped in a matrix of grey plastic clay*	25
Grey and yellowish plastic clay, with rare remains of shells	4
Sandy bluish grey clay	4
Lignites	6½
Bluish plastic clay	4
Whitish sand passing into greenish	16
Plastic clay	?"

M. Graves gives the following section of the hill-top at Coivrel, south of Montdidier:—

	feet.
"Yellowish and ferruginous sands with sandstone	23
Compact green clay	2

* According to M. Graves (p. 243), it is—sands and pebbles 26 feet. The shells beneath he states are the *Ostrea Bellovacina* and *Paludina lenta.*

	feet.
Greenish marl with *Ostrea Bellovacina, Melania inquinata, Cerithium acutum, Cyrena cuneiformis*, &c.	1
Green clay	4
Earthy lignite mixed with some red clay and flat pieces of iron pyrites	$3\frac{1}{4}$
Green clay	2
White sand."	

At Pronleroy, a short distance south of Coivrel, is this section (p. 244). The lower sands here commence to exhibit the marine fossils of Bracheux.

	feet.
"Mottled grey and buff stiff clay containing petrified wood	2
Hard greyish fissile limestone full of *Chara* seeds	$3\frac{1}{4}$
Greenish marl with *Ostrea Bellovacina* in abundance	1
Green sand with the same oysters	$2\frac{1}{2}$
Whitish-grey sand, with *Cucullææ, Crassatella sulcata, Venericardia multicostata, Turritella edita*, &c.	5
Yellow sands with the same shells more numerous	8
Chloritic sands without fossils,—the Chalk at a slight but variable depth."	

This series is extremely variable. The following is the section (p. 234) at St. Sauveur, near Pont St. Maxence, one of the places where the beds over the lignite (but belonging to that series) contain marine shells.

	feet.
"Superficial soil	$1\frac{1}{3}$
Yellow sand, containing an immense quantity of *Ostrea Bellovacina, Cerithium mutabile, Cyrena cuneiformis, Pectunculus terebratularis*, &c.	$8\frac{1}{2}$
Grey glauconiferous sand	$3\frac{1}{4}$
Bluish marl with *lacustrine shells*	$3\frac{1}{4}$
Earthy lignite	2
Greenish and bluish Fuller's-earth	4
Lignite, soft	$0\frac{3}{4}$
Blackish *shelly* marl	$1\frac{1}{2}$
Lignite, harder	$0\frac{2}{3}$
Marly yellowish-white limestone, hard, fissile, and *shelly*	1
Hard compact lignite, with plants, and bones of *Lophiodon, Crocodile*, &c.	4
Blue marl with selenite	$3\frac{1}{4}$
White clay	5
Grey glauconiferous sands, to the water-level	$8\frac{1}{2}$

These beds dip beneath the Glauconie moyenne (Graves)."

A well at Clermont gave the following section (p. 288):—

	feet.
"Sands belonging to the Glauconie moyenne	$19\frac{1}{2}$
Brown clay	$6\frac{1}{2}$
Sandy marl with *Cyrena, Ostrea, Cerithium*, &c.	$1\frac{1}{2}$
Earthy lignite	1
Blackish clay	$1\frac{1}{3}$
Earthy lignite	$1\frac{1}{4}$
Greenish-yellow glauconiferous sands."	

At Boulincourt, near Agnetz, the thickness and number of the beds forming the lignite series varies very greatly. At Froidmont, between Clermont and Beauvais, is this section (p. 249):—

	feet.
"Yellowish clayey sand with flint-pebbles, *Ostrea Bellovacina*, and veins of white marl,—very variable	11
Several beds of earthy lignite, separated by greyish clayey marl—very variable	3
Bluish-grey clay	$6\frac{1}{2}$
Fine grey sand, compact—maximum thickness	13
Earthy lignite, containing pyritous wood and nodules of iron pyrites	2
Marly limestone with lacustrine fossils	$0\frac{1}{3}$

	feet.
Bluish-grey clay	2
Earthy lignite with petrified wood and bones of reptiles	2
Bluish-grey clay	$2\frac{1}{3}$
Very compact grey clay	10 to 16"

The section at Bonvillers (p. 250), near Noailles, shows a mottled clay above the lignites :—

	feet.
"Yellowish clay, mottled purple, with flint-pebbles; it is sometimes entirely red	$7\frac{1}{2}$
Green clay with broken shells, *Ostrea*, *Cyrena*, &c.	2
Bluish-grey laminated marl	$6\frac{1}{2}$
Earthy lignite mixed with clay	$1\frac{2}{3}$
Ferruginous grey sand	4
Hard lignite	1
Grey compact clay	$1\frac{1}{3}$
Lignite, petrified wood, and bitumiuous trunks of trees, nodules and beads of iron pyrites, remains of reptiles, &c.	$5\frac{1}{2}$
Bluish-grey clay	16
White sand."	

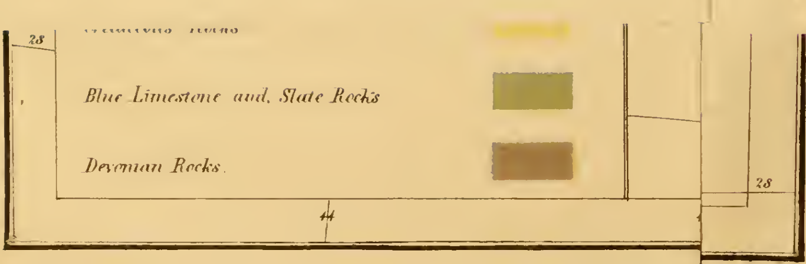
At Noailles and Abbecourt, the lignite series may in both cases be seen in the slight cuttings on the sides of the lanes, overlying yellowish sands without fossils at the top, but abounding with the ordinary Bracheux shells lower down, and then the Chalk. M. Graves gives the following section of the pit at Bracheux, near Beauvais (p. 188) :—

	feet.
"Superficial soil	$1\frac{1}{2}$
Disturbed beds, with shell-debris	2
Thin layers of *Ostreæ* lying flat, with remains of fishes and broken shells ...	$6\frac{1}{2}$
Irregular vein of iron-sandstone	$0\frac{1}{2}$
Bed of crushed shells, very abundant, replaced at places by a friable white marl	$2\frac{1}{2}$
Yellow sand containing a small number of perfect shells, especially *Cucullæa* and *Venericardia*	$2\frac{1}{3}$
Finer sand with green grains—the same shells more numerous, but friable ...	$2\frac{1}{2}$
Bed of the crushed shells very abundant in the same sand	1
Grey chloritic sands with entire fossils, not numerous, and flint-pebbles of all sizes	$7\frac{1}{2}$
Chalk, with its superficial bed of broken flints."	

There are no sections of the lower beds between the Dep[t]. of the Oise and Paris. The following is M. Chas. d'Orbigny's section of Meudon* near Paris, which may serve as a type for the lower beds of that district, except that the fossiliferous lignites and conglomerates, Nos. 6 to 8, are only of local occurrence,—and that traces of the lignites and clays with fluviatile shells, the equivalent of the above-described lignites and clays of the Soissonnais, are occasionally found overlying the mottled clays (No. 10).

	No.		feet.
Calcaire grossier.	12.	"Calcaire grossier	46
	11.	Glauconiferous sands	$2\frac{1}{2}$
Argile Plastique.	10.	Plastic clay, red, grey, &c.	6 to 26
	9.	White marl, with calcareous nodules	1
	8.	Lignite, with large *Paludina* and *Anodon*	$1\frac{1}{4}$
	7.	Laminated clay, with selenite, iron-sandstone, &c.	$0\frac{2}{3}$
	6.	Conglomerate with remains of Mammals, Reptiles, Fishes, marine and fluviatile shells, &c.	$1\frac{1}{2}$
	3–5.	Pisolitic limestone	6
	1–2.	Chalk."	

* Bull. Soc. Géol. de France, vol. vii. p. 281.


28
Blue Limestone and Slate Rocks
Devonian Rocks.
44
28

On the Geology *of portions of the* Turko-Persian Frontier, *and of the* districts adjoining. By William Kennett Loftus, Esq., F.G.S.

(Communicated from the Foreign Office, by order of the Earl of Clarendon.)

[Read June 21*, 1854.]

[Plate IX.]

Note.—The publication of this Memoir having been unavoidably postponed, the Council thought proper that a full Abstract should appear in its place in No. 40 of the Society's Journal. This Abstract (Journ. vol. x. p. 464, &c.) will prove of the more service, as illness before the completion of the Survey, and afterwards multiplicity of business previous to his second departure from England, rendered it impossible for the Author himself to draw up a summary of his views, or even to conclude his Memoir, as he had intended, with general remarks on the whole subject.—Ed.

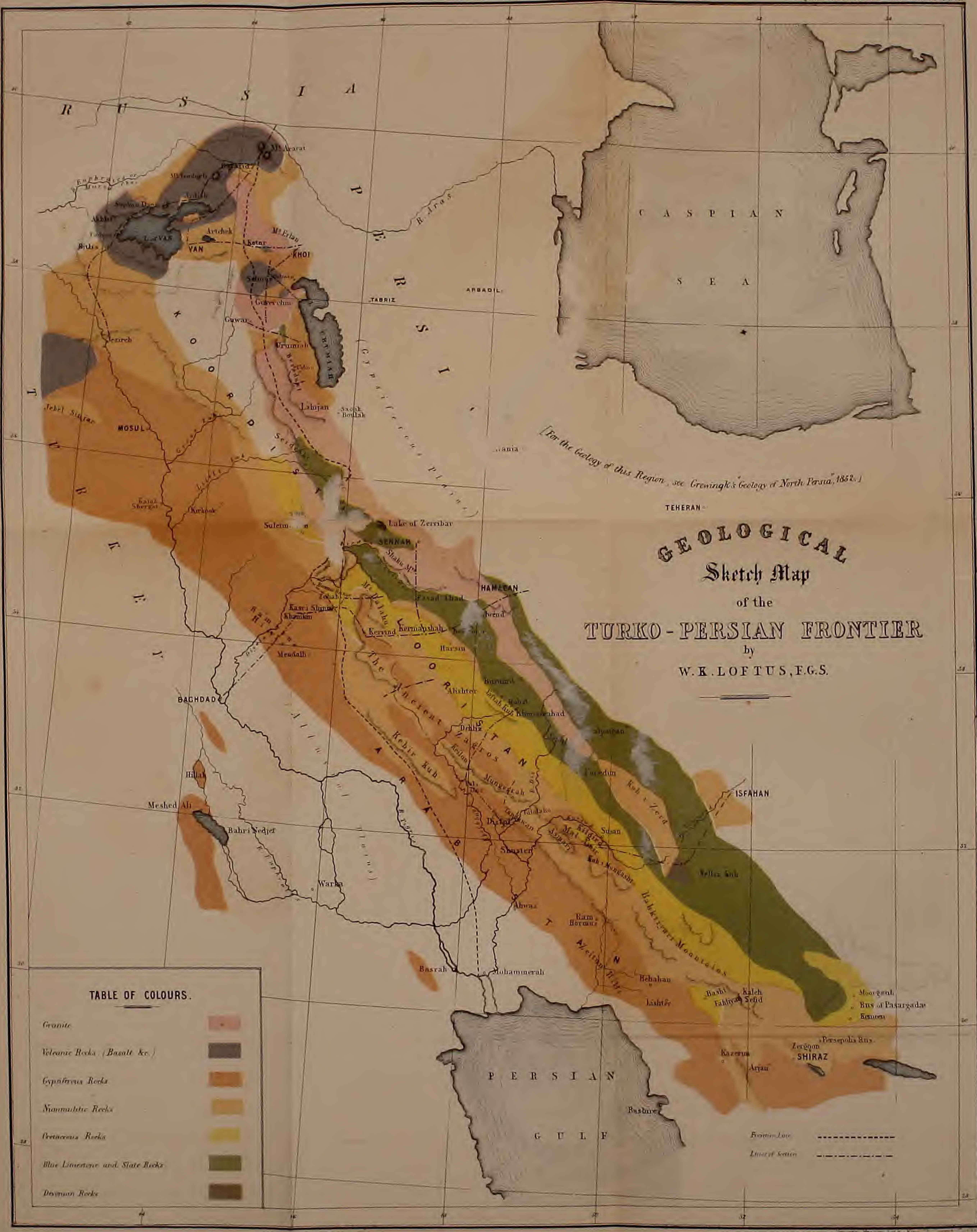
[Contents.]

Introduction.—The notes from which the following paper† has been compiled 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 demarkation of the Turko-Persian Frontier.

For the greater part of the first three years various political questions detained the Commissioners on the alluvial banks of the Lower Tigris, where but little scope exists for the labours of the geologist.

* For the other Communications read at this Evening Meeting, see Quart. Journ. Geol. Soc. vol. x. p. 454, &c.

† The collections of rock-specimens and fossils made by Mr. Loftus are deposited in the British Museum, the Museum of Practical Geology, and the Museum of the Geological Society.—Ed.


GEOLOGICAL
Sketch Map
of the
TURKO-PERSIAN FRONTIER
by
W. K. LOFTUS, F.G.S.
TABLE OF COLOURS.
Granite
Volcanic Rocks (Basalt &c.)
Gypsiferous Rocks
Nummulitic Rocks
Cretaceous Rocks
Blue Limestone and Slate Rocks
Devonian Rocks
Frontier Line
Line of Section
[For the Geology of this Region, see Grewingk's "Geology of North Persia," 1853.]
CASPIAN SEA
PERSIAN GULF
RUSSIA
PERSIA
TURKEY
KOORDISTAN
LOORISTAN
ARABIA
Mt. Ararat
VAN
KHOI
TABRIZ
ARDABIL
URUMIAH
MOSUL
Kirkook
Lake of Zerribar
SENNAH
HAMADAN
Kermanshah
TEHERAN
BAGHDAD
Hillah
Meshed Ali
Warka
ISFAHAN
Shuster
Ahwaz
Basrah
Mohammerah
Behbahan
Kazerun
SHIRAZ
Persepolis Ruins
Bushire
Bakhtiyari Mountains

When at length the running survey of the mountainous portion of the frontier was proceeded with, it advanced with such rapidity that the party was seldom two days encamped upon the same spot; thus there occurred no opportunities for minute geological investigation.

Other difficulties of no ordinary nature presented themselves. Our route lay through the midst of those wild mountain tribes who from time immemorial have never acknowledged law or subjection, and who regarded our movements with infinite distrust. Owing to the insecurity of the country, habitations were so few that we were frequently obliged to carry provisions for many days together. Add to these facts the ruggedness and inaccessibility of the passes and mountains, as well as the intense heat of the climate (sometimes reaching 124° Fahr. in the shade), and it may be conceived that our labours were attended with considerable danger as well as difficulty. Under these circumstances, I trust that every allowance will be made for the imperfect nature of this communication.

In this place I cannot omit returning my sincere thanks to Her Britannic Majesty's Commissioner, Lieut.-Col. Williams, C.B., for the facilities he invariably afforded me, and without which it would have been utterly impossible to have reached such localities as I considered desirable for the prosecution of my researches.

Mr. Ainsworth is the only geological author who has, from actual observation, written on the structure of any portion of the country under consideration; and, although I had no opportunity of going over the same ground, his 'Researches in Assyria, Babylonia, and Chaldæa,' in connexion with the labours of the Euphrates Expedition, have been of considerable aid to me in tracing the geographical extent of the various formations in their western range.

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. See Map, Pl. IX.

The first 250 miles, from Mohammerah to near Mendáli, is an arid and deserted waste, infested by plundering parties of Arábs and Kúrds, but capable for the most part of extensive cultivation.

From Mendáli to Zoháb (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. See General Section*, fig. 1.

From this point to near the Lake of Zerribar (60 miles) is a succession of regular saddle-shaped 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, constitute the axis of the vast barrier-ridge nearly as far as Bayázíd at the southern foot of Mount Ararat, a distance of 270 miles.

* The woodcut diagrams, reduced from the original sections, are to be found at pp. 326–344.

The journeys of the English Commission, and my own when on detached service, extended, however, as far south as Shiráz (lat. 29° 36′ N.). Many of my most valuable sections were obtained during these journeys; and, as they throw light on the order of succession of the different formations upon the immediate line of the Frontier, I have ventured frequently to refer to them.

If a traveller approach the dominions of the Shah from the Persian Gulf, or from Lower Mesopotamia,—that is, between the parallels of latitude of Shiráz and Súleimánia (29° 36′ and 35° 16′ N.),—he must cross the vast range of the ancient Zagros, and invariably meet with the greater portion of the section as exhibited in fig. 1. Further northwards, however, the igneous eruptions alter and contort the sedimentary rocks in such a manner as to render their recognition no very easy task. I therefore deem it advisable to describe, in the first place, the least complicated and best developed sections in the south, extending as far northward as the A′b-í-Shírwán (lat. 35° 8′ N.); and, in the second place, to describe certain sections in the north, which throw light on the age of the disturbing forces, and present some interesting phænomena connected with the deposits of travertin.

PART I.

Although contrary to the usual course, I propose describing the various formations in descending order, because they so present themselves to the traveller going eastward, and because this plan is more likely to be serviceable to such European travellers as may feel desirous of adding to our scanty knowledge of the geology of those little-visited regions.

I. Recent Deposits.

1. *Alluvium.*—This term has usually, with regard to the Mesopotamian plains, been applied to the soil composing the basins of all the great rivers falling into the Persian Gulf, and extending from the Hamríne Hills, on the east of the Tigris, to the Báhr-í-Nedjef, on the west of the Euphrates. The alluvial formations are, however, much more circumscribed, and do not extend beyond a few miles eastward of the Tigris, where they pass imperceptibly into the underlying light reddish sands or fine gravels of the beds 2 of figs. 1 & 2, of which the Hamríne Hills are composed. These older beds frequently dip at an angle of 70°, and gradually become horizontal in their extension westward. The similarity of their general aspect with the alluvial beds, which have chiefly been derived from their denudation, renders it very difficult to define the exact limit of either formation.

The alluvium may be clearly divided into—(A.) fluviatile and (B.) marine.

(A.) The fluviatile alluvium, now in process of deposition, is limited to the banks of the rivers, with the adjoining marshes and canals. It consists of a stiff blue, or fine arenaceous grey clay, and fine sand or gravel. These deposits are dried and cracked in every direction by the intense heat of the sun, and are on this account exceedingly difficult for a horseman to traverse. They afford a rich soil for the cultivation of maize, rice, water-melons, cucumbers, and the ordinary vegetables of the Arábs; and they frequently contain imbedded shells of extinct species of the genera *Cyrena*, *Unio*, *Melanopsis*, *Helix*, &c. At the junction of the Diyála River with the Tigris below Bághdád the deposit is a tenacious deep-red clay, derived from the Hamríne red range, through which this river passes in its course from the higher mountains.

At Bághdád the foundations of all good buildings are laid on this clay, at a depth of 15 or 18 feet below the surface, upon which rests an arenaceous grey clay used for common fictile purposes. During an extraordinary rise of the Tigris in the spring of 1849, the deposit on its banks at Bághdád attained the height of six feet.

(B.) The marine beds of the alluvium are much more extensive than the fluviatile, and consist of dark-grey or reddish-yellow loose sands and sandy marls. These are usually seen in the desert, at some distance from the rivers; and, where not otherwise distinguishable from the beds of the underlying rocks, are to be recognized by the growth of saline plants, and by dark wet patches, produced by the presence of chloride of sodium. They are sometimes accompanied by fossils.

In the neighbourhood of Mohammerah, Sáblah on the Kárún, and Busrah, are the following shells, identical with species now living at the mouth of the Persian Gulf,—so far at least as they have been compared with a small collection, made by the late Captain Newbold, E.I.C.S., from the beach of Bushir. (Identified specimens are marked with an asterisk.)

Fossil Shells from Mohammerah, Sáblah, and Busrah.

Venus.	Neritina crepidularia, *Lamk.*	*Purpura (Rapana).
Arca.	Purpura.	*Cerithium.
Melanopsis.		Cypræa.

Strewed over the desert in the neighbourhood of the extensive ruins of Worka and Sinkara, in Lower Chaldæa, and on the verge of the marshes of the Euphrates, are innumerable fossils, of which I collected 30 species, many of the specimens exhibiting distinct traces of colour. The Arab women of the Mádán tribes collect and wear them in their hair as ornaments.

Fossils from Worka and Sinkara.

Astræa.	Neritina sp.	Strombus.
Meandrina.	Nerita.	Nassa.
Balanus ?	Trochus.	Columbella.
Venus.	Cerithium.	Mitra.
*Cardium.	Planaxis sulcata.	Cypræa; 2 sp.
Spondylus.	Purpura.	Ancillaria.
Dentalium octangulum.	*—— (Rapana).	Oliva.
—— sp.	Murex.	Conus; 2 sp.
Melanopsis.	Triton ?	Otolite of a Fish.
Neritina crepidularia, *Lamk.*		

Mr. Ainsworth met with abundance of similar fossils near the first-mentioned locality, at Gerah on the Euphrates; and Messrs. Fraser and Ross, during a journey through the Jezireh of Chaldæa, observed a large surface of the desert on the banks of the Shat-el-Hie, a few miles to the N.E. of Worka, literally composed of shells. It is to be regretted that none were preserved.

Still further to the north, in the centre of the Jezireh, in about lat. 32° 10′ N., between the Lemlúm marshes and the ruins of Niffr, I picked up numerous pieces of silicified shell-conglomerate with a white and siliceo-calcareous matrix. From the abundance of these fragments, and from their angular aspect, it is evident that they must have been derived from the immediate locality, although the outcrop and position of the beds, with relation to the older and newer deposits, are entirely concealed beneath the drifted sands of the desert.

Mr. Ainsworth, who had good opportunities for examining the order of stratification of these beds, exposed in the sections upon the banks of the Euphrates, divides this marine formation into two parts:—"the upper and more sandy beds were characterized by the trochoidal and buccinoidal forms of turrited univalves;" and the most abundant shells in the lower argillaceous beds were a *Venus*, a *Cyrena*, a Mytilaceous shell, and some turrited univalves. (*Op. cit.* p.123.)

An examination of the fossils of this marine deposit proves, that at a comparatively recent period the littoral margin of the Persian Gulf extended certainly 250 miles further to the N.W. than the present embouchure of the Shat-el-Aráb—the combined stream of the Tigris and Euphrates, and 150 miles beyond the junction of these two great rivers at Korna.

The actual extent of this marine deposit to the N.W. it is impossible to define, as, from the nature of its formation in the shallow estuary, it probably passes upwards gradually into the more recent fluviatile beds.

Mr. Ainsworth, in his 'Researches,' and Col. Rawlinson, in a paper read before the Geographical Society in 1850, have both shown the rapid accumulation of this alluvial deposit, which is represented to increase a mile in thirty years at the head of the Persian Gulf. It is therefore needless here to repeat the investigation;—especially as I have no new matter to add upon the subject.

2. *Lacustrine Deposit.*—The only deposit of this nature which I was so fortunate as to meet with was in the mountains of Lúristán, upon the elevated plateau of Hassan-í-Gowdar, between Khorremábád and Bisútún. This plateau is surrounded on all sides by lofty peaks, and presents the appearance of having been at some time or other the basin of a lake. A small stream on the north side of the plain exposed a section 12 feet deep, and exhibited a friable, loose, yellowish limestone, filled with freshwater shells, viz.—

Planorbis; allied to *P. corneus*.
Planorbis; a striated species.
Planorbis; allied to *P. marginatus*.
Lymnæus; an elongated species.

The entire absence, with the above exception, of Lacustrine Deposits in the region I am describing is somewhat remarkable, when it is considered that such are the most extensive and largely developed of all stratified rocks throughout the adjoining districts of Asia Minor.

In this place it would be proper to discuss the recent deposits of calcareous tufa (see Part II. of this Memoir); but, as these do not appear in the Southern part of the Frontier, and as they constitute a very important feature in the investigation of the rocks at the northern end, I omit the consideration of them at present, and proceed to the subject of the gravels underlying the above-described fluviatile and marine alluvia.

3. *Limestone Gravel.*—In many localities (especially in the neighbourhood of Dizfúl; see fig. 4, p. 329) on the outskirts of the great chain, an enormous accumulation of gravel reposes nearly horizontally on the upturned edges of the tertiary strata, or dips at a slight angle towards the plains on the S.W., in which direction it gradually thins out. Seen from the plains at sunset, these gravel-masses present a very peculiar appearance, their surfaces being cut up and deeply furrowed by innumerable channels, caused by the heavy periodical rains. Towards the N.E. and E., at their greatest elevation, they frequently terminate abruptly in a perpendicular escarpment. A very remarkable instance of this occurs about twelve miles N.E. of Dizfúl, where, after attaining the summit of the range, the road is carried to the valley of Giláláhú by a zigzag path down the face of a cliff, which, judging by the eye, must be 200 feet in height, and is entirely composed of this limestone gravel (see also fig. 3, p. 328). The escarpment bears 12° S. of E. for a distance of about twenty miles, being only interrupted by the passage of the River Diz and the Kúnak Stream. Magnificent sections are obtained along the course of these streams, as well as at the debouchure of the River Kerkhah into the plains of Arábistán. Masses of this deposit frequently stand isolated from the main range, and, being precipitous on all sides, were formerly the strongholds of the mountain-chiefs. Tangaván, at the N.W. extremity of the escarpment above alluded to, is a conspicuous and fine example of an isolated gravel-fortress.

The town of Dizfúl is situated on the left bank of the River Diz, which here cuts through cliffs of this gravel 60 feet high. The actual thickness of the deposit is certainly not less than 100 feet in this locality (see fig. 4).

The serdaubs, or cellars, in which the natives pass the day during the scorching heat of summer, are excavated in it, and are reached by long flights of steps.

Subterraneous canals called Konáts, for irrigation derived from the river, have been cut by Persian perseverance for miles through the gravel at a great depth below the surface. Their course is traceable by the heaps of pebbles thrown out at regular intervals through wells. To one of these Konáts, $1\frac{1}{4}$ mile E. of Dizfúl in the direction of the mountains, I descended by 60 steps of 13 inches each; *i.e.* 65 feet.

The same deposit is cut through by the Áb-í-Zál, in its course from the higher ranges to its junction with the Kerkhah. The section of the cliffs at the ruins of the Sassanian Bridge over the Zál shows a perpendicular height of 80 feet.

Not having examined the west skirts of the Pushtí Kúh, I am not able to state whether the gravel extends N.W. of the Kerkhah; but from the contour of the outer range seen from a distance, it most probably does so. Eastward of the Pushtí Kúh, however, it occurs in the trough of the Máh Sábádán, resting, as usual, unconformably on the gravels, sands, and marls of the gypsum-series. The road along this valley is exceedingly painful and difficult, as the boulders are of enormous size and obstruct the pathway. They cease, however, at the junction of the Kashghán and Húlílán streams, which constitute the Kerkhah.

Similar masses of gravel are met with in the plain of Hershel, at the point where the River Shírwán emerges from the gorge of Semirám. They repose horizontally on the edges of the gypsiferous rocks, and abut against the side of the Bámú limestone-range.

The components of this gravel, wherever met with, are essentially the same; and prove beyond a doubt that the deposit is everywhere due to the same cause, whatever that may have been.

At Dizfúl we have the following per-centage of the component materials:—

Pebbles of	*Character.*
1. Compact, blue, crystalline limestone.	Generally oval, or with the angles worn off, frequently 2 feet in diameter; 43 per cent.
2. White or cream-coloured nummulitic limestone.	Ditto ditto, but not quite so large; 38 per cent.
3. Breccia of small angular fragments of coloured cherts in a matrix of hard sand.	Oval, 9 inches in length; 5 per cent.
4. Fine-grained, friable, red sandstone.	The largest 1 foot in diameter, cubical angles worn off; 5 per cent.
5. Red, dull-green, and other coloured cherts.	½ inch in diameter; 5 per cent.
6. Quartzose yellow sandstone.	Rounded, 3 inches in diameter; 4 per cent.
7. White quartz.	Less than 1 in. square; 4 per cent.

North of Shuster I observed likewise a few angular and rounded lumps of bitumen; but in no instance was there a fragment of igneous rock. Kidney-shaped calcareous nodules frequently occur, having a large central cavity, lined with small crystals of calcareous spar.

The matrix is of two kinds:—

1. Fine cherty sand.
2. Calcareous yellow paste.

The two varieties, which are equally common, occur together. The first is, however, more frequent than the other in the plains on the eastern skirts; and the latter in the mountains.

The pebbles are firmly cemented together, and are frequently covered with a thick calcareous *enduit*.

The blue limestone-boulders are sometimes much weather-worn; numerous regularly-formed channels radiate from a slightly projecting centre, and give the boulders somewhat the appearance of the radiating concretionary nodules found in the Magnesian Limestone of Sunderland. This, however, only occurs on the surface of the blue limestone-pebbles, and is not observed on that of any other of the components of this gravel.

Throughout the whole of this vast accumulation the various pebbles are thrown together without the slightest appearance of order or stratification. They are nearly, if not all, derived from the rocks composing the mountains immediately adjacent; namely, the blue limestone from the ambiguous Lower Secondary series;—the white and cream-coloured limestone and the pebble-breccia, from the Nummulitic formation;—the red sandstones and variegated cherts, with probably the quartzose sandstone and white quartz, from the sands and gravels of the Gypsum-series, which this gravel-conglomerate immediately overlies. It is remarkable that the boulders derived from the greatest distance are the most common, while a very small per-centage is found of the nearer rocks. This, however, may be accounted for by the soft and friable nature of all the latter, which have been ground down and form the sandy matrix.

No trace of fossils has been met with in the limestone-gravel, excepting such few as occur in the pebbles themselves.

II. Tertiary Rocks.

1. *Gypsiferous Series.*

In this series I include all the stratified deposits above the Nummulitic limestone, to be hereafter described.

The series consists of the following beds in descending order of stratification:—

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.

I have traced this formation in a N.W. direction, from Kázerún to Jezíreh-ibn-Omár (lat. 29° 47′ to 36° 00′ N.), nearly 700 geographical miles. How much further it extends in either direction I am unable to say with certainty, though there is every reason to believe that towards the south-east it passes through Belúchistán, and is a prolongation of a similar formation described by Captain Vicary as occurring in Scinde.

Beyond Jezíreh-ibn-Omár, it follows the line of the Taurus, bearing to the S.W., and is partially represented on the Euphrates by the gypsiferous marls, &c. described by Mr. Ainsworth as extending from Bális, on the N., to Meshid Sandábiya, on the S. (*Op. cit.* p. 64–92.)

The actual breadth of this zone varies considerably, and, in consequence of the beds passing imperceptibly under the alluvium to the westward, it is very difficult, as I have previously remarked, to define its limits in that direction (p. 249).

Along the northern portion of the frontier detached patches of this formation are frequently met with,—in some localities (as west of Urumia) forming distinct ranges of considerable elevation. It may probably be traced into the Caucasus.

Considerable outliers of this formation extend in long lines of sandstone and gravel hills parallel to, and at a distance of twenty or thirty miles from, the main chain.

Striking off from it near Behbehán, in lat. 30° 14′ N., the Zeitún Hills rise into bold, rounded, and sometimes precipitous cliffs, through which the Jerráhí River forces a passage into the plains of Dorák. After continuing about fifty miles, the range sinks into the desert, and is just distinguishable from the general level by a low, continuous, undulating line on the horizon, of thirty miles in extent. It again rises into the Ahwáz range, and, crossing the River Kárún, constitutes the celebrated ledge of rocks known as the Bund (Dam) of Ahwáz, of which advantage has been taken for the construction of an artificial dam, by which the water of the river was diverted in ancient times from the original channel, for the purpose of irrigating the country to the east.

About midway between Ahwáz and Náhr Háshem, on the River Kerkhah, the sandstone-hill called Jebel Mansúr (Prospect Hill) is a very conspicuous point.

On the west bank of the Kerkhah, the sandstone-range again appears, running in the same general direction, a few miles north of Háwízá, when it again sinks into low undulations which cross the Dúwárij and Tíb Rivers and joins the main chain west of Deh Lúrán. About 100 miles still further northward, the outlier again strikes off at Kúh-í-Mánisht, passes to the east of Mendállí, and rises into the high range known as the Hamríne, or Red Hills (from the colour of the sandstone). See figs. 1 & 2. These cross the Diyála River (called Shírwán during its course through the mountains) between the villages of Khánikín and Shehrebán,—form the Bund across the Athem River,—cross the Tigris in lat. 35° 06′, just below the junction of the Little Záb,—and are lost to my knowledge in the deserts S.W. of the ruins of Al Hádhr.

I have been somewhat diffuse in tracing the geographical extent of these outlying ranges, because some doubts have been expressed as to whether they are composed of rocks belonging to the same geological age.

From actual observation of all, except the Zeitún Hills (of which however there can be no question), I can certify that they are composed of the two upper divisions of the gypsum-series, namely, fine gravel, and friable, red, calcareous sandstone; and that the persistent character of the beds continues throughout the whole of this extended line of 500 miles.

But these outliers do not indicate the extreme western limit of the gypsum-formation; for I am convinced that, after forming a trough under the alluvial basin of the Tigris and Euphrates, through which it occasionally appears as islands in a shallow, the same series is continued into the deserts of the Aneiza Bedouíns; and it is probably again represented in Syria.

At Meshed Alí, the sacred shrine of the Sheah Mahomedans, the banks of the Báhr-í-Nedjef and the cutting of a new canal expose a section of about 50 feet through horizontal beds of—

1. Very fine white quartz-gravel, imbedded in friable, reddish, calcareous marl; 12 feet.
2. Similar quartz-gravel, in friable calcareous earth; 40 feet.

Midway between Musseïb on the Euphrates and Kerbella is a slight rise in the surface of the ground, and which, from its whiteness, attracts attention. It is a bed of loosely cemented fine gravel, resting on amorphous gypsum, and contains crystals of selenite. The road passes for half a mile over the south-eastern extremity of the bed, which extends in a low undulation towards the N.W., and is lost on the horizon.

The components of this gravel are precisely similar to that at Iskendería Khán (alluded to below), between Bághdád and Babylon, where gypsum again appears, and causes a remarkable ridge on the otherwise level desert. It is first met with half a mile to the north of the Khán, and runs in a general direction N.N.W. by S.S.E. To the south of the Khán it is one mile broad. It sinks into the alluvial plain on both sides, but reappears near Mizerakjí Khán, on the west about two miles, whence another ridge trends away to the N.N.W. The gypsum protrudes in small masses, exhibiting no regular stratification, but appears contorted and irregular; in some places it is hard, compact, and disposed almost in the form of septaria, or with a resemblance to a tessellated pavement. In both varieties small pebbles are observed, which do not, however, exceed a quarter of an inch in diameter, if even so much.

Mr. Ainsworth casually mentions the pebble-beds of Iskendería; but he appears to have overlooked the gypseous deposit, which is here quarried to the depth of 3 or 4 feet, burned, and conveyed to Bághdád, where it is used in the internal decoration of houses.

The pebbles associated with this gypsum deposit are:—

1. White, reddish, yellowish, and milk-white quartz.
2. Siliceous stone, of pinkish quartz with white grains of imbedded quartz (one specimen).
3. Flint, with white and reddish-white coating.
4. Hornstone, approaching agate.
5. Semi-transparent agates (a few).
6. Cherts of various colours, from grey to almost black.
7. Light-green chert, approaching jade.

8. Brown indurated clays, passing into jasper.
9. Jasper, chiefly red, and brown-veined.
10. Waxy indurated limestone, whitish, green, grey, blue-black, and black; some varieties approaching marble.
11. Brownish and pinkish quartzite-sandstone.
12. Flinty slate, from grey to black.
13. Shining black flinty slate, with semi-conchoidal fracture.
14. Highly indurated serpentine, almost flinty (rare).
15. Granite, of fine-grained variety; greenish-grey colour; consisting of quartz, dark mica, and a very little greenish feldspar (very rare).
16. Fragments of angular gypsum; evidently not transported from a great distance.
17. Pebbles of bitumen, slightly rolled.

With the exception of the last two, all the other ingredients of this gravel are much rolled and rounded; and generally they do not exceed an inch in diameter.

At Akker-Koof, twelve miles N.W. of Bághdád, the ruins stand upon a slight elevation of gravel, consisting of the same pebbles as at Iskendería, excepting those mentioned in the list as rare.

In addition I collected there the following—

Flat pebble, with its exterior weather-worn; interior showing hornblende and feldspar of bottle-green colour (rare).
Pinkish granite, composed of quartz, feldspar, and oxide of iron (rare).
Porphyry? (one).
Light-brown compact limestone, with veins of serpentine.
Limestone, of a brown matrix with small Nummulites imbedded (rare).
Coralline limestone (rare).
Rolled bitumen; and doubtful fragment of bone.

Many quartz, jasper, chert, and limestone pebbles, flattened,—so as to be easily mistaken at first sight for coins.

The following is a rough per-centage of the pebbles found at Iskendería and Akker-Koof:—

	per cent.
Quartz	30
Chert, flint, and jasper	40
Limestone, sandstone, flinty slate, serpentine, porphyry?, granite, and nummulitic and coralline limestones.	30

At Zobeir, near Busrah, the calcareous sands and superimposed gravels are largely developed, and may be traced northwards at intervals across the desert to near Súk-el-Sheïoukh, on the Euphrates. In some localities the gravel is wholly composed of white quartz, and at others of coloured cherts.

Wherever wells exist in these deserts, the water is invariably bitter and brackish, and in this respect resembles all streams flowing among gypsum-deposits.

From the above facts it may be presumed, although positive sections are wanting, that the gypsum formation passes beneath the basin of the Tigris and Euphrates,—that it rises to the surface, in low rounded patches or elongated ridges, at certain localities between those rivers,—and that it reappears in the deserts to the west of the Euphrates.

The difficulty of obtaining sections in the deserts is unfortunate, because I am unable to state with certainty the exact position of the gravels, sands, and gypsum-beds of the above localities with respect to the well-defined sections on the verge of the mountains.

It is worthy of remark, that I have nowhere but in the plains of the great rivers observed gypsum immediately overlaid by quartz- and chert-gravel. It is therefore possible that these deposits are subsequent to the sands and gravels of the Hamríne Hills and the gypsum-beds further to the east.

Section (fig. 2) *from Bághdád to Zoháb*.—In passing from Bághdád along the great caravan-road into Persia, by way of Khánikín and Kásrí Shírín (see fig. 2), we have a constant appearance of cherty and quartzose gravel-beds of the same character as those at Iskendería.

From Bághdád to Shehrebán (48 miles) is a perfectly level desert; but between the latter place and Kisil Robát the road crosses the low range of the Hamríne Hills. These consist of reddish, yellow, coarse, calcareous sandstones and loose gravels, alternating with red sandy marls; the whole series has a gentle dip to the N.E., and is covered by the gravel detached from its original bed.

Between Kisil Robát and Khánikín there intervenes a still higher range of precisely similar composition, the beds of which have the same dip towards the N.E.

The elevation of these ranges appears to be due to lateral pressure; and faults no doubt exist beneath the alluvial sandy plains of Kisil Robát and Khánikín, whereby the continuity of the beds is broken.

These reappear to the N.E. of Khánikín, and run without intermission to Kásr-í-Shírín (fig. 2). The peculiar character of the sandstone-portion of the gypsum-series now begins to show itself. It consists of low tabular hills, when the stratification is nearly horizontal; the red chert-gravel towards the S.W. forming cappings, but alternating with a succession of friable red sandstones and marls. Proceeding eastward, the marls predominate over the sandstones; and the beds, which previously appear dipping one way and then another, take a S.W. direction on approaching Kásr-í-Shírín, and present a succession of little escarpments towards the village. At this place the sandstones and underlying marls rest conformably, at an angle of about 15°, on the high ridges of pure gypsum which terminate the N.W. extremity of the limestone-range of hills called Sumbúlah.

This range is the first appearance of the great limestone which constitutes the main feature of the Zagros, and here protrudes through the newer gypsum-deposits.

Between the village and ruins of Kásr-í-Shírín the gypsum curves over in a low ridge, and is again overlaid by the marls and sandstones which fill up the valley of Goura-tú, dipping to the N.E., and terminates in the range called Kárayez. Nothing can exceed the barrenness of this valley, except where a small tributary of the Díyála flows through a thick growth of reeds. Seen from any high point in the neighbourhood, this part of the disputed province of Zoháb presents an extraordinary scene. On all sides, up to the base of the great limestone-chain of Bámú on the north, and extending to the N.W. and S.E. until lost in the distance, is a vast sea of unprofitable sandstone-ridges, which can of themselves be of no value to either the Turkish or Persian Government. Excepting the small stream above-mentioned, there is no water to be procured, while the succession of zigzags formed by the outcrop of the beds renders travelling by no means agreeable.

Such is the character of the upper and middle portions of the gypsum-series here; and, I may say, their aspect is alike wherever they are met with on the western flanks of the mountains. I have crossed them in various directions, far apart from each other, and have found the same invariable succession of strata,—scarcity of water, and that bitter and brackish,—sterility,—succession of zigzag ridges and short escarpments,—and the like disposition to produce fever and ague. And yet, with all these disadvantages, these sandstone-ridges were, in the days of the Sassanian monarchs, the favourite abodes of the Persians, whose ruined dwellings are continually to be met with. Within the greater ranges, however, these remarks do not always apply.

In the direction of Zoháb, the series of gypsiferous deposits disappear near the naphtha-springs of Hámám Alí and at the range called Kárayez, in whose cliffs, facing the S.W., the sandstones and marls are capped by a thick bed of cherty and quartzose gravel.

A great fault to the east of this range throws up the cretaceous rocks to the eastward of Zoháb, and at the same time elevates the nummulitic limestone trough of the Ban-í-Zárdah, behind the town, to the height of 2000 feet (fig. 2). In this trough, isolated at so great a height above the corresponding beds of the same age, rest sandstones, variegated marls, and gypsum; the successive layers of which crop out within the basin, and, curving upwards, rest conformably upon the almost vertical limestone which forms a series of high serrated peaks, facing the Kúh-í-Dáláhú on the north-east.

The same order of superposition is here observed as elsewhere on the western skirts of the Zágros: the sandstones overlie the marls; the latter in their lower part being associated with gypsum. These beds are not again met with east of Dáláhú.

Section from Dizfúl to the Valley of Giláláhú.—Sections near Dizfúl (figs. 3 & 4) exhibit the gypsum-series in less broken succession than it occurs further to the north-west.

The valley of Gilálàhú presents a highly instructive section (fig. 3). It is a denuded valley of elevation in the sandstone-series, having a central axis parallel to the main range,—namely N.W. and S.E.

On descending from the gravel cliffs which I have previously described as intervening between Dizfúl and this valley, the axis of sandstone is seen in the form of an elongated saddle, extending in a straight line down the valley for many miles to the south-east. This axis is flanked on either side by regular parallel ridges of similar sandstone, which slope outwards, having abrupt and broken escarpments facing towards the axis. The extreme regularity of these ridges gives the valley the appearance of a well-ploughed field on a gigantic scale. The dip near the axis is at an angle of about 25°, but this angle increases towards the sides of the valley, and on the S.W. the strata at length become almost vertical; and their denuded edges are covered unconformably by horizontal limestone-gravel (see fig. 3). Several patches of gravel rest on the summit of the central axis in tabular masses; but I had no opportunity of ascertaining whether they belong to the limestone-conglomerate described at p. 253, or whether they are merely denuded portions of a bed intercalated between the layers of sandstone.

Beds of fine gravel frequently alternate with the sandstones here as well as in the Hamrínes and at Kásr-í-Shírín. In descending, the gravels give place to variegated marls with crystals of selenite. The sandstone is of the usual type; very friable, calcareous, and reddish from the abundance of fragments of red chert. The surface of the beds is generally smooth; but it frequently resembles a pavement of uniform diamond-shaped blocks, separated from each other by deep cracks. This appearance is probably due to rupture during elevation; the fissures being subsequently filled up with a calcareous deposit.

A small stream flows across the valley, cutting its way through the ridges. When it comes in contact with the smooth surfaces of the beds, a thick incrustation of chloride of sodium above the level of the water-line is the result. As the water is not yet become salt, the mineral must exist in the rock itself.

The Oleander and the Tamarisk are the usual shrubs which grow along the banks of this and other streams flowing through the sandstone rocks.

I did not cross the valley sufficiently far to the N.E. to be able to state whether any deposits of gypsum are there to be met with.

Section at Shúster.—At Shúster are exhibited some very fine sections of the gravel and sandstone beds. The A'b-í-Gárgár division of the Kárún River, after passing the Búnd-í-Kaisár, enters a channel between cliffs of these rocks, 70 feet in height. The stratification is horizontal, and in the lower part consists entirely of fine yellowish-red sandstone. In ascending, however, the laminæ become coarser, much disturbed, and mixed with gravel; while still higher up the pebbles are larger and more common, until at the surface they cover the cliffs. Frequent and very violent currents must have been in action during the deposition of the whole upper part of the gypsum-series. Upon the right bank of the Shtaït the pebbles are large, and are cemented in a calcareous paste, with large boulders of the limestone-conglomerate of Dizfúl. Serdaubs or cellars, probably of great antiquity, are here excavated in the sands and conglomerate-rock ; and in the bed of the stream are huge masses of the latter, which, from being undermined, have fallen from their position. The serdaubs in the town are excavated deep in the sandstone ; and some little attention is paid to architectural embellishments, such as columns and pilasters.

The finer sandstone is here generally used for building-purposes ; but when exposed to the atmosphere it peels off in flakes or rapidly disintegrates. This character pervades the whole of the gypsum-sandstones.

Section (fig. 4) *from Dizfúl to Khorremábád.*—The road between Dizfúl and Khorremábád passes only a few miles to the N.W. of the section last described at Gilááhú; and here we have presented a similar order of stratification. The saddle-axis has, however, sunk down ; the beds dip somewhat more irregularly, and are contorted ; which appears to be owing to several undulations or folds, still bearing in the same N.W. direction, but having the general dip towards the S.W.

From Dizfúl to the Báládrúd River, a distance of fourteen miles, the road rises over a sand- and gravel-plain, without any particular order of stratification being visible. At the point where the river is crossed, near a ruined bridge, the banks are 150 feet high and afford the following section :—

1. Coarse gravel-conglomerate, with large boulders of nummulitic limestone.
2. Fine gravel, and reddish calcareous sandstone, passing into
3. Fine gravel (chert, quartz, &c.).
4. Thin layers of red calcareous marl.
5. Red sandstone (the same as No. 2).

A large block, of the sandstone No. 5, had, from being undermined by the river, fallen a few feet from its position. The upper surface was thus exposed, and exhibited distinct ripple-marks. Upon the under-surface of the overlying marl, which remained *in situ*, were the corresponding impressions, strongly marked.

From the same cliff, and from the bed of sandstone No. 2, I obtained relief-casts of impressions made by rain-drops, which had fallen on the red clay : pieces of clay adhered to the casts.

Between the Báládrúd River and the Bedderhú Stream are gravels, sands, and variegated marls, arranged in the usual order. On the S.W. the gravels predominate in extensive beds ;—proceeding N.E., these alternate with calcareous red sandstones, but at length give place to considerable deposits of red and vandyke-coloured marls, though they still occur in connection with the sandstones intercalated between the marls, but without any trace of gypsum. At Housseïnéah, where the sandstones are of great thickness, I procured natural casts of footprints, which belong to some animal of the feline order*.

* See Note A, at the end of this paper, p. 325.

One of these footprints is remarkably distinct (and is now in the British Museum). The pads of the foot and of the four toes, as well as of the claws, are well developed. On comparing it with the right fore-foot of a full-grown Chetah (*Felis jubata*, Schr.), in the possession of Col. Tcherikoff, the Russian Commissioner, I found a perfect resemblance in size, namely $4\frac{1}{2}$ inches long, by $3\frac{1}{4}$ inches wide. In form, however, there is a slight difference; the pads of the toes in the cast are somewhat more elongated. Adhering to the hollows are pieces of red clay. About an inch behind the first cast, is another, probably of the hind-foot, but not very distinct. On the same slab are traces of Fucoids.

Other indistinct and irregular marks are sometimes seen on sandstones of this formation, but this is the only instance in which I have observed any indications of the existence of animal life so high up in the gypsum-series.

The lithological structure of the rocks, and the foot-prints which occur in them, appear to indicate some connection with the conglomerate-sandstones and bone-beds of Scinde and the Himalaya. They all occupy a similar position with regard to the underlying Nummulitic rocks, and show that they have been deposited under similar conditions,—namely, on the shore of a shallow estuary, frequented by land and fluviatile animals.

If it be possible to found an argument from the presence of but one fossil, we might remark that a similar generic distribution of animals seems to have prevailed formerly as now in the respective regions in which they occur. Thus, while on the flanks of the Himalaya the large elephantine groups abounded and still abound, and in Scinde the crocodile continues to appear as the characteristic animal,—so in Lúristán, where those genera are entirely absent at the present day, the feline tribes occupy their place, and (as far as our evidence goes) are alone represented in the fossil state.

The Bedderhú Stream affording more moisture than is usually to be found in this inhospitable sandstone-region, the Lúrs have sedulously availed themselves of every level plot of ground for cultivation, and many are the little oases seen among these otherwise desert sandstone-ridges.

On quitting the Bedderhú Stream for Káláh í Ríza, the road follows along the strike of the beds at that portion of the series where the variegated marls are evidently preponderating over the sandstones, and dipping as usual to the S.E. About ten miles to the east of the road, a few thin and unimportant beds of gypsum crop out from under the marls, and rest against the slope of the limestone-chain of Túkomání, being now and then covered by nearly horizontal deposits of limestone-gravel and -breccia in a reddish-yellow, pasty matrix.

All the beds are conformable to each other; but, while the sandstones west of the Bedderhú dip to the S.W. at an angle of 15° or 20°, the gypsum slopes off from the great range at an angle of 50° or 60°. Kúhí Túkomání is the first appearance of the Nummulitic limestone N.E. of Dizfúl.

From the Bedderhú to Káláh í Ríza (about five miles) the same series of sandstones and marls is continued; but from the latter place an alluvial plain of five miles is passed over to the A'b í Zál. This plain is covered over with enormous limestone-boulders and gravel-conglomerate, generally concealing the underlying strata; but the outcrop of the gypsum may still be observed, resting against the slope of the range. I examined the junction of these rocks with great care, and there can be no doubt of the perfect conformability of the gypsum to the limestone. The beds of the former here retain the same earthy and cavernous structure throughout their total thickness, without any alteration in appearance.

Proceeding N.W. from the A'b í Zál, we enter the trough formed by the limestone-saddle of the Kebír Kúh, on the S.W., and of the Keálún Range, on the N.E. At first, the rocks of the gypsum-series, overlaid by limestone-conglomerate and -boulders, occupy the whole breadth of the trough (about eight miles across); and exhibit powerful beds of compact, massive, calcareous gypsum, of dirty-white or grey colour, traversed by blue veins or markings.

A variety, quite white, earthy, containing crystals of selenite, very cavernous and friable, is observable where the beds are much contorted; which is often the case in this lowest portion of the series, when crushed together in a trough. These beds of gypsum may be followed with the eye for an immense distance, as they strike out in long lines, or form conspicuous patches parallel to, and extending along, the base of the limestone-ranges.

At Púl í Táng, ten miles above the A'b í Zál, the underlying limestone protrudes through the gypsum-rocks, dividing the deposits in the trough into two parts, and throwing them up with much contortion against the skirts of the ranges which bound the valley. The two kinds of gypsum associated with variegated marls are thus largely developed at Bagh i Khán, on the western base of the pass over Kúh í Keálún, the colours of the latter, red, blue, and green, almost rivaling the brightness of our own beautiful section at Alum Bay. After descending from the Keálún Mountain, the road for fifteen miles crosses an extensive tract, known *par excellence* as the Chúl, or Desert,—a succession of very much contorted sands, variegated marls, and gypsum; the coloured marls occupying the north side of the undulating plain. The scene is barren in the extreme at the end of September, and possesses neither habitations, trees, nor streams of water. In spring, however, this Chúl must be very beautiful. It is then frequented by numerous tribes of the Lúrs on account of the rich herbage which everywhere abounds; but the scorching heat of the summer soon converts its bright green sward into a glaring yellow grass-stubble, covering the hills and concealing the stratification. A few well-built tombs are the only signs that man ever dwells here; and these, coated with pure white plaster derived from the gypsum, are excellent land-marks for the lost traveller.

To the Chúl succeeds a wide valley of elevation, bounded on the south by the range of Táng í Kháshow, and on the north by that of Deh í Líz. These ranges are composed of the Nummulitic formation; but the centre of the valley shows a thick series of bituminous blue shales (fig. 4, 4 *d*), dipping conformably under the limestones, and probably of the age of the Chalk.

The descent from Deh í Líz is covered by a thick oak-forest, growing upon limestone-debris, which entirely conceals the stratification to the north of the Pass; but, soon after leaving the plain of Jeudikí, the marls and gypsum with soft sands appear, dipping at an angle of 30° towards the chain of Deh í Liz. Some of these beds afterwards attain a great development, and rising into considerable mountains studded with oak, are traversed by several large streams, which form magnificent gorges, and are bounded by high perpendicular cliffs of blue and red marl, and red sand-rocks, in which gypsum does not appear.

This order prevails until the limestone is again thrust up at Tang í Chemish, with a dip of about 45° to the S.W.

North of this chain, the strata are concealed by debris, as in the same position at Deh í Liz. As soon, however, as this debris ceases, contorted beds of sands, marls, and gypsum, the last being less abundant, occupy the trough between Tang í Chemish and Kúh í Dádáwa, a distance of about three miles. The limestone then rises in high undulations, which, forming the Kúh í Bebbé, finally slope down at Tang í Sibbúr into the alluvial plain of Khorremábád. The last appearance of the gypsiferous series to the N.E. in this part of the Zágros is on the southern base of the cretaceous limestone-range of Yáftah Kúh, which thrusts up the red sands and marls at an angle of 35° towards the south.

It would be useless to enumerate the various sections in which the rocks composing the gypsum-series present the same order of succession. It is sufficient to have shown that such order is universally preserved. To trace the numerous beds throughout their whole extent, would be a work extremely minute in detail, which would require much time and labour without affording (that I can see) adequate remuneration. The absence of nearly all trace of organic life would render such an investigation in all respects unsatisfactory; and, moreover, the numerous layers of the sandstones, marls, or gypsums so exactly resemble each other, as to render the discrimination of any one of them a matter of great difficulty, if not of utter impossibility. It is true that in some localities among the marls are a few bands of impure limestone containing an assemblage of crushed shells, which are probably large *Cyclades* or *Cyrenæ*; but, as the characteristic features are in all cases destroyed, they would afford little or no assistance.

The total thickness of these deposits must be very great, certainly not less than 2000 feet; but, never having seen a perpendicular section through them, I can only give this as a somewhat rough approximation.

The greatest heights at which these deposits have been observed are near Hindí Mayní, in the trough of the Kerkhah about lat. 33° 10′ N., and at Kirrind.

Section (fig. 5) *in the Valley of the Kerkhah.*—In this locality, at an altitude of about 6000 feet above the sea, a section across the trough exhibits a somewhat uncommon elevation of the gypsum-rocks.

The limestone-range on the north-eastern side of the valley is formed of two folds, Kúh í Vayzáníyah and Kúh í Búnár, which in their elevation have detached a considerable patch of the deposits from their solid mass in the valley below. This patch is much contorted, spreads over the summit of the Kúh í Búnár (the smaller range), and hangs dipping over the slope towards the valley, exposing to view only a small surface of the curved limestone of the mountain. The corresponding beds in the valley take the same dip, pass under the alluvial plain of the Kerkhah, and again appear resting on the slope of the Kebír Kúh on the south-western side of the trough.

Sections (figs. 6 & 7) *at Kirrind.*—The plain of Kirrind is but a widely extended trough, and therefore exhibits less contortion than usual in the gypsum-deposits which occupy it. The town of Kirrind is situated on the N.E. side of the plain, at the mouth of a highly picturesque gorge in the limestone-range behind, which dips at an angle of 60° towards the plain. Resting against this slope on either side, but high above the town, is a set of deposits affording interesting sections of the gypsum-marls, the highest point of which has an elevation of 5500 feet above the sea.

On the S.E. section (fig. 7) the beds appear to have retained their original position to a certain extent, as they only dip at an angle of 25° towards the N.E. They seem to have slipped very quietly down the sloping surface of the limestone during its elevation, and so to have taken up their present position.

On the N.W. section (fig. 6) a much more violent action has taken place; the beds furthest removed from the rock have a general dip at an angle of 75° from it and towards the S.W., while those which are first visible from under the limestone-debris, by which the edges of many of the beds are covered near the rock, curve at their outcrop, as though they formed a dome over the adjoining layers to the S.W. Whether this whole set of beds has been turned bodily over, and the newest overlapped by the lowest members of the series, —or whether the upper layers were pressed downwards by the limestone,—there is no evidence to show, since the same order of succession does not occur on both sections.

For comparison, the various beds are enumerated as they occur:—

North-west Section (fig. 6), commencing at their first appearance from under the debris, some distance from the rock:—

1. Pinkish plastic clay.
2. Thin bed of mottled marl; with several species of fossils*.
3. Blue marl.

* Enumerated at p. 267.

4. Red marl.
5. Fine-grained grey sandstone.
6. Coarse red sandstone, with pebbles of pink marl; passing into
7. Fine grey sandstone.
8. Red marl.
9. Grey sandstone.
10. Red marl: } several thin beds alternating.
11. Blue marl: }
12. Red marl, with a thin band of grey siliceous limestone.
13. Blue marl, with layers of slaty and marly limestone, containing indistinct impressions of plants or insects.
14. Red marl.
15. Grey marly limestone, with *Balani*, *Cyrenæ*, &c.
16. Several beds, covered up by limestone-debris.

South-east Section (fig. 7), commencing at top:—

1. Thick bed of red marl.
2. Grey sandstone (fossiliferous).
3. Red marl.
4. Grey sandstone (fossiliferous).
5. Red marl.
6. Thin bed of compact, hard, fine-grained, red sandstone.
7. Loose red sandstone: } thin beds.
8. Red marl: }
9. Thin bed of slaty blue limestone.
10. Thin bed of blue marl.
11. Grey limestone.
12. Variegated marl.
13. Slaty red sandstone.
14. Red and blue marls.
15. Grey sandstones.
16. Red marls.
17. Thin bed of blue, siliceous, slaty limestone.
18. Red marl.
19. Grey sandstone.
20. Red marl and sand.
21. Grey sandstone, passing into
22. Thin bed of blue marl.
23. Grey sandstone.
24. Marls.
25. Thick bed of blue and grey sandstone.
26. Coarse red marl.
27. Fine red sandstone.

The total thickness of either Section may be estimated roughly at 500 feet.

From the general aspect of the various beds, I suppose them to belong to the lowest part of the gypsum-series, probably the very lowest in this locality.

In one respect the Kirrind Sections are much more interesting than any other observed in this peculiar formation, inasmuch as they contain fossils (which are however nearly all in the form of casts).

In the bed No. 2 of the N.W. Section we have

The jaw and teeth of *Sphærodus*?	Natica.	Lucina.
Remains of Crustaceans.	Mytilus?	Nucula?
Balanus.	Astarte, 2 sp.	Chama.
Murex.	Modiola.	Several Bivalves; genera undetermined.
	Pholas?	

In beds Nos. 2 and 4 of the S.E. Section are

* Remains of Crustaceans.	* Astarte.	* Mytilus?
* Balanus.	* Lucina.	* Anomia.
Flustra.	Cardium.	Several Bivalves; genera undetermined.
* Natica.	Cardita.	Serpula.
Cerithium.	Pinna.	Astræa.
Oliva.	Arca, 2 sp.	
Calyptræa.		

Note.—The species marked (*) are identical with those from the former section.

The outcrop of the beds immediately in juxtaposition with the limestone is, as I have said, entirely concealed by limestone-debris, so that I am unable to state if any fossils are common to the two formations. In the first visible stratum of the limestone the fossils are perfectly distinct from those of the newer marls, and consist of *Nummulites Biaritzensis* and microscopic forms peculiar to the Nummulitic formation.

Section at the Tauk í Gírrah Pass.—The only locality at which there is anything like a gradual passage from the nummulitic beds to the superimposed gypsum-marls is at the summit of the Tauk í Gírrah Pass, on the descent from the mountainous region of Persia to the plains of Zoháb.

The following descending section is there presented:—

1. A succession of calcareous and variegated marls, with thin beds of fine yellow sandstone at intervals; the last most abundant in the upper part of the series. These beds are of great thickness and are unfossiliferous.
2. Yellow calcareous marl, filled with a crenulated *Ostræa*, and a small *Anomia* .... 2 ft.
3. Hard calcareous marl, with supposed *Cyrenæ*?, crushed together in mass: none distinct .... 1 ft.
4. Soft blue marl, containing fossils identical with those from the fossiliferous beds above described at Kirrind .... 1 ft.
5. Hard compact limestone, filled with exceedingly small pebbles of red chert; of considerable thickness, and containing small *Nummulites Biaritzensis*.

This sequence appears to be complete; but the organic remains are characteristic of the separate beds in which they occur, and do not pass into any others.

An examination of the fossil contents of the gypsum-series with those of the underlying nummulitic rocks does not show one form extending through both formations. As the lithological character also of these two formations is so totally dissimilar, I have thought it best to describe them separately. Still, however, when the universal and perfect conformability of the gypsiferous marls to the nummulitic limestone is considered (whether the beds of the latter lie horizontally, or rise in lofty domes), we cannot by any means pronounce them to belong to a different geological epoch, but rather consider them as a transition from the older to the newer tertiary period.

I am disposed to think that a sudden elevation of the whole bottom of the ocean took place at the close of the period when the nummulitic limestone was deposited, by which the species then living were totally extinguished. This elevation must have been accompanied and succeeded by the frequent discharge of sulphuric vapours from below, which, acting upon the calcareous matter held in solution by the water, deposited it in the form of sulphate of lime. I am the more inclined to adopt this mode of accounting for the origin of this mineral deposit, because it occupies no fixed position in the marls, but is stratified and intercalated irregularly among them, generally however in their lowest part. Where gypsum occurs, it usually spreads over a large surface, showing it to be the result of a widely extended cause. The entire absence of animal life during its deposition has frequently been remarked.

The order of superposition of the beds of this formation, as above described, differs materially from that observed by Mr. W. J. Hamilton of the beds of the same formation in Asia Minor generally. That gentleman noticed the variegated marls and gypsum resting unconformably * upon underlying sandstones, which latter were in juxtaposition to the nummulitic limestone.

On the flanks of the Zágros, however, as I have endeavoured to show, the marls and gypsums are the lower beds, and rest conformably on the limestone, while the sandstones are superimposed upon them.

I do not think that this inversion of order need be of serious importance, when the great distance between the deposits (750 geographical miles) is taken into consideration. It is evident, from the very numerous layers in the various beds, that continual changes occurred; and therefore there need be no difficulty in supposing that, while sandstones were undergoing deposition in Asia Minor, marls and gypsums might be forming along the Zágros, and *vice versâ*.

The marls and gypsum of Mr. Hamilton's sections (Quart. Journ. Geol. Soc. vol. v. p. 373) are represented as lying horizontally upon the elevated and even vertical sandstones. This, however, may be the result of the Taurus having been thrown up at a different period from the Zágros. It is by no means improbable that in some other

* Quart. Journ. Geol. Soc. vol. v. p. 373. In another district, however, of Asia Minor, Mr. Hamilton observed gypsiferous beds conformable with the red and yellow marl and sandstone; see Trans. Geol. Soc. Lond. 2 ser. vol. v. pp. 590 & 592.—Ed.

locality in Asia Minor marls may be found conformable to the sandstones*.

The arrangement of the gypsum-series of the Zágros agrees, however, with that of the newer tertiary beds of the Hálá Range, and the formations of Scinde, as described by Captain Vicary†.

Bituminous Products.—Before quitting the subject of the gypsum-formation, it is necessary to say a few words on the bitumen- and naphtha-springs which abound in its lowest deposits in connection with the associated marls and gypsum. Instances occur in which bitumen-springs rise from the nummulitic limestone, but these are exceedingly rare. The spring in the Citadel on the summit of the Rock of Ván in Armenia may be adduced as an example.

As a general rule, however, where bituminous products appear in Mesopotamia or in the Persian Zágros, we may be assured that they rise from the gypsum-deposits. The most remarkable and well-known instances of this fact are those of Hit, on the Lower Euphrates,—of Kerkúk, on the Hamríne,—of Hámám A'lí, on the Tigris, near Nimrúd,—of Hámám A'lí, near Zoháb,—those near Mendalí,—and further south, near Rám Hormúzd. The only bitumen-springs which I had an opportunity of closely examining were in the Bákhtiyárí Mountains, between the curious and ancient temple called Mesjid í Súleïmán and the Mountain of Asmárí; these probably are the most copious of any. They are situated in a wild and barren region of much-contorted and highly elevated ridges of sandstones, marls, and gypsum. Their immediate source is in a narrow ravine between lofty walls of the earthy and cavernous variety of the last-named rock, having the strata dipping in every possible direction, and furnishing abundance of sulphur, which is sold in the bazaars of Dizfúl. A small stream of cold water rises high up the ravine, and is increased as it descends by streamlets from a multitude of sources, most of which furnish a supply of liquid black bitumen and white naphtha, mixed together,—some of them very abundantly. One spring yields yellow naphtha alone. These oily substances float upon the surface of the stream, and are conveyed to an artificial dam. When the dam is nearly full, the water is drawn off at the bottom, and the bituminous mixture is left exposed to the heat of the sun, until reduced to the consistency of soft mud. It is then placed in a large caldron, covered over, and submitted to a slight heat by heaping fire on the lid. After a gentle simmering for a short time, the fire is removed; and the substance, when cold, is bitumen prepared for use. The Seÿids (or descendants of Mahomed) at Shúster enjoy the sole right and privilege of making bitumen here.

The black slime floating on the surface, or settling on the white gypsum banks and detached blocks, produces a curious and striking contrast. The water contains a great quantity of sulphur in solution, which is deposited along the bed of the stream, and is collected. The stench of sulphur in the ravine is almost unbearable. From these springs are collected annually about 2000 mauns (or 12,000 lbs.

* See previous note.—Ed.

† See Quart. Journ. Geol. Soc. vol. iii. p. 331, &c.

English) of liquid naphtha and prepared bitumen; which, including the expense of collecting, of manufacturing, and of carriage, are sold in Shúster at the following rate:—Liquid naphtha, $1\frac{1}{2}$ Keran per maun, or $2\frac{1}{2}d.$ per lb.,—Bitumen, at 2 Kerans per maun, or $3\frac{1}{4}d.$ per lb. There might be collected 7000 or 8000 mauns annually, if there were sufficient demand. There are various other bitumen-springs in the immediate neighbourhood, the refuse-waters of which fall into the A'b í Súr ("Salt River"), which is the receptacle for every species of villanous water, whether bituminous, naphthous, salty, or sulphureous, rising among the gypseous deposits of that region.

2. *Nummulitic Series.*

The rocks of the Nummulitic Series constitute the most remarkable feature of the Zágros, and extend, to my knowledge, from Shíráz to Mount Ararat, a distance of 800 geographical miles.

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 quâquâversal 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.

Of the saddle-formed ridges the most remarkable is the range of Keálún (fig. 4). It forms the eastern edge of the trough through which the Kerkhah River flows before passing into the plains; and it extends 35 miles in a perfectly straight line. Seen in perspective, its outline resembles a gigantic model of the Crystal Palace, the uniform curve of the dome being very remarkable and imposing.

The Kebír Kúh, which bounds the western side of the same trough (fig. 4), is another example of a similar kind; but the continuity of the layers is frequently broken on the summit, and thus considerable precipices are the result, the jagged edges of which were invaluable points for the survey of the frontier.

Innumerable examples of the saddle-shaped ranges might be adduced; for, in fact, this is the usual form in which the nummulitic rocks show themselves on the west of the central axis, where the elevating force has been less generally experienced than in the interior of the chain. In the latter position, as is naturally to be expected, the strata have been forced asunder, and present mural cliffs of great height on either side of long valleys of elevation.

Of isolated masses of the nummulitic limestone, I may refer to the impregnable fort of Jáffer Kúlí Khán, the notorious chief of the Bákhtiyárí Mountains,—Cháouní in Lúristán (fig. 8),—the Kúh-í-Seffíd, between Shíráz and Behbehán,—and particularly to the Ban-í-Zárdah near Zoháb (fig. 2).

During the elevation of this portion of the ancient Zágros, the subterranean force acted with such intensity as to sever the limestone-strata of Kúh-í-Dáláhú; and a huge mass on the S.W. side, called Bán-í-Zárdah, was broken off from the main chain. [This will be understood by referring to fig. 2, p. 327.] It stands in the form of an elongated trough, eight miles in length from S.E. to N.W., and about four miles wide, separated by a deep valley from the broken south-western escarpment of Dáláhú. Towards the N.W. the Ban-í-Zárdah projects in a semi-oval snout, considerably beyond the rest of the mountain, and presents a perpendicular escarpment of 2000 feet on the N.W. and S.W., the stratification dipping from the edge to the centre of the trough.

The Ban-í-Zárdah is one of the finest specimens of the numerous natural fortresses which exist in Persia; and, from its strong position, it was chosen by the weak and unfortunate Yezdíjird, the last of the Sassanian kings, whereon to make his final stand against the conquering arms of the Moslem invaders.

The distant outline of these ranges is straight and uniform, sometimes presenting a few protuberances, but never rising into lofty and picturesque peaks*.

The summit of a "Diz," or natural fortress, is usually flat or but slightly undulating, owing to the vertical elevation of the mass, and consequent horizontality of the beds†.

The great ranges composed of the limestone of this formation everywhere present a formidable barrier to access from the west. All the passes from Turkey into Persia are carried over them; and, as those in the interior are reached by gradually mounting higher and higher, step by step, they were described by the Greek historians by the appropriate name of *κλίμακες* or *ladders*. In some instances the passes follow a zigzag path up the precipitous face of an escarpment, and are paved with rude blocks, but generally they are little better than goats' tracks and almost impassable. The surfaces of these dome-shaped mountains, which in the distance look smooth and easy of ascent, are upon nearer acquaintance found to be covered with huge blocks and sharp broken pieces of hard limestone, or a breccia with a yellow calcareous matrix. This breccia frequently conceals the superposition of the gypsum-deposits upon the skirts of the limestone-dome.

From the base to about 6000 feet above the sea dwarf Oaks abound; but beyond that height they gradually disappear; at 8000 feet the Astragalus only grows. The nummulitic rocks attain an elevation of from 9000 to 10,000 feet.

Exposed to the weather, the limestone assumes a warm ochreous tint; but on fracture it is yellowish or grey.

In close proximity to the igneous axis of the whole chain of the Frontier are highly crystalline blue limestones, some of which are undoubtedly an altered condition of the nummulitic limestone, the fossils being destroyed.

In consequence of the rarity of fossil remains throughout the whole

* The outline of the ranges as seen from Dizfúl is represented in Section VIII. of the original Memoir.—Ed.

† A diagram-sketch of a portion of the Mungerrah Mountain geologically coloured, and showing this configuration, accompanies Mr. Loftus's MS.—Ed.

of this formation, and of their being when present for the most part in the state of casts, I have been unable to ascertain the newest beds. The compact and crystalline nature of the rock presents a universality of character along the whole line of its range which does not lessen the difficulty.

In very few instances have good sections been met with, because of the peculiar saddles, which seldom expose more than the upper layers. Even when a section is obtained, through the heart of any of these saddles, we gain no information further than that it is composed of 2000 feet and upwards of layers of unfossiliferous compact or crystalline limestone.

Section (fig. 8) *at Mungerrah.*—The most detailed section that came under my observation is at Mungerrah, two long days' journey N.N.W. of Dizfúl, in the interior of the Lúrish Mountains, where the English and Russian Commissioners passed the summer of 1850.

The valley of Mungerrah is an extensive and irregular basin, enclosed on all sides by perpendicular cliffs, except on the south, where it is entered by a narrow valley called Ser-í-Deriah. The strata of which the bowl of this valley is composed are red gravel and sandstone. Upon these rest conformably solid beds of limestone, which rise to the summits of the mountains around forming the sides of the basin. The dip of the whole series is 8° 30′ towards the south.

The following is a section from the top of the great cliff at the foot of which our camp was situated (see fig. 8, p. 331):—

1. Limestone-breccia, derived from the underlying beds, and cemented in a yellow calcareous matrix.
2. (fig. 8, 3 *a*) Grey compact limestone, sometimes of a light slate colour; fracture saccharoidal; emitting a bell-sound, when struck with the hammer; surface rough, weathering in deep and large holes, as if bored by gigantic lithodomous mollusca. It contains a few *Ostreæ*, *Pectines*, *Echini*, casts of *Cerithia*, and Univalves, which, however, it is impossible to extract, owing to the flinty hardness of the rock. In the upper layers are huge tabular masses of opake, white, and dark-brown flint.
3. (3 *a*) Thick bed of very hard, compact, somewhat argillaceous, light-grey limestone, with fossils similar to the above.
4. (3 *a*) Compact greyish-yellow limestone; the lower portion in very thin layers. Fossils very rare.
5. (3 *b*) Very hard gravel-conglomerate, in a deep-red argillo-calcareous matrix; the pebbles consist of highly indurated, dark-red and dull-green clays and cherts, mixed with a few of dark-blue limestone and yellow sandstone; the fragments of chert and clay being small and much worn by transport.
6. (3 *c*) Yellowish and reddish sandstone, with thin and regular layers of the above pebbles, which are most frequent in the upper part of the bed.

7. (3 *d*) Blue, grey, or fawn-coloured limestone, exceedingly hard, compact, and heavy; containing *Nummulites perforata* (small variety), *N.* (*Assilina*) *exponens*, *Orbitoides dispansus*, *Alveolina subpyrenaica*; with a few spines and broken shells of Echinoderms. This bed passes into the following—
8. (3 *e*) Bluish-grey rock, consisting of Nummulites, &c., cemented in carbonate of lime, and containing the same fossils as occur in bed No. 7: interspersed are a few layers of fragile grey marl.

By barometrical measurement, our camp on the gravel-conglomerate (bed No. 5) was 1951 feet below the summit-edge of the overhanging cliff. The above section, therefore, cannot be less than 3000 feet in height. I regret that I am unable to give the thickness of the several beds; but the nature of the cliff renders measurement quite out of the question.

From the presence of an *Ostrea* (sp. undet.) in the limestone No. 2, and also at the head of the Tauk-í-Gírrah Pass, as before mentioned (p. 267), in connexion with the gypseous deposits, there is reason to believe that the bed No. 2 lies near, if not quite at the top of the nummulitic rocks. It is just possible that it may represent the fossiliferous marls of the gypsum-series discovered at Kirrind (see p. 265), since the forms of the contained fossils appear to be nearly allied; although casts, such as these, are always difficult to identify.

The beds Nos. 7 and 8 were well exposed in the sides of a deep ravine, formed by a mountain torrent in the basin of Mungerrah, which afterwards forces its way through a difficult gorge to join the Bálád-rúd River. Large blocks of this shell-conglomerate, literally composed of *Nummulites perforata* and *N. exponens*, with *Alveolina subpyrenaica*, lie in the channel of the stream a few miles below the gorge, showing that this bed is very largely developed somewhere in the neighbourhood, though I was not so fortunate as to discover the particular locality. The last-named fossil is called by the natives "Sangí Berinj," or *Rice-stone*, from its fancied resemblance to grains of rice. See p. 278.

The Section fig. 8, taken from the summit of Cháouní, gives a general idea of the arrangement of the beds of this formation, and of the strange dislocation which has taken place near Mungerrah by the elevation of the Bí A'b Mountain. The upper beds of the limestone, which is here white and saccharoidal, are inverted, and form a high peak, with quantities of angular debris upon the slope. This peak in the outline of the mountains as seen from Dizfúl* is represented by a conical protuberance. Not having had an opportunity of examining the Bí A'b, I am unable to say positively to what formation the rocks composing it belong, but I have seen fragments of Ammonites which were said to have been picked up in crossing it. This, together with the conformable dip of the overlying beds, leads me to the conclusion that it is cretaceous.

* The author has given in the original MS. a coloured sketch of the outline here alluded to.—Ed.

From the great elevation of Cháouní, the order of the Mungerrah section is seen prevailing throughout the adjoining mountains, for the deep-red of the chert-conglomerate (bed No. 6) may be distinctly traced, from its contrast with the other beds, forming a wide band wherever a cliff-section is presented*.

The origin of the red-chert-gravel, which is very widely extended, is to me a complete mystery. It is true that a bed of solid red chert is seen in the Lúr mountains at Hársin,—and a thin bed (of the cretaceous age) crops out in the plains of Kermánsháh and Máhídesht, and at Kásley Gúl near Mount Ararat; but these are too insignificant to have been the nucleus from whence such an enormous quantity of gravel was derived. In these two localities there is no waxy-green-coloured chert, which is abundantly found mixed with the red-chert-gravel wherever that occurs. These rocks may, however, exist in mass in some unexplored region of the Lúr or Kúrd Mountains.

From the summit of Cháouní, the red-chert-gravel is traceable in a N.W. direction for a distance of twenty or thirty miles, until it is shut out of view by the intervening mountains.

Section (fig. 4) *at Tang-í-Kháshow*.—The lower portion of the Mungerrah Section is crossed at the Tang-í-Kháshow, between Dizfúl and Khorremábád, about forty miles N.W. of Cháouní (see fig. 4, p. 329). Here the road passes through an easy gorge, having on either side a cliff of about 800 feet high, with the strata dipping to the S.W. at an angle of 40°, or thereabouts. To the N.E. is a broken face of rock exposing the following section:—

Mungerrah beds... {
No. 4; a thin bed.
No. 5.
No. 6.
No. 7.
No. 8; containing *Alveolina subpyrenaica* in very great abundance, with *Nummulites perforata* and *N. exponens*.

9. Thick deposits of reddish sandstone, fine-grained and hard, without fossils; but containing a few thin bands of darker-coloured hard iron-sandstone, tolerably heavy (=4 *b* & 4 *c* of fig. 4).

10. At about 1½ mile from the entrance of the pass these sandstones are succeeded by enormous beds of slate-coloured bituminous shales and marls (4 *d*, fig. 4), which fill up the entire centre of the valley between Tang-í-Kháshow and the Pass of Deh-í-Liz, and afford a rich soil for the forest of dwarf oaks which here abound. The water flowing among these marls is scanty, and highly impregnated with iron. No traces of fossils were here observed. It is highly

* In the MS. Memoir the author has given a diagram-sketch, geologically coloured, sketched by Lieut. Glascott, R.N. with the theodolite from this position, and looking to the N.E. It shows the wild character of this region. Mr. Loftus adds that "the irregular upper outline of the red gravel is owing to its being overlaid by limestone debris fallen from above. In other sections the underlying beds are discernible, especially in the bluff south-eastern extremity of the Keálún range, and in the lofty mountain called Kús, across the Bí A'b, north of Cháouní." —Ed.

probable that these marls are a prolongation of the beds which crop out on the north side of Cháouní, from under the Mungerrah section, and rest upon the curve of the Bí A'b (see fig. 8).

It has been previously mentioned, that in the centre of the trough of the Kerkhah (fig. 4) a slight curve of limestone occurs at Púl-í Tang, "the Bridge of the Cleft," through which the river flows at a depth of 100 feet. At the point where the river issues from the gorge, and where the limestone again dips under the gypsum and marls, upon the right bank, several large blocks have been from some cause or other torn from their places and overturned,—perhaps by the force of the stream when very high. The under-sides of these blocks are composed of layers of *Scutella* (sp. undesc.) with abundant casts of *Turritella, Pecten,* and other shells. The same limestone probably curves upwards, and surmounts the great range of the Kebír Kúh (fig. 4).

Núah (Noah?) Kúh, the S.W. edge of the trough of Kirrind, is a saddle of highly crystalline grey limestone, of the usual character (see fig. 9). Upon its summit is a conspicuous rock called Púl-í-Now, containing a large cavern with stalactitic columns. At the mouth of the cave the crystalline limestone is covered by a thin bed of compact, yellow, calcareous marl, containing *Num. perforata* in great abundance. This marl has undergone considerable disturbance during or immediately subsequent to its deposition; for its upper layers are broken, and pass into a calcareous paste, containing small angular fragments of the marl, and also abounding with *N. perforata.* This is the only locality where such fine specimens of this species have been met with in the immediate vicinity of the Frontier. A single specimen shows a passage from *N. perforata,* D'Arch., into *N. Bellardii,* D'Arch. (a Nice species), as pointed out by Mr. T. Rupert Jones, to whose kindness I am indebted for the determination of the *Foraminifera* mentioned in this paper.

From the neighbourhood of Kirrind, the natives brought me specimens of *N. Biaritzensis,* D'Arch.; but they would not indicate the spot from whence they were procured.

Section (fig. 9) *between Kirrind and Máhídesht.*—A magnificent section of the Nummulitic rocks and of the underlying beds is presented between Kirrind and Máhídesht, on the road to Kermánsháh. At the first-mentioned place the rock behind the village dips at an angle of 75° towards the S.W., and the edges of the several beds of which it is composed may be well examined within the gorge at the gardens and spring. The rock rises to the height of 1500 feet above the plain; but the total thickness of a vertical section of the beds, as far as visible, cannot exceed 800 feet. We here have

1. (fig. 9, 3 *a.*) Compact beds of white marble, very hard and saccharoidal.
2. (3 *b.*) Compact white marls, and limestone.
3. (3 *c.*) Thin bed of limestone and red sandstone breccia.
4. (3 *d.*) Thin bed of small rounded gravel of coloured chert.

5. (3 *e.*) Thin bed of yellow sandstone, with slight traces of Vegetable remains.
6. (3 *f.*) Yellowish calcareous marl, abounding with fossils; the lower part with *Alveolina subpyrenaica*, in particular (see p. 277).

From the spring a short but difficult pass conducts to the Bíwánij plain over a succession of thick layers of

7. (3 *g.*) Compact, grey and white, hard limestone, sometimes arenaceous.

This rock extends as far as the A'b-í-Zúmákán, and must therefore be of enormous thickness. In the descent to this stream, however, it becomes of a sudden exceedingly friable; in some places it resembles the upper chalk of England, and at others its open and fibrous structure is so similar to travertin, as to lead to the belief of its having been deposited by springs highly charged with calcareous particles.

On crossing the A'b-í-Zúmákán we come upon

8. (3 *h.*) Red marls, containing rounded chert-pebbles of various colours.

I was at first inclined to consider this marl as corresponding in age with the chert-conglomerate No. 5 of the Mungerrah Section (p. 272). If, however, a geological horizon be indicated by the presence of *Alveolina subpyrenaica*, which occurs in bed No. 6 (3 *f*) of the present section, these red marls are about equivalent in age to the reddish sandstones No. 9 of Tang-í-Kháshow (p. 274). The absence of fossils is here a great loss.

The little village of Gourájúh*, on the left bank of the stream, is built on the red marls, and behind it rises the lofty crag called Kúh-í-Buzzáhú, the base of which is of red marls, and the summit of grey, compact, arenaceous limestone, probably the same as No. 7 (3 *g*) on the west bank of the Zúmákán. Winding round to the south of this crag, the road is clothed with the dwarf oak, and it is worthy of notice that wherever the red marls and chert-gravel abound the oak flourishes. Is this attributable to the iron contained in the soil?

The base of the crag is loaded with talus (1*) from its limestone-capping, and the stratification is concealed; but, on reaching Gáwárah, the red marls reappear, and are succeeded by

9. (4 *a.*) Bituminous, grey and dark blue, indurated, calcareous

* The following section through the *red marls* at this locality would indicate that the same causes which produced the travertinous layers of the limestone, No. 7, had begun to operate during the deposition of the marls.

7. (3 *g.*)......	Limestone.
8. (3 *h.*)... {	Red marls. Red sandstone, or fine gravel of variously coloured and rounded cherts. Red marls. Friable white travertin. Red marls.

marls and fissile clays, similar to those east of Tang-í-Khá-show (p. 274).

From this point the country assumes a totally different aspect. The rich foliage of the oak ceases, and scarcely a blade of vegetation exists further to the east of this section. The blue marls are underlaid by

10. (4 *b*.) Cream-coloured limestone, splitting up in very thin layers; sometimes crystalline and sonorous, arenaceous, and traversed by veins of white and coloured quartz.

Although fossils are entirely absent in this limestone, as well as in the overlying blue marls, there is every reason to believe that these deposits are, from circumstances hereafter to be noticed, referable to the Cretaceous age, and are conformably overlaid by the Nummulitic rocks.

Thus far across the section the whole of the beds have a constant dip to the S.W., at an angle of about 15° or 20°, but in advancing over the cream-coloured limestone the beds gradually become horizontal, and at the village of Gáwárah (situated on the summit of a low anticlinal ridge) the beds take an opposite dip, and to the N.E. are overlaid by blue marls, which rise in contortions up the slope of the Káláh Kází range.

This range separates the irregular valley or plain of Gáwárah from that of Máhídesht, and its summit is capped by horizontal beds of the same grey, compact, crystalline, arenaceous limestone (3 *g*), which occur in the same position at Kúh-í-Buzzáhú; the underlying red marls of the latter locality being, however, entirely absent. This limestone is fossiliferous, but so hard as to defy all attempts to extract its contents, and I was consequently unable to procure any for comparison. Small Corals were abundant, with casts of shells apparently of the same species as from the bed No. 6 at Kirrind (see below). No *Nummulites* nor *Alveolinæ*, however, were noticed.

The blue marls, after a good deal of contortion up the slopes, pass horizontally at the summit under the limestone (No. 7, 3 *g*) which rests apparently conformably on them.

The rocks of this formation do not appear again to the east of Káláh Kází.

The number of fossils procured from the bed No. 6 of the Kirrind limestone (fig. 9, 3 *f*) is between 70 and 80 species. This bed does not exceed 30 feet in thickness. The lower portion being more argillaceous than the upper, the fossils, chiefly *Num. Biaritzensis* and *Alveolina subpyrenaica*, are easily detached.

The fossils are

Clione, 2 sp.
Several undetermined Zoophyta.
Orbitoides dispansus, *Sow.* sp.
Nummulites Biaritzensis, *D'Arch.*
Operculina granulosa ?, *Leym.*
Alveolina subpyrenaica, *Leym.*
Spines of Cidaris.
Temnopleurus.
Conoclypleus Flemingii, *D'Arch.*
Spatangus obliquatus ?, *Sow.*
Hemiaster and Schízaster.
Teredo, in wood ?, 2 sp.

Corbula.
Tellina.
Corbis ?
Lucina, 2 sp ?
Venus.
Cardium, 2 sp.
Cardita.
Isocardia ?
Arca.
Pectunculus.
Nucula.
Chama.
Modiola.
Mytilus, 2 sp.
Perna.
Spondylus; allied to *S. Dutempleanus*, D'Orb,—a chalk species.
Pecten.
Ostrea; 4 smooth sp.
—— 1 plicated sp.
—— 1 vulselliform sp.
Anomia.
Nerita (Velates); allied to *N. Schmideliana*, Chemn.
Nerita; sp. tuberculated.
Natica (Globulus).
—— 2 sp.
Turbo ?
Trochus ?
Cerithium ?
Purpura.
Pleurotoma, 3 sp.
Fusus.
Pyrula.
Rostellaria, 1 or 2 sp.
Strombus, 3 sp.
Voluta, 2 sp.
Seraphs.
Cypræa, 3 sp.
Oliva.
Pileopsis (Hipponyx).
Nautilus.
A few undetermined Mollusca.
Crustacea.
Teeth of Shark (imperfect).
—— of Gyrodus.
—— of an undetermined species of Fish.

The *Alveolina subpyrenaica* frequently occurs in the limestone along the Frontier. The rock is sometimes almost entirely composed of these fossil bodies, without any other form appearing; at other times they are associated with *Nummulites*.

The *Alveolina* is a very characteristic fossil. I have met with it as far south as the Koi Kánún, the celebrated but unfinished cutting made by Sháh A'bbás in the Bákhtiyárí mountains for the purpose of conveying the water of the Kúrán into the channel of the Zenderúd, for the better supply of the city of Ispáhán. The excavation is made through compact yellow limestone, the surface of which is broken up into small angular fragments, and again cemented by a calcareous paste, containing numerous specimens of *Nummulites*. This bed is about 20 feet thick, and is underlaid to the further depth of 80 feet by the same yellow limestone with *Alveolina*, which constitutes the centre of the mass.

The most northerly point at which I found this fossil is at Werkántz, about midway between Bitlis and Sert, S.W. of the Lake of Ván. It there occurs in a hard, compact, brownish-blue limestone. It is found abundantly also in the province of Zoháb, where some fine sections of the Nummulitic rocks are exposed.

From Kirrind the Nummulitic range is prolonged to the N.W., and, rising into the lofty mountain of Dáláhú, is terminated by abrupt escarpments (especially that of Ban Zárdáh before alluded to, p. 259, fig. 2), where we have, bending over a central dome, a thickness of 2000 feet and upwards of a crystalline mass of grey limestone, in thick beds, compact and exceedingly hard, with abundance of *Nummulites* and *Alveolinæ*, the upper beds with flinty concretions frequently taking the form of Corals and Sponges, and containing large *Pectines*, *Echini*, and *Foraminifera*.

East of Zoháb, blue calcareous rotten shales, with thin layers of white limestone without fossils, crop out from under the above nummulitic limestone. These are underlaid by very considerable beds of white and cream-coloured compact limestone, splitting in thin layers, in which I found portions of a small Ammonite,—traces of *Fuci*,—and Worm-like casts. Blue shales similar to those above lie next in order. I refer the beds below the great limestone to the Chalk, but cannot say positively that the limestone lies conformably upon them, though I am inclined to believe that it does.

At Kúh í Bámú, a lofty range bounding the plain of Zoháb on the N.W., the upper layers of the limestone are positively filled with large *N. complanata*, Lamk., and microscopic bodies.

At the Derbend Khání, where the Shírwán River passes through the north-western prolongation of the Bámú chain, a good section is presented in the cliffs on the right bank from a precipitous east face. The beds bend from the summit of the mountain, and dip on the S.W. into the plain nearly vertically, throwing off the gypsum-deposits in great contortions. The following descending section of 1000 feet (roughly estimated) is observed on entering the gorge :—

1. Saccharoidal, compact, hard, white marble.
2. Thick bed of bluish-grey, calcareous, indurated marl.
3. Yellowish calcareous grit and fine gravel.

The whole of these beds are conformable to each other, and contain *Nummulites* and *Operculinæ*. The marl is completely charged with *Alveolinæ*, and is probably an extension of the Kirrind bed No. 6 (fig. 9, 3 *f*). Lower beds are not here exposed.

An east and west fault occurs at the Derbend Khání, whereby the range on the northern side of the Shírwán is thrust nearly a quarter of a mile westward of the southern portion of the chain, the river flowing through the line of fault.

Kúh í Bizenán is a lofty range, connecting Kúh í Bamú with Kárâyez. The mountain is cleft in the centre, along the line of its axis, from S.E. to N.W., and on either side of the gorge or valley thus formed the order of conformable superposition is as follows (descending) :—

1. Thick bed of crystalline and of compact, hard, cherty, white limestone (weathering reddish-yellow), 500 feet; contains Corals, spines of Echinoderms, and minute microscopic bodies, associated with *Orbitoides dispansus*.
2. Thin bed of fawn-coloured lithographic limestone, easily separable into very fine layers, and resembling the "paper-limestone" from the dolomitic rocks of Marsden, in the county of Durham. It is unfossiliferous ; and thin lines of solid flint are intercalated in the limestone.
3. White indurated limestone and fissile clunch, greyish or fawn-coloured, in regularly deposited thin beds, but of great thickness in the aggregate, contains flint-nodules distributed at intervals, and a few indistinct traces of Fucoids.

The two lower beds of this section, from the resemblance to the limestone containing Ammonites, which is intercalated between the rotten blue shales at the foot of Dáláhú, and from numerous similar sections, are certainly referable to the Lower Chalk deposits of Europe.

Other sections will be alluded to showing the position of the Nummulitic Limestones with regard to the Cretaceous equivalents; and it is especially remarkable, that while the former are compact and crystalline, and contain *Nummulites* and allied forms of *Foraminifera* in abundance, the latter are composed of fawn-coloured fissile layers, which are softer, though sometimes indurated, or of rotten, blue, bituminous shales.

Although the beds of the two formations are conformable to each other, the characteristic fossils of each never appear together in any intermediate bed. *Ammonites* only exist in the fawn-coloured layers of limestone and in the blue shales; but, as soon as these rocks cease and the crystalline limestones succeed in ascending order, the fossil forms are perfectly distinct. How these changes have occurred it is exceedingly difficult to explain; but certain it is, that such is the fact, and that the crystalline is perfectly conformable to the fissile limestone.

Altered Nummulitic Limestone.—To the eastward of the deposits thus far described, and extending from Persepolis to near Mount Ararat, are great mountains of highly crystalline, dark-blue, and fœtid limestone, in close proximity to the grand central axis of igneous origin, which causes the parallelism of all the exterior ranges. The crystalline and contorted structure of these deposits is necessarily to be ascribed to the protrusion or concealed presence of the igneous mass. When stratification is apparent, it is so contorted and crushed that there is no possibility of tracing the beds. Generally all traces of stratification are absent, and the mass is of homogeneous texture throughout. The colour of the stone is usually dark-blue, but it sometimes varies to light-grey, and even in some cases to white. It is compact, rough to the touch, excessively hard, and heavy, with a saccharoidal fracture, and a bituminous or fœtid odour when struck with the hammer. It is a good building-stone, assumes a fine polish, and is equally suitable for internal or external decoration, as is well shown at the deserted and ruined palaces of Persepolis and Súsa.

When in immediate proximity to the igneous rocks, it becomes almost black, and is traversed by innumerable threads and thin veins of white carbonate of lime. Mountains of this character rise very abruptly from elevated plateaux of rich alluvial soil, and are, as it were, pinched up at their summits into jagged and well-defined angular peaks. Many of the beautiful plains between Ispáhán and Hámádán are bounded by picturesque ranges and solitary peaks of this limestone.

The Rock of Bísútún, so frequently described by antiquarians, is a very fine example.

Mr. Hamilton, in his "Observations on the Geology of Asia Minor" (Quart. Journ. Geol. Soc. vol. iv. p. 367), describes deposits of similarly altered character as occurring to the W. and N.W. of the region under consideration, and he classifies them provisionally as "Lower Secondary." At first meeting with these rocks, I was induced to regard them in the same light, but after having examined them in various localities and under various conditions, I am satisfied that the most considerable portion is referable to the Nummulitic age, and that other portions belong to the Secondary and even Palæozoic Series.

The lithological character and homogeneous structure of these rocks are everywhere, however, so precisely similar, as utterly to preclude the possibility of my pointing out any decided line of geological demarkation (although their western boundary is tolerably well defined); and it is to the fossil contents, therefore, that we must look for information.

It may be imagined that in deposits so altered and metamorphosed as these are, the presence of organic remains is exceedingly rare. I have been so fortunate, however, as to meet with a few fossils; and, although these are very indistinct and contorted, I satisfied myself at the spots in which they occur (except in one instance *), that they rather belong to the Tertiary, than to any earlier geological period. The really characteristic forms of *Nummulites* and their allies it is true are absent, but so are also *Ammonites* and the peculiar fossils of the secondary and older rocks. At Bisútún I observed a large buccinoid shell,—at Persepolis, near the tombs of the kings, are *Ostrea, Cardium, Turritella, Fusus*?, *Echinites,* and *Zoophyta* more abundant than in any other observed locality of this rock.

It may be objected to my supposition of these rocks chiefly belonging to the Tertiary period, that they for the most part rise too boldly from the plain, and constitute a too well-defined N.W. and S.E. line invariably to the east of the undoubtedly Cretaceous deposits;—that, while the mountains composed of Nummulitic rocks have their sides and frequently their summits clothed with rich forest-trees, the blue crystalline limestone is totally devoid of trees, and generally of vegetation;—and that the jagged and serrated crests of the latter form a remarkable contrast with the smooth and regular outline of the former. These differences might appear to point to a difference in the geological age of the two rocks, but they may surely be accounted for by the abrupt fracture and separation of their masses during elevation and crystallization, and by the altered state of those portions in proximity to the igneous axis.

I do not, however, insist upon the correctness of my assumption; it must rather be considered as a provisional arrangement, until further information is obtained to enable us to decide satisfactorily on the subject. At present we have very insufficient data to enable us to determine the question.

The section (fig. 10) between Kermánsháh and Asávlá shows the eruption of granite and syenite (accompanied by green porphyry and serpentine, and trap-rocks) through the limestone which I believe to be of the tertiary age. In rising the Mewárí Pass we find the limestone is so altered by the intrusion of trap-veins as to be converted into

* See page 290.

a dark-green heavy chert and cherty breccia, weathering brown. A small patch of the same limestone is observed on the north side of the Pass in the descent of the valley between Asávlá and the Gárdáná í Dú Broder. It rests at a steep angle high up on the slope of the range.

It is not requisite to multiply examples of this kind, which are exceedingly numerous.

"Tangs," or transverse Clefts in the limestone-saddles.—Before quitting the subject of the Nummulitic rocks, I must not omit to mention the numerous and enormous clefts which pass through the elongated limestone-saddles.

These clefts, or "Tangs" (as they are called in Persian), 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 Zágros; and, as their course is generally from north to south, they cross the ridges of the great chain diagonally. The manner in which this is 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," —which appears almost to be formed expressly for the purpose. On reaching the next gypsum-trough, it follows its original S.E. course, and again passes through the next chain in the same manner, until it reaches the plains of Assyria and Súsiana. 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 a perpendicular section of 1000 feet and upwards. The width of Tangs varies considerably, sometimes being exceedingly narrow, and at other times a mile or more across.

It is quite out of the question to suppose that the rivers themselves have been in the least degree instrumental in cutting these clefts; for, if so, we should expect to find a lacustrine deposit in each trough between the limestone-saddles. There are no such deposits. Moreover, if the rivers had been pent up in the troughs, they would certainly have forced their passage through the soft gypsiferous rocks, rather than through the massive crystalline barriers.

That Tangs are due to the tension of the cooling mass at right angles to the axis of the chains in which they occur, and have been formed during the cooling of the crystalline mass is, I think, self-evident, the entering and re-entering angles on either side of a Tang exactly corresponding with each other. The best example of this is shown in the Derbend, or Pass, between the plain of Denever and that of Chámbátán, behind and east of the celebrated rock-sculptures of Bisútún, near Kermánsháh. This tang is no less than ten miles in length, and one and a half in breadth, and has three salient, and two re-entering angles on the N.W. side, with corresponding bays and projections on the other.

Tangs are so numerous that it would be useless to enumerate them. The following may, however, be mentioned as fine examples:—the Gorge of the Ab í Zál at Kirkí,—of the Káshghán River, at Púl í Jaïdár,—of the Kerkáh at Púl í Tang, through Kúh í Vayzanéah into the plain of Seimarrah,—of Tang í Zimsa *, through Kúh í Chármin,—and of the Shírwán, through the Derbend Kháni.

Longitudinal Fractures.—But these chains have also been ruptured along the line of their central axis, as at Kúh-í-Bizenán. This kind of fracture is not, however, of nearly such frequent occurrence as the former; but, when it does occur, valuable sections are afforded us.

Tangs have probably been produced instantaneously by the cooling of the mass, but fracture along the line of axis appears to be due to another cause, viz. to the resistance offered by the overlapping of the numerous beds during their elevation from an horizontal position. This kind of fracture is frequently observed on the summit of a limestone-saddle; where the upper layers are broken, while the central mass remains entire. A very striking example of this occurs in the rock of Kirrind†, where the uppermost beds, acted upon by the intensity of the subterranean force, are bent down almost vertically, and broken off near the summit of the rock, presenting a strange pinnacled and drawn-out appearance of the broken edge, as if torn asunder while in a plastic state. Time and weather have of course had their effect in channeling and fashioning these pinnacles in some measure to their present forms, but their origin must be attributed to the cause assigned.

Besides these clefts traversing along the axis of the saddles, there are numerous other parallel crevices upon the surface of all chains, which must be due to similar causes. They are of various lengths and depths, but usually not exceeding a few feet across.

Vertical crevices are well marked on the north-western extremity of the Chenárí range, upon the right bank of the Ab-í-Zál.

III. Secondary Rocks.

As we proceed downwards in geological sequence, it becomes a matter of impossibility to define the precise limits of the Secondary Rocks.

Organic remains are much more rare than in the Tertiary formations, and they are in such a crushed state as almost to defy the practised eye of the palæontologist. Sections are also more difficult to be met with, and the beds are frequently so altered by their con-

* Mr. Loftus's Memoir is accompanied by several water-colour sketches of localities interesting in a geological point of view, by himself and Mr. H. A. Churchill, the Secretary of the English Commission. Amongst these the outline sketch No. III. represents the Tang í Zimsa, through Kúh í Chármin, as seen from near the range above Kaylán; it presents the peculiar features of tangs in general.

Mr. Churchill's sketch, No. IV., exhibits the gorge of the Káshghán at Púl í Jaïdár, in which the strata are seen curving to the S.W.—Ed.

† Mr. Churchill's drawings No. V. and VI. accompanying the MS. Memoir illustrate this locality.—Ed.

tact with igneous rocks near the central axis as to render their determination during rapid travelling quite out of the question.

In the upper part of the Secondary Rocks of the Zágros some portion of the Cretaceous Series is certainly represented, but where to draw the line of its basement is not easily determined.

In one locality the blue schists of this formation appear, however, to pass downwards imperceptibly into the crystalline blue limestone which constitutes the eastern portion of the mountain ranges on the Frontier.

1. *Upper Secondary or Cretaceous Series.*

In describing the Nummulitic Series, I have already referred to a few sections in which the beds of the Cretaceous age are apparently overlaid conformably by those older Tertiary Rocks.

Along the Frontier no sections fell under my observation which were sufficiently well developed to place this fact beyond a doubt; and it was only in the interior of the Bákhtíyárí Mountains that I was fortunate enough to satisfy myself completely on the subject.

Section (fig. 11) *from Mál A'mi to Ser Khún, Bákhtíyárí Mountains.*—This section is on the direct road between Káláh Túl and Isfáhán.

The crystalline (cretaceous) limestone forming the range of Kilgird having been crossed from the plain of Mál-A'mír by the Ráh-í-Súltán, the Kúrán River is reached in a narrow valley, flowing through a gravel-deposit which rests in a trough of the gypsum-series. On quitting the river the road is carried by a steep ascent up the prettily wooded ravine of Ríkát over reddish-yellow sandstones, blue and red marls, and gypsum, in the same order of succession as elsewhere observed; the dip being slightly towards the Kúrán, but a good deal disturbed. From the head of the ravine an undulating plain of contorted sandstones and marls, well-wooded, is crossed to the village of Deh-í-Diz, at the foot of the Músh Kúh. The western side of the range is composed of indurated cream-coloured clunch, without fossils, which, after the first steep ascent from Deh-í-Diz, forms an excellent road to the summit. This rock dips at a great angle to the west, adapting itself to the saddle-shaped curve of the central mass. Near the summit, however, the clunch ceases, and the underlying rock appears from beneath it,—at first having the same westerly inclination, but gradually at the summit curving over, until it dips at an angle of 45° in the opposite direction. This rock (fig. 11, 4 *c*) is a hard, light-grey, and indurated limestone, belonging, I conceive, to the Upper Chalk, since I found in it a fragment of a Sphærulite*. After a descent of several hundred feet, this limestone is overlaid by fissile blue shales and indurated marl (4 *b*) having the same dip.

The Mewárí Pass is next crossed, in the ascent of which the limestone beds (4 *a*) occur in ascending order.

* For remarks on *Radiolites* (*Sphærulites*) in general, and for a notice of the specimens of *Hippurites* which Mr. Loftus brought from the East, see Mr. Woodward's Memoir, Quart. Journ. Geol. Soc. No. 41, Feb. 1855. The locality for the Asiatic Hippurites there described should have been Hakim Khan in Turkey in Asia, instead of the Bákhtíyárí Mountains.—Ed.

The cream-coloured limestone, containing marks of *Fuci*, appears to pass imperceptibly into the overlying Nummulitic Rocks (3), which are, as usual, highly crystalline, and contain Nummulites and Pectens*.

The summit of the Pass consists of this crystalline limestone, and the descent eastward to the Ab-í-Bázúft is over the same beds, dipping at an angle of 70°. On the right bank of this river, which flows through a wild, confined, and deep gorge, the limestone becomes less crystalline and more marly, and an inconsiderable bed contains Sharks' teeth, Nummulites, Pectens, &c., similar to those at Púl-í-Tang (p. 275).

This marly bed is soon concealed by a powerful series of the gypsiferous rocks, which rise from the Ab-í-Bázúft into high cliffs of gypsum and of red and fawn-coloured earths, mingled with gravel-conglomerate and breccia, in a confused mass, as if the bed had been shot off the side of Merwárí during its sudden elevation. Masses of gravel-conglomerate lie in the bed of the stream, and high up on the slopes of the mountain through which the Ab-í-Bázúft flows.†

In this section, then, we have between the Sphærulitic limestone and the Nummulitic rocks a series of blue marls and cream-coloured limestones, the latter passing imperceptibly into the Nummulitic rocks. Unfortunately these marls and limestones are without characteristic fossils, but, as I have elsewhere remarked, as soon as the Nummulitic rock assumes its usual crystalline appearance, the peculiar and very characteristic remains of that series show themselves in remarkable abundance. If we had only this section, we should be at a loss whether to consider the marls and cream-coloured limestone as belonging to the cretaceous or to the Nummulitic rocks. Fortunately we have elsewhere sufficient evidence of organic remains to prove that they must be undoubtedly classed as cretaceous. It is very remarkable, however, that in no instance have I met with any admixture of chalk and nummulitic fossils, although a gradual transition certainly takes place in lithological character.

Having shown the above regular order of superposition, I now refer to sections of the blue marls and cream-coloured limestones, containing chalk-fossils, as observed in other localities.

The first locality at which undoubted chalk-fossils were discovered in the cream-coloured lithographic limestone was in the plain of Bishíwah.

The south-eastern extremity of this plain, which bounds the Ban-í-Zárdáh on the south, is a *cul de sac*, formed by the Nummulitic limestone ranges of Zángáleán and Tauk-í-Gírrah on the N.E., Núah Kúh on the S.E., and Dúkaní Dáoud on the S.W. These mountains present precipitous faces to the plain, and have their bases so much encumbered by loose rocks and debris as entirely to conceal the position of the lower beds of the Nummulitic series in relation

* Unfortunately my specimens from these localities are lost.

† A few miles N.E. of this stream (but before reaching the left bank of the Kúran at Du Pulim) I procured from a hard rock of the blue marly limestone a gigantic species of *Alveolina*, 3 inches in length.

to the underlying series. Near the valley of Khosrauábád, at the foot of the Tauk-í-Gírrah Pass, however, a long low hill rises from the level of the plain and extends towards the N.W. It forms a saddle of cream-coloured lithographic limestone, which is compact, hard, and sometimes crystalline, and consists of innumerable thin layers which easily separate by a blow with a hammer. It contains thin tabular beds of milky-white or blackish flint. As the beds of the surrounding ranges all dip from the plain at a slight angle, and as the lithographic limestone apparently is the axis of elevation, there is every reason to conclude that the Nummulitic limestone rests conformably upon it, especially as in the neighbouring locality of Kúh-í-Bizenán this is undoubtedly the case.

The limestone contains crushed specimens of

Turrilites; resembling *T. tuberculatus.* }
Belemnites. } Casts.
Ammonites; one of them $2\frac{1}{2}$ feet in diameter. }
A. planulatus, *Sow.* (*A. Mayorianus,* D'Orb.) }
Pecten.
Turrited Univalve.
Fuci.

I have already alluded (p. 279) to the section exposed by the cleft along the axis of Kúh-í-Bizenán, a few miles to the N.W. of the last section. The cream-coloured limestones are there of considerable thickness, devoid of fossils, but undoubtedly overlaid conformably by nummulitic rocks.

At other localities a somewhat different order prevails, and thick deposits of blue bituminous marls occur between the nummulitic and cream-coloured limestones, as at the base of Kúh-í-Dáláhú, east of Zoháb.

This is especially observable in the Kirrind and Máhídesht section (p. 275, and fig. 9, p. 332), in which the following apparently conformable order of superposition at Káláh Kází has been noticed.

7. (3 *g.*) Compact, hard, arenaceous, grey, and white limestone, in thick layers; of the Nummulitic series.
9. (4 *a* and 4 *a**.) Schistose, bituminous, grey or dark-blue, indurated, calcareous marls, and fissile clays.
10. (4 *b.*) Cream-coloured limestone, splitting into very thin layers, sometimes with crystalline, arenaceous, and sonorous bands; traversed by veins of quartz.

The beds 3 *g* and 4 *b* agree in so remarkable a manner with the beds 4 *d*, 4 *b*, 4 *a* of the Bákhtíyárí section (p. 284, and fig. 11, p. 334) as to lithological character, that they may be recognized at a glance. They are very largely developed, and from Gáwáráh their course is well marked by the valley of the Ab-í-Zúmíkán, which flows along their line of junction. Towards the N.W. the beds gradually sink down into the plain of Bívánij, where they are covered by a thin layer of alluvial soil; and, after passing under the mass of the Dáláhú range, they again appear, as before stated (p. 278), in the wild hills east of Zoháb;

extending thence in the same direction, east of Kúh-í-Bámú, to the Shírwán River, beyond which I have not examined the region.

On the west side of the Káláh Kází Range (fig. 9), above a small village called Chïábúr, the strata dip at angle of 45° to the N.E. The arenaceous limestone (3 *g*) lies at the top, and is underlaid by a thick series of schists (4 *a* and 4 *a**), with a few layers of a lighter-grey colour. Lying diagonally in one of the indurated beds, which is itself bituminous, I found a large unshapely mass of a compact, bright, lustrous bitumen; which at first sight might be mistaken for cannel-coal. Its fracture is foliated; and its specific gravity much less than coal, but heavier than jet; it is not electrical by friction; leaves a slightly brown mark on paper when rubbed hard; burns when exposed to the flame (but not well); and, of course, emits a strong bituminous odour.

In the centre of the mass was a brown, striated, roundish Carpolite,—while the marl close by contained the spinous stem or root of a plant, two inches in diameter,—a small bivalve (apparently a *Nucula*),—and specimens of a smooth *Terebratula* (resembling *T. carnea*) which were found in a batch in this particular spot, as if these animals had a particular penchant for the plant or mineral.

It struck me at the time of the discovery that the mineral was derived from a bitumen-spring in the cretaceous sea, around which the *Terebratulæ* had congregated. It is certainly a very curious association of animal, vegetable, and mineral.

To the east of Káláh Kází the bituminous blue marls, with associated reddish and white bands, appear in the plain of Máhidesht, at the south-east extremity of which the Zángáleán range intervenes between it and the plain of Kermánsháh. The range is composed of yellow fissile limestone (4 *b* of Section fig. 9), dipping to the N.E. at an angle of 25°, and overlying the marls. The dip of the latter could not be detected, as their outcrop was concealed by debris. The limestone, however, contains numerous *Ammonites*, of the same species as those at Khosrauábád, in the plain of Bíshíwah (p. 286), and appears to be overlaid by beds of hard red chert, which rock again appears on the hill W. of the town of Kermánsháh, at the burial-ground.

From Kermánsháh towards the S.E. opportunities did not occur of tracing the exact course of the cretaceous rocks. During rapid journeys of the English Commission, beds apparently of this age were observed in several localities.

The south-western side of the plain of Kermánsháh is bounded by a range of low white limestone hills (fig. 10), through which the united waters of the Kárá Sú and the Gámásáb force their passage. These limestones dip to the S.W., and are, I imagine, an extension of the Gáwáráh and Zángáleán cretaceous beds, containing *Ammonites*, &c. I did not, however, visit this portion of the chain.

At Khorremábád the lofty and imposing range of the Yáftah Kúh rises abruptly from the plain (fig. 4, p. 329), and is, in my opinion, of the cretaceous age. It consists of light-grey or bluish cherty limestone, with alternating and continuous layers of variously coloured flint, chiefly black. The limestone is exceedingly hard and compact, breaks with a conchoidal fracture, and emits a highly bituminous odour when struck. It is unfossiliferous.

A saddle is formed by the curvature of the beds, the continuity of which is, however, broken at the summit. At the centre a good deal of zigzag contortion is perceptible in the lower beds; but this gradually becomes less, and eventually dies out in the upper beds. The dip on the south is at an angle of 37°, and on the north 25°.

On quitting Khorremábád in a N.W. direction the stratification in the valley of the river which waters the town is concealed under loose gravel; but, about half-way to Robát a considerable range of gravel-conglomerate is crossed, dipping to the N.N.E., at an angle of 68°. It is almost entirely composed of red and coloured chert-pebbles, moderately rounded, and not exceeding six inches in diameter. The red cherts are by far the more abundant. Limestone-pebbles are rare. The matrix is a reddish calcareous sand, very hard. This conglomerate is overlaid by a thin bed of light-grey crystalline limestone, in which was observed a specimen of the Pul í Tang species of *Scutella*.

The chert-conglomerate and grey limestone, I conceive, may represent the lowest part of 3 *a* and 3 *b* of the Mungerrah Section, p. 272, and fig. 8, p. 331.

The stratification between Robát and Bisútún is much disturbed, and the rapidity of our march across it was not favourable to geological investigation. There were noticed, however, several bands of iron-stone.

In describing the section fig. 4 (pp. 264 & 274), I have hinted the probability that the blue bituminous shales and marls (4 *d*) between Tang í Kháshow and Deh í Liz belong to the cretaceous series. Their position with regard to the overlying reddish sandstones (4 *c*), containing bands of iron-stone, beneath the nummulitic limestone, as well as their striking resemblance to similar beds at Káláh Kází (p. 276, 4 *a* in fig. 9, p. 332) Zoháb, and the Bákhtíyárí section (p. 284, 4 *b*, fig. 11, p. 334), certainly favour this conclusion.

The next point in a S.E. direction at which I met with cretaceous rocks is the Kilgird Range, on the Kúrán, between Mál A'mír and Súsán, in the Bákhtíyárí Mountains. This range is of a light-grey, compact, and sometimes crystalline limestone, containing *Ammonites*, —a small plicated *Ostrea*,—a *Venus*,—and turbinated and turrited Univalves. The beds are much crushed and contorted, but dip generally to the S.W., as is evident in the ascent of the Pass from Mál A'mír, where their surface is so smooth and slippery as to render it a most difficult task for either man or beast to stand upon his legs.

Still further south-eastward, between Káláh Túl and Isfáhán, we have the well-developed Section (fig. 11, p. 334), which so admirably exposes the various beds between the Sphærulitic limestone and the Nummulitic Rocks.

The most south-easterly point reached by our Commission was Mádre í Súleïmán (the Pasargadæ of the Greeks), at which place the ruined Káäbá is built of a yellowish-white fine-grained marble, containing plicated *Terebratulæ* (*Rhynchonellæ*), and apparently Corals, *Exogyra*, &c., referable to the Chalk. The stone was not observed in the immediate locality, but Baron de Bode, in his "Travels in Louristan" (vol. i. p. 79), says that "he heard of quarries of this stone near Deh-bid, about 9 farsangs (or 27 miles) to the north of Múrgáb, and that there are none nearer."

Between this place and Persepolis the range which bounds the plain of Kemín on the south, dipping at an angle of 65° towards the N.E., is composed of beds of yellow clunch, overlaid by crystalline, white, unfossiliferous limestone. In the clunch-beds I found a single crushed specimen of Ammonite.

[*Note.*—The localities that have yielded Cretaceous fossils appear to have been—

East of Zoháb (p. 279).
Small Ammonite.
Fuci.
Worm-casts.

Bí A'b ? (p. 273).
Ammonites.

Músh Kúh (p. 284).
Radiolites.

Káláh Kází (p. 287).
Terebratula (like *T. carnea*, Sow.).
Nucula ?
Plant-remains.

Bishíwah Plain (p. 286).
Turrilites; resembling *T. tuberculatus*.
Ammonites, one of them 2½ ft. in diam.
Am. planulatus.
Belemnites.
Pecten.
Turrited Univalve.
Fuci.

Zángáleán Range (p. 287).
Ammonites.

Kilgird Range (p. 288).
Ammonites.
Small plicate Ostrea.
Venus.
Turbinate and turrited Univalves.

Dehbid ? (p. 289).
Rhynchonellæ.
Exogyra.
Corals.

Imám Meer Achmet (p. 289, *infra*).
Ammonites.
Voluta.
Tellina.
Gryphæa.
Serpula.

—Editor.]

2. *Lower Secondary Series.*

In describing the Nummulitic rocks, I have remarked that some portions of the great masses of altered and fœtid blue limestone may belong to the Lower Secondary Series (p. 281). That such is the case cannot be doubted in many instances, seeing that the altered limestone is certainly overlaid by the Cretaceous rocks, as shown in sections figs. 12 & 13, p. 335 & 336.

At Imám Meer A'chmet, between Básht and Faylaún, the neighbouring range is composed as follows :—

1. Hard, yellow, compact, crystalline limestone, probably belonging to the Nummulitic Limestone. In the lowest beds it becomes cream-coloured, and passes into—
2. Hard, reddish, grey or cream-coloured, lithographic limestone, very compact, but splitting into thin layers, with abundant specimens of *Ammonites* (crushed), *Gryphæa*, *Serpula*, *Tellina*, and *Voluta*.

   Interstratified with this limestone are numerous tabular layers of a black siliceous substance, giving out a remarkably strong odour of bitumen, when struck.

3. Highly crystalline, blue, fœtid limestone.

At the Pass between the plains of Ser A'b í Sír and Faylaún (Section, fig. 12), the blue limestone, 5, is much contorted, and surrounded by the yellow, 4, which appears to be conformably deposited upon it.

In this neighbourhood the yellow limestone constitutes the summits of many isolated tabular forts, and rests on a base of blue limestone. The notorious Káláh Seffeed is a fine example of this.

IV. Palæozoic Rocks.

The only instance in which undoubted deposits of this age were observed by me was on the east side of the Kúh í Kellar range, between Naughún and the plain of Cherághúr, in the heart of the Bákhtíyárí Mountains. This range is composed of the ambiguous, altered, blue limestone; but I had only an opportunity of examining an insignificant portion of it, overlooking the plain of Cherághúr, where I gained no information whatever. Just before entering the plain from the west, however, I stumbled upon two or three blocks of highly crystalline grey limestone, weathering rusty-yellow, filled with a species of *Orthis*, which Mr. J. Morris considers as a form intermediate between the Devonian and Silurian species.

Want of time during a hasty journey prevented my giving the locality the attention it deserved; but I was informed by the natives that at the summit of the range are great quantities of similar fossils.

With the *Orthis* are associated a small *Nucula* and a few other indistinct fossil forms.

V. Metamorphic Schists.

In the more disturbed portions of the blue limestone we have nothing whatever to guide us in determining the age of the underlying rocks.

At Senna in A'rdelán, the Kúh í A'b í Der, which overlooks the town on the S.W., is composed of an alternating series of blue limestones,—dark-yellow, arenaceous, and calcareous slates, exceedingly hard, compact, and sonorous,—and dark-blue schists. These rocks pass into each other insensibly,—are so utterly devoid of fossil contents,—and are so completely isolated, by the intervention of the granitic chain of Merwári, from the less complicated blue limestone masses on the West,—as to leave us in utter ignorance of their true age.

Between Bisútún and Essádábád (see fig. 1, 6, p. 326), as well as in several localities between Hámádán and Isfáhán, the blue limestone rests unconformably on yellow calcareous slates.

In immediate juxtaposition with the igneous rocks are vast deposits of dark-blue, indurated, calcareous, and fissile clay-slates, which extend on the west of Kúh Elwend from the district of Ferídún, in the Bákhtíyárí, through the plains of Búrújírd and

Nehávend, to Essád-ábád. On the east of the same chain they continue along the skirts of the same range to Hámádán.

They probably extend to the plains of Senna, from whence they bear in a N.W. direction, by Banna and Ser Desht, to Láhíján, at the southern extremity of the Lake of Urúmia,—and afterwards appear at intervals along the whole extension of the frontier, to within a short distance of Mount Ararat.

These slates are largely developed in the Pass over Kúh Elwend, between Essád-ábád and Hámádán. Upon the south ascent of the range the beds have a general dip to the S.W., at an angle of 50° or 60° ; but on the opposite side they take a contrary direction, and are there seen tilted high up the range, resting against the highly elevated granitic peaks. The slates are traversed by veins of compact and granulated quartz, having various tinges of blue and yellow. Some of these veins are of great thickness.

Between the foot of the Pass and Hámádán mica-schists occur, in conjunction with the clay-slates, dipping at a high angle, but their position with regard to each other is not apparent.

The following rocks appear in ascending the ravine from Hámádán to the Rock Sculptures; the strata dip at an angle of 70° to the N.E.

1. Black and crystalline altered limestone.
2. Yellow quartzose rock ; and
3. Coloured micaceous schists; containing garnets.

No fossils whatever occur in these rocks in any locality where they have been examined; and consequently, until more detailed sections are discovered, showing their connection with the newer deposits, it would be useless guessing at their place in the geological sequence.

VI. Plutonic Rocks.

Granites.—Along the Southern portion of the Frontier no igneous rocks are exposed in its immediate vicinity; but the central axis of the chain at some distance to the eastward consists of granitic compounds, which there appear to the almost entire exclusion of other igneous rocks.

The first point in the south at which the granite shows itself is, I believe, in the low range called Fárájábád, or Khákhwáh, between Gúlpaigán and Jápúlák, in lat. about 32° 15′ N. and long. about 49° 20′ E. From thence it forms the Eastern boundary of the plains of Jápúlák, Búrújird, and Nehávend; gradually rising in elevation, until it attains the height of 13,780 feet above the sea-level, according to the measurement of Col. Rawlinson at the summit of Kúh Elwend (the ancient Orontes). See fig. 1, 7, p. 326. Extending in a N.W. direction, the granitic rocks spread over the country in the neighbourhood of Senna; but the main chain passes through the centre of the triangle formed by the three large towns of Hámádán, Senna, and Kermánsháh. It continues along the Avromán range, and crosses the Frontier between Súleimánía and

Bánna, from whence it may be traced in a continuous line, associated with other igneous rocks and forming the lofty boundary-chain to within a short distance of Bayázíd at the foot of Mount Ararat.

From their first appearance near Gúlpaigán the granitic rocks extend about 120 geographical miles in a single unbroken axis, without offsets, to beyond Hámádán.

This portion of the chain I have crossed at two points,—once between Essádábád and Hámádán,—and again between the plains of Jápúlák and Búrújird.

At Hámádán the granite of Kúh Elwend varies considerably in character.

Sometimes it is white and very coarsely grained, with a few straggling laminæ of mica, having a somewhat dendritic arrangement. In another variety the crystals of quartz and felspar are smaller (though still coarse), and the mica is more abundantly diffused in grains. This passes into a fine-grained grey granite; and finally becomes a yellowish quartzose rock, enclosing large splashes of hornblende, precious garnets, and a little mica. All these varieties occur close to the Trilingual Tablets. Gold is occasionally found in the courses of the streams flowing from Kúh Elwend.

Throughout the whole line of its occurrence the granite of these regions, owing to the abundance of felspar in its composition, is of a very perishable nature, and therefore the ranges which it composes have a rounded and undulating outline, not presenting any picturesque or remarkable peaks.

In ascending the Merwárí Pass between Kermánsháh and Senna we have a coarse grey syenite, with large crystals of hornblende in a base of white quartz and felspar, and containing magnetic oxide of iron richly diffused through it. The same metal also occurs disseminated through the dark-grey granite which constitutes the great mass of the Pass. The summit is of red decomposed granite without the metal.

Between the plains of Jápúlák and Búrújird we have an interesting section (fig. 13). The plain of Jápúlák is a denuded valley of elevation, in which the outcrop of blue clay-slates from beneath the alluvial covering is frequently detected;—the slates dipping from the central axis, and traversed by veins of coloured quartz.

On the low hills east of A'líábád village, at the northern end of the plain, the quartz suddenly assumes a great development, and is succeeded by a fine-grained and friable syenite, which is injected through in low rounded bosses, elevating the slate-rocks into almost a vertical position. On entering the Derbend, or Pass, the syenite overlies a thick bed of white altered limestone, having been forced through with such violence as to break up and carry with it large masses and layers of the limestone, and also to spread itself over the surface of the beds *in situ*, which are thrown down at an angle of 45° towards the East. Crushed and contorted, fissile blue clays crop out conformably from below the white limestone. At the entrance of the Jápúlák stream through a gorge on the Western side of the Derbend these rocks appear to have been thrown down by a fault, and present a bluff escarpment to the west; while on the left bank of the stream the white limestone rests upon the flank of the limestone-beds of the U'shterán Kúh, from which they seem to have slid down to their present position.

Fossils are entirely wanting in all these altered rocks, but I believe that the slates of Jápúlák plain belong to an early series, and are of the same age as the Elwend slates.

The white limestone and blue clays of the Derbend I am inclined to assign to the age of the cretaceous deposits; while the beds of the U'shterán Kúh are probably lower secondary. The last, however, I had no opportunity of reaching.

As to the date of the eruption of the granitic chain, there can be no doubt of its having taken place subsequently to the deposition of all the rocks in the vicinity; and, although no positive evidence exists of the fact in this portion of the region under examination, there is every reason to pronounce, from examination of other localities, that it occurred after the formation of the Nummulitic and Gypsiferous series, and after the accumulation of the comparatively modern gravel-conglomerate on the western outskirts of the whole chain.

VII. Trappean Rocks.

Porphyry occurs sparingly on the skirts of the granitic chain, but does not assume any great development. It shows itself in this position in a range of low hills on the S.E. of Nehávend, erupted through, and elevating, altered blue limestone. It is there red and argillaceous, and is associated with serpentine.

Trap-porphyry occurs in considerable veins on the Western side of the Merwárí Pass already alluded to (p. 281 & 292), where it is injected not only through the altered limestone and chert, but also through the syenite and older trap-veins.

Serpentine is generally met with in the same localities as the trap-porphyry, but is much more abundantly diffused, and frequently forms very considerable sombre-looking peaks, as in the neighbourhood of Senna. At the Merwárí Pass a light-green serpentine in felspar appears to have been injected into the limestones previously to the elevation of the granitic axis (see fig. 1, s); and is in turn traversed by veins of newer porphyry.

The usual kind of serpentine is an exceedingly hard, massive, dark-green variety, accompanied by steatite.

PART II.

Contents.

[Figs. 14–23 are to be found at pp. 335–344.]

Introduction.—In the former part of this paper I have endeavoured to describe the order of succession of the various formations, which prevails in the southern portion of the Frontier, where less contortion in the deposits is exhibited than is observable further to the north.

In continuing the subject, it is impossible to enter into such detail as hitherto, owing to the rapidity with which the latter portion of the frontier was traversed. I shall therefore briefly allude to such road-sections as may be considered of interest.

Between the Derbend Kháni on the Shírwán, and Ushnú near the Lake of U'rúmia, I had no opportunity of making investigations, having been detached from the Commission during the progress of the Survey between those localities. While *en route* to rejoin the party I was attacked by a severe fever, which incapacitated me from giving proper attention to the geology of the country between Senna and Láhíján.

The following rough notes, however, concerning this tract may not be uninteresting:—

Between Senna and Láhíján.

On quitting Senna the road gradually ascends along the north slope of the Kúh A'b-í-der, crossing numerous slate-spurs which shoot out from the mountain. After an ascent of two hours and a half, the summit of the range is at length attained by the A'rríz Pass. An uninviting sea of barren and ferruginous undulations is seen extending over a vast elevated plateau, from whence the numerous sources of the Shírwán have their rise. The stratification consists of highly fissile blue schists, passing upwards into thin altered beds of blue limestone, weathering rusty-brown; the prevailing dip being to the N.E. Far in the west, the lofty A'vromán range of igneous rocks rises boldly from beneath the schists. After two long days' journey over these slates, the foot of the Garrin Pass is reached, where an agreeable change takes place in the scenery. Thick forests of oaks and other trees occur, but no visible alteration is perceptible in the geognostic features. The Garrin Pass is wholly composed of the same friable schists. These continue to the Turkish Frontier, a day and a half further, on approaching which blocks of porphyry and altered limestone become abundant in all the mountain-streams, and the blue limestone and associated schists are thrown up into disorderly mountain masses on all sides, indicating the proximity of the igneous rocks.

The igneous rocks themselves at length make their appearance, running in an east direction, and forming the high range called Bird í Koteh Resh. After sweeping in a wide circuit, they bear away to the N.W., thus giving to the Turks a considerable projection into the Persian territory. The direct road from Senna to Banna, therefore, twice crosses the frontier.

At the first Pass (Kel í Melek), where the Bird í Koteh Resh is reached, the axial rock of dark-green porphyry is protruded through fissile slates, which are thrown up vertically on either side of the Pass. A succession of slate-spurs occurs on the road to Weyna, at the foot of the second Pass called Kel í Hangerjál.

The ascent from Weyna is extremely abrupt. It passes through a forest of gall-oaks, and over vertical slates strewed with blocks of compact, green, felspathic rocks, fine-grained grey rock (of quartz, carbonate of lime, and mica), talcose rock, blue limestone, porphyry, and quartz, which have fallen from the lofty peaks of the range. Detached masses of altered blue limestone are frequently seen elevated upon the slopes, and even the summits, of the igneous peaks. The remainder of the day's journey from Weyna to Banna is over the slates capped by blue limestone and traversed by quartz-veins, containing iron-ore, and sometimes auriferous, which also extend from the latter place, along the valley or undulating plain of the River Kellú, or Lesser Záb, to Ser Desht. This valley or plain is bounded on the west by the Frontier Range, and on the east by the Kúh í Kúrtek,—both igneous chains. The latter is chiefly composed of green porphyry, traversed by veins of syenite, but has two or three of its peaks crowned with limestone crags. Thrown off from the Kúh í Kúrtek, at the village of Nístán, and dipping towards it at an angle of 45°, is a dark-coloured rock of quartz with mica, in fine layers, and decomposed talcose slates. From Nístán, these slates form a sloping plain towards the A'b í Kellú, on the south; but they are in a great measure covered by reddish alluvium, through which the tributary streams from the north cut their way in ravines of from 500 to 800 feet in depth. Near the river, where the alluvium is of the greatest thickness, the plain is destitute of oaks. Where, however, the slates become mixed with the alluvium, a genial soil for the gall-oak is the result, and the forest extends in a broad zone over the slates to their junction with the igneous rocks, where it entirely ceases. An extensive and very elevated range intervenes between the Plain of Ser Desht and that of Láhíján, consisting of infinite varieties of serpentine, porphyry, and granitic compounds, in mass and in veins,—a splendid field for the mineralogist with time at his disposal.

On the descent to Láhíján, the igneous rocks are again concealed by the appearance of the slates and altered limestone. Undulating hills of the latter traverse the plain of Láhíján in every direction, and rise in little rounded hillocks in its centre. The strata exhibit much contortion, and are traversed by threads of carbonate of lime.

Kúh í Komárend, which separates the sources of the Záb and the Gáder, is an offshoot from the great chain of the Frontier. The blue limestone is here converted into cream-coloured and purely white marble, resting unconformably on a mass of stratified, micaceous, grey schist. Quartz and felspar are irregularly interspersed in layers in the midst of a matrix of finely-grained mica. This rock cleaves into beautiful regular, elongated, rectangular parallelopipeds, sometimes contains crystals of pinkish felspar, and passes downwards into a finely-grained granite.

To the N.W. of this range are a series of low limestone-hills skirting the plain of U'shnú.

Kel í Shín Pass.

The height of this Pass above the sea is stated by Mr. Ainsworth (Journal of Roy. Geogr. Soc. vol. xi. p. 62) to be 6000 feet, but at p. 64, and in the section annexed to the memoir he gives it an elevation of upwards of 10,568 feet.

Unfortunately all the barometers of the Commission were broken soon after reaching the mountain-districts, so that we had no means of ascertaining which measurement is the correct one. At a guess, it is, I should imagine, 10,000 or 11,000 feet above the sea-level, the higher peaks of the range being 2000 feet more.

Various rocks show themselves on the descent from the N.E., and of these the following were noted whilst we were ascending:—

Altered blue limestone, with veins of carbonate of lime.
Red iron-clay, with serpentine.
Dark blue serpentine, with veins of steatite.
White quartzose rock.
Decomposing, fine-grained, white granite.
White quartzose rock, with grey serpentine.

At the summit, a few paces from the celebrated pillar (with the cuneiform inscription) which gives its name to the Pass, is a rock dipping at an angle of 45° to the east, presenting an ascending section as below:—

Light green serpentine.
Red indurated clays, approaching to jasper, and containing ironstone.
Dark-grey quartzose rock, weathering rusty-brown.

A vein of very dark-green and hard serpentine traverses the line of bearing between the two first-named rocks.

The pillar itself is cut out of a hard hornblendic rock, with long acicular crystals and containing numerous large, empty, vesicular cavities. This rock is not observed in the immediate vicinity, though the lofty black peak to the south, called Seah Kúh, is probably composed of it. The stone is black, but in particular lights looks bluish; hence its name, "Kel í Shín," "the blue tombstone." The upright stone at the head of a grave is called in Kourdish "Kel;" and certainly the form of this ancient landmark is precisely that of a gravestone. The hard and vesicular nature of the stone must have rendered it a matter of difficulty to cut the inscription, which, I imagine, was originally but rudely executed and always somewhat illegible on this account. Its long exposure has not of course bettered its condition.

The view from the Kel í Shín into Turkish Kourdistán is of the most rugged description;—lofty jagged peaks, having their summits capped with eternal snow, raise their heads out of deep and precipitous valleys, the heat of which seems, as it were, to be indicated by the deep red colour of the rocks.

Wild grandeur is the peculiar feature of the scene, and it is among its vast mountains and difficult ravines that the Nestorian Christians have their fastnesses.

Section from U'shnú to Mergáver, over the Bird í Zerd and Kúh í U'lúkh Passes. Fig. 14.

The following descending section is observed at these Passes:—

1. Cream-coloured limestone, sometimes compact, and containing carbonate of copper in quartz.
2. Alternating layers of thin, purple, argillaceous limestone and carbonate of lime. Each layer compact and heavy, and easily separated.
3. Thick beds of altered blue limestone; sometimes hard, compact, and crystalline; and at other times composed of thin layers, alternating with others, coloured light-yellow and purple. The latter variety exhibits much contortion. On the S.W. side of the pass, between Bird í Zerd and Kúh í U'lúkh, the limestone of the former mountain is white, weathering cream-coloured, and is impregnated with copper. The beds dip to the S.S.W., at an angle of 40°.
4. Bluish-green altered schists, with serpentine.
5. Grey granite, exceedingly friable. At Kúl í Rundúlah, it passes into rudely columnar blocks of various sizes.

At a point where the Frontier range dips into the plain of Mergáver, which it bounds on the west, there is a remarkable black conical peak, having in the distance a very igneous aspect, its sloping sides being covered with cinereous-looking rocks. On visiting it, however, the black mass proves to be limestone, completely metamorphosed by the action of heat. The lowest visible beds are black, broken up into small fragments, and covered with black powder, as if they had been half-burned. They give out a strongly bituminous odour. Some patches of compact, white limestone repose upon the slope of the cone. No igneous rocks occur in the immediate vicinity, but the great range is composed of granite.

The eastern boundary of the Mergáver Plain is a moderately elevated range, which is, I believe, composed of altered limestone.

A low and broad elevated tract alone separates the plain of Mergáver from that of Desht. In a ravine in the Frontier Range, at the junction of these plains, is a bed of iron-ore, which is disseminated in large irregular masses of clay-iron-stone, imbedded in a micaceous rock, coloured with the oxide, but not sufficiently rich to be worked.

All along this portion of the Frontier there are indications of the presence of ores, especially copper and iron; but the jealousy of the natives is such as to render it extremely difficult for a passing traveller to obtain any accurate information. I am quite convinced that a careful investigation of this region would bring to light great mineral riches. It is well known that valuable mines are worked in the districts to the west; for instance, at Júlámerk, where the mines of sulphate of arsenic are among the most important belonging to the Turkish Government. These, if properly conducted, would prove to be a source of large revenue. But generally, however rich a mine may be, the great want of fuel and water throughout this region would be a bar to its being worked with advantage. To this difficulty must be added the inclemency of a long winter-season, and the utter ignorance of the natives in the art of practical mining.

Section between U'rúmia and Gáwár. Fig. 15.

The alluvial plain of U'rúmia is bounded on the west by a considerable range of sandstone, which separates it from the plain of Desht.

This range rises at Seyr Dágh to the height of 7260 feet above the sea (according to barometric measurement made by the members of the American Mission), and has a constant dip of 5° or thereabouts to the N.E.

Following up the course of the Sháher stream through the range, the geologist recognizes in the beds composing it characters which at once class them with the Gypsum-series described in Part I. of this paper (p. 254), as occurring along the western skirts of the Zagros, between Behbehán and Mosúl.

These characters are not to be mistaken. The sandstones of the Seyr Dágh belong to the uppermost part of the gypsum-series,—in the lower beds alternating with marls and impure limestones, and in the upper with conglomerate-gravels. The colour of the sandstones is yellow or brownish; in this respect differing from the same rocks in the west, which are generally reddish.

The upper beds are in places covered unconformably by a mass of loose gravel, or gravel-conglomerate with calcareous paste.

It is remarkable that the gravels associated with the sandstones are composed of pebbles of blue and white altered limestone, quartz, micaceous sandstone, and quartzose sandstone, without any intermixture of igneous rocks; on the other hand, the superficial gravel chiefly consists of pebbles derived from the adjoining igneous chain. This fact is of considerable importance, as tending to establish the fact of the very recent elevation of the Frontier chain,—subsequently indeed to the deposition of the sandstones and associated gravels. It is moreover evident that crystalline action preceded the deposition of the lowest beds of sandstone and gravels, since all the contained limestone-pebbles show that they were altered and rolled before they were imbedded in the matrix of the gravel.

At the N.W. end of the Desht plain, and at the head of the ravine through which the Sháher stream flows to Urúmia, a spur projects from the great range, and shows the metamorphosed blue limestone resting on pinkish quartz-rock.

Quitting the Desht plain, the road follows up a narrow ravine formed by the junction of the gypsum-sandstones on the east with underlying blue limestone on the west.

A low ridge of the same limestone is afterwards crossed, and the plain of Mergáver entered. This plain is bounded on the east by the sandstone and conglomerate hills; and a patch of the same rocks is crossed just before entering the ravine of the Júra stream, which separates the plains of Mergáver and Beradúst.

The mountain-masses which occur between Mergáver and Gáwár do not present any conspicuous peaks, but consist of a series of vast undulations, across which but few roads are found, and these only along the watercourses. In the transverse section there are shown two eruptions of igneous matter; a rock of massive hornblende at Bird í Resh, and a rounded peak of granite to the west of Dayra.

On entering the gorge of Arzin by the Júra ravine, on the east of the chain, the first rock met with is a cream-coloured limestone, having its layers much broken and presenting some rugged peaks. The colour of this limestone changes from cream-colour in its upper part to grey and dark-blue beneath. In its lower layers it is of similar character to the crystalline blue limestone of Bisutun, near Kermanshah, &c. All the beds are traversed by threads of carbonate of lime.

I have in the section (fig. 15) numbered these beds separately, but I am quite convinced that the blue is only an altered condition of the yellow or nummulitic limestone of the south, caused by the neighbouring eruption of the igneous rocks. I have elsewhere expressed my opinion (p. 280) as to the geological age of the greater portion of the blue limestone;—there can be no doubt as regards the rock here (as also between Ushnu and Mergáver, and at the black conical peak Seah Kuh, on the west of Mergáver) because it conformably underlies the yellow limestone, into which it passes by a gradual transition.

Further up the ravine, the blue limestone is underlaid by blue calcareous schists, into which it makes a very marked passage. The limestone first becomes schistose; and then in this condition alternates with the slates. These are in turn underlaid by dark-brown ironstone-clays. These schists and clays probably represent the marls of the Kirrind and Mahidesht section, p. 275 (Part I.), fig. 9.

In advancing to the westward, the ironstone-clay is crushed in a fold, and encloses a trough of contorted slates between eruptions of hornblende-rock and granite.

The hornblende is exceedingly hard, compact, and heavy, and contains numerous elongated acicular crystals, resembling the stone at Kel í Shin.

The granite is of the usual character, fine- and large-grained, and easily decomposes.

Immediately beyond the granite there occur undulating and contorted beds, of enormous thickness and extent, composed of gravel-conglomerate, sandstones, and marls, with intercalated layers of impure limestone and sandstone. I have no hesitation in assigning these deposits to the age of the gypsum-series. The sandstones present the same indistinct casts and curious marks which were observed in the south near Dizful (p. 261);—none were, however, sufficiently characteristic to be brought away as specimens. These beds are much disturbed, and dip in every direction of the compass; thus showing the intensity of the elevating force. They continue without intermission to the Plain of Gawar, where they are covered up by alluvial soil. Before reaching it, they constitute the Ziniyásiv Pass (the greatest elevation attained by the road along this section), one of the highest passes across the chain; the summit being about 12,000 feet above the sea.

Between Gawar and Berádúst, by way of Basseh and Bazirgah, the only rocks visible are those of the gypsum-series, and they exhibit the same bends and contortions as in the previous section.

From the mountains to the east of the above section there was brought to me some heavy and rich ore of magnetic oxide of iron in quartz, but the exact locality was not indicated.

Section from Berádúst, across the Plain of Selmas, to Derik. Fig. 16.

On quitting the rich alluvial plain of Berádúst, a low gravel-range is crossed to reach the District of Somai, which is an extensive irregular undulating plain, owing its contour to the presence of masses of superficial gravel. Gradually ascending in a northerly direction towards the high range called Shetkha or Anjulukh Dagh, low cliffs of compact and vesicular basalt, with crystals of leucite, for the first time along the Frontier make their appearance. These are succeeded by an elevated plain, in which decomposing mica-schists now and then protrude through the soil; but I could not make out their position with regard to the trap-rocks.

The Pass over the Anjulukh Range exhibits an infinite variety of porphyritic and granitic compounds on the summit, before attaining which on either side are complicated mixtures and interchanges of hornblende, felspar, and mica, similar to those described by Mr. Ainsworth (Geogr. Journal, vol. xi. p. 60) as met with by him to the west of the same neighbourhood, on Zendesht Dagh, between Selmas and Jemáláwá. These rocks on the south of the Plain of

Selmas would repay careful examination. The changes are rung on the various minerals entering into their composition in the most extraordinary and perplexing manner. At one locality near the summit is a mass of grey syenite, containing magnetic oxide of iron.

On the descent to the Chehrik stream the sandstones and gravels of the gypsum-series again make their appearance, dipping at a slight angle to the river and towards the north. Just before gaining the river, a very interesting and remarkable phænomenon presents itself. The upturned edges of the sands and gravels are overlaid by basalt;—an overflow probably from the mountains on the west, forming an extensive *coulée* over the whole upper part of the Plain of Selmas *. The river itself flows between natural cliffs of about 300 feet in height, exposing a fine section.

The basalt, which constitutes one half of the cliff, is in its lower portion highly compact and regularly columnar; but in passing upwards the columnar structure ceases, and the rock becomes less compact, until at the surface it is a highly vesicular basalt. Dispersed throughout are crystals of leucite and other volcanic minerals. The castle of Chehrik is built upon a very picturesque rock of the columnar basalt, which is separated from the main mass and stands isolated in the centre of the ravine. The sandstones and gravels exhibit much less change near the overflow of igneous matter than might be expected; the sandstones, however, are somewhat hardened, and the pebbles appear as though they had been submitted to the action of fire.

Mixed here and there with the vesicular basalt are amorphous masses of pink, cellular, basaltic scoriæ.

Many of the cells are filled with yellowish carbonate of lime, and contain volcanic crystals, especially olivine and hornblende, with a little mica. Their exterior is more compact than the interior, exhibits a greater proportion of calcareous matter, and is frequently coated with a thick *enduit* of the same. It has been suggested, that these masses are volcanic bombs, but the large size of many of them is opposed to this idea. In my opinion, they are portions of calcareous tufa, torn from their parent rock during the flow of the basalt over it, and they have assumed their present character by being rolled up and fused in the heated mass, and by the injection of igneous gases.

In favour of this hypothesis we have on the north side of Anjulukh Dagh, a very conspicuous peak of stratified travertin, which bears on its summit a famous Castle called Kalah Karni. This peak has been forced up by the granitic rocks of the Dagh, having its strata dipping to the north at an angle of 45°. Its base is concealed under the basalt. The extreme whiteness of this peak forms a striking contrast with the black igneous rock of the adjoining plain.

* I had no opportunity of visiting the country west of Chehrik, to ascertain the point from which the basalt has its origin. At some distance, however, beyond Chehrik, there exists a high peak, with a small extinct volcanic crater, around the base of which Lieut. Glascott, R.N., and Mr. Jackson, I.N., observed a vast circuit of basaltic matter. It is not improbable that the basaltic flow over the Plain of Selmas has proceeded from this crater.

The eastern limit of the basalt is pretty correctly marked across the Plain of Selmas by numerous little rounded knolls of this rock, which extend along a line drawn from the east of Kalah Karni, on the south, to the Derik stream on the north.

Soon after quitting the village of Selmas, on the road to Derik, the red sandstones which were previously observed on the descent from the Anjulukh Pass, again appear from beneath the rich alluvial soil of the plain. The beds dip on their first appearance at an angle of 20° to the south, but this dip increases in ascending the ravine of the Derik stream, until the beds become perfectly vertical. Layers of gravel-conglomerate are associated with the upper part of the sandstone-series. In one locality a thin bed of loose gravel rests on the broken edges of the sandstones, and is overlaid by an horizontal deposit of cream-coloured travertin. The vertical sandstones and the travertin are again covered by the basalt, which dips at an angle of 2° to the south. Towards the north the basalt gradually decreases in thickness, becoming less columnar and more vesicular, until it finally dies out somewhat abruptly on the west bank of the ravine, where it overlies a considerable bed of travertin. On the east of the stream, the basalt only occurs in one insignificant patch, upon the summit of a small peak of sandstone. Wherever the travertin is in contact with the basalt it is rendered hard and compact.

In the bed of the stream are blocks of pink basaltic scoriæ, similar to those which were observed in connexion with the basalt in the Chehrik Cliffs, near Kalah Karni; but they contain a much larger quantity of calcareous matter. Further up the ravine the tufa exhibits much contortion, and is penetrated by a peak of dark-coloured heavy rock of decomposing felspar mixed with dark carbonate of lime. Upon the sides of this peak are several detached pieces of tufa, torn away from the parent mass, and so metamorphosed, that it would be almost impossible to recognize it in the pure white marble into which it has been converted, were it not that we can trace it through all its phases. In some instances it bears a remarkable similarity to some of the beds of Nummulitic limestone in the south. Passing onwards to the north of the felspathic peak, we again have the tufa contorted, and resting against and upon it. It afterwards bends down towards the little village of Derik, where powerful springs are now in action, producing travertin in abundance, and showing the agency which deposited the older and altered tufa. The narrow valley of Derik is bounded on the north by high mountains of igneous rocks, among which the felspathic and hornblende compounds, so common in this region, are found.

Travertin Springs.—As calcareous-tufa-springs, from this point northwards, are of continual occurrence, and as the deposits formed by them have vast geological importance, a description of those at Derik, which is a good example of all, is worth recording.

The springs are close to the village. They are numerous, though two only have any great flow of water. These are about six yards from each other, and rise from the bottom of irregular-shaped basins, between 4 and 5 feet in depth. The water rises with great force in the more northerly basin, at regular intervals, but in the other irregularly, at intervals of five or seven seconds, gurgling from below, and throwing up a strong jet to the height of a foot above the surface. The temperature of the two springs is the same, viz. 96° Fahr., indicating a common origin. The water is strongly nitrous and chalybeate. As the surface of the water cools, numerous thin lamellæ of cream-coloured carbonate of lime are formed, and float about like scum. These lamellæ are sometimes two inches long, and about the thickness of a wafer; the upper surface is smooth and shining, as if strongly glazed, and the under surface frequently shows its crystallized structure. They are carried along by the water as it flows from the basins, and form a thin coating upon the surface of the rapidly forming travertin. Under the feet these lamellæ crackle and break like thin "cat-ice."

As the water flows onwards, cooling in its passage, it deposits its heavier calcareous matter in small granules of cream-coloured carbonate of lime, which become cemented together by the continual infiltration of the water through them, and at length are sufficiently compact to be called travertin. In passing over and among these forming granules, the water is soaked up as if by a sponge, and hence it has frequently been described by travellers as becoming petrified on the spot!

The process of deposition of the calcareous particles is without doubt exceedingly rapid; but not sufficiently so to be observed instantaneously.

Sometimes the calcareous matter is deposited in thin concentric circles (the exterior one frequently a quarter of an inch in diameter), granulated on the surface. The great body of the water, however, passes over the curved mass of the travertin into the ravine below, increasing the bulk with additional layers. The travertin assumes the stalactitic form when the water flows over some pendent plant or other body; in such cases a rippled and honeycombed aspect is produced. From the hot springs to the bottom of the ravine is a depth of about 60 feet,—a solid mass of travertin; while at three times that height above the springs the older and altered deposit rests on the slope of the felspathic rock.

Other springs flow in small streams from holes in the travertin; they are less saline, and more strongly chalybeate, while the temperature does not exceed 90° or 92° Fahr.

Above the village is the basin of an extinct spring. The hot springs of Derik are much resorted to for every species of complaint to which the Kourd is subject.

It may be worth while to recur to the various changes which have taken place since the deposition of the red sandstones and gravel beds, which I assume to be of the same age as the similar beds occurring near Dizful, and containing evidences of the existence of feline animals, and therefore of comparatively modern formation. We have:—

1. The elevation of these beds from an horizontal into a vertical

position, and the production of the Plain of Selmas, probably by the eruption of the hornblendic rocks on the north and south.
2. The denudation of the edges of the upraised rocks, and the deposition of the horizontal thin bed of coarse gravel.
3. The formation of a vast bed of travertin from thermal springs.
4. The eruption of the felspathic mass, carrying with it portions of travertin, torn from the deposit *in situ,* and contorted during instantaneous elevation.
5. The overflow of the basaltic *coulée* from the west or north-west, covering up and altering the edges of the vertical sandstones and contorted travertin ; and the cooling of the heated mass, whereby probably was formed the fault or crevice through which the Chehrik stream flows.
6. The deposition of the alluvial soil of the Plain of Selmas.
7. The present action of the thermal springs, depositing powerful beds of travertin ; which action must have been constant since the end of the second period above alluded to.

Section from Selmas to Gúverjin Kalah, on the Lake of Urúmia, viâ *Issi Sú.* Fig. 17.

On quitting the Plain of Selmas, the road traverses an open pass at the village of Ali-ábád, between Zendesht Dagh (an extension of Anjúlukh Dagh), on the west, and the peak of Súret Burní (so called from the sculptured equestrian figures of the Sassanian dynasty), on the east. The rocks here consist of blue, altered, and crystalline limestone, much contorted. A little further on, to the left of the road, there rises from the plain a solitary peak, the summit of which is of the same blue limestone, passing downwards into a heavier compact variety, filled with small transparent crystals of carbonate of lime, which give it the aspect of a calcareous grit. This is underlaid by hard, fine-grained, red, compact fluor, associated with red jasper. The jasper reposes on a mass of pink, quartzy, granitic rock. The above-mentioned deposits here dip towards the north, as they likewise do on the south side of Zendesht Dagh, at the base of which is the hot sulphur-spring of Issi Sú. This spring rises from beneath a mass of altered blue limestone, surmounting grey limestone-breccia, which emits a strong odour of sulphur; both of these rocks have been thrown off from the side of the range. The temperature of the spring is 99° 5′ Fahr. It deposits a considerable efflorescence of carbonate of soda, generally pure white, but frequently tinged with yellow and red, from the presence of oxide of iron. In the same neighbourhood, at a place called Temtemah, there is a cold spring depositing travertin, which I omitted visiting.

From Issi Sú, the road crosses a considerable spur running in an easterly direction from the main chain. It is composed of pink quartzy rock,—pink felspathic granite,—a highly micaceous dark granite,—compact hornblende-rock,—and various hornblendic mixtures.

A gradual descent conducts to the small plain of Kúrt Kerán, containing numerous villages.

Further eastward, where this spur projects into the Lake of Urúmia, it is composed chiefly of compact hornblende, and compounds of the same mineral with others. On the south side of the extremity of the spur these igneous rocks are capped by blue crystalline limestones of the same character as at Zendesht Dagh, and dipping to the S.E. On the summit and northern side are patches of hard, heavy, white chert, frequently tinged with red, and containing common opals.

Between the Plain of Kúrt Kerán and Gúverjin Kalah, there intervenes another spur called Wurgowiz, parallel to the former, and which, projecting into the Lake of Urúmia, forms the promontory of Gúverjin. It is also composed of the same granitic, hornblendic, and pink-quartzy rocks. The mountain slopes gradually towards the Lake, and leaves a plain about a mile in width at its southern base, between it and the Lake. Connected with the mainland by a narrow slip of sand and shingle of well-rolled pebbles of limestone and igneous rocks, a white limestone rock, about 400 feet in height and perpendicular on all sides, rises out of the Lake. Upon this are the ruins of an ancient castle, called Gúverjin Kalah, which takes its name from the abundance of pigeons which frequent it. A similar perpendicular rock, but completely surrounded by the Lake, is another prominent object to the N.N.E., at a distance of about a quarter of a mile, and there are several smaller islands at a still greater distance in the same direction.

The following is a careful descending section of the Castle Rock. The beds are all conformable to each other, and dip at an angle of 7° towards the E.S.E., which dip is of course due to the igneous rocks of the Wurgowiz spur on the north.

1. Compact, hard, crystalline, white limestone, becoming concretionary in passing downwards, afterwards marly.
2. Light-blue marl, with hard flesh-coloured flints and nodules and irregular fragments of limestone. It contains abundant Corals *in situ* and in layers, below which are numerous specimens of *Clypeaster*, *Echinolampus*, *Pecten*, *Serpula*, and casts of various Univalve and Bivalve shells.
3. Compact mass of highly crystalline coralline nodules in hard marl.

The thickness of the above three beds is about	250 feet.
4. Fine reddish gravel, or coarse sand-conglomerate, much hardened, and filled with fragments of fossils	18 ,,
5. Friable yellow sandstone, very finely grained, with fragmentary fossils	15 ,,
This bed passes into	
6. Hard and compact, grey, marly limestone, filled with Corals and casts of shells	6 ,,
7. Hard reddish marl, abounding in shells	21 ,,
8. Brownish-yellow, friable sandstones, with several thin layers of gravel and conglomerate, of variously-sized rounded pebbles..................	100 ,,
Total thickness of Section..	410 feet.

I was informed by Mr. Perkins (the head of the American Missionary Establishment at Urúmia, whose geological remarks on that neighbourhood have been published by Prof. Hitchcock) that he had heard of the existence of fossil vegetables on some of the islands at Gúverjin.

There are certainly none at the Kalah, and as there were no boats on the Lake, I had no means of access to these islands. Possibly, however, the vermiform casts, which are not uncommon in the sandstones, may have been mistaken for remains of plants.

Many of the fossils derived from the Kalah Rock have a remarkable resemblance to those of Kirrind and Púl í Tang; but they have not yet undergone careful examination. There is, however, an entire absence of the characteristic Nummulites of those localities.

In this short section we have limestone assuming three different forms; viz. the white limestone of Gúverjin Kalah,—the blue limestone of Wurgowiz and Zendesht,—and the chert with opals of Wurgowiz.

Are we to conclude that these were deposited at different epochs, or is it more reasonable to suppose that they are only varieties of the same deposit, formed under different circumstances? That white limestone is converted into blue by its proximity to the igneous rocks has been pretty clearly shown in previous sections; and that fossils should by the same cause be altogether obliterated, is an established fact. I am therefore inclined to regard the three varieties of limestone in this district as the same deposit, and probably of nearly identical age with the upper beds of the Nummulitic rocks of the south.

Lake of Urúmia.

As considerable beds of rock-salt exist in the neighbourhood of the Lake of Urúmia, and as a former condition of the Lake itself appears in some measure to have assisted in the formation of this valuable mineral, and therefore to be within the scope of the geologist's researches,—I trust it will not be considered a digression, if I briefly make a few remarks upon this lake.

The Lake of Urúmia measures about 82 miles in length, from north to south, and about 24 miles at its greatest breadth, from east to west. Its level is 4100 feet* above the sea. The water is of a deep-azure colour, but there is something exceedingly unnatural in its heavy stillness and want of life. Small fragments of Fuci, saturated with salt, and thrown ashore, form a low ridge at the margin of the Lake, and emit such a noxious effluvium under a hot sun, as to produce nausea at the stomach. The sulphuretted hydrogen generated from the Lake itself without doubt adds to this sensation.

The water is intensely salt, and evaporates so rapidly, that a man, who swam in to bring me a bottle of the water for analysis, on coming out was covered with particles of salt, and looked as white and ludicrous as though he had been thrown into a flour tub.

* According to the measurement of the Rev. Mr. Stoddard of Urúmia.

According to Prof. Hitchcock, the specific gravity of the water of Urúmia Lake is 1·155, and his analysis of 500 grains gave 102·1 of salts, or more than one-fifth of the whole. The water of the ocean only yields one-thirtieth of its weight in salts.

At Gúverjin Kalah the temperature of the water on the 14th August 1852, at $11^{h} 45^{m}$ A.M., was 78° Fahr., which is high; possibly on account of the proximity of the limestone rocks.

I carefully examined the surface of the rocks at the water's edge, but could detect no indications of the Lake having ever been higher than at present. The natives say, that they remember no change of level, beyond a slight annual rise and fall attendant on the melting of the snows. This does not agree with the account of Mr. Perkins, who, from many years' careful observation, says, that the Lake of Urúmia is rapidly diminishing in extent;—that the small dykes which existed eighteen years ago for the purpose of restraining the water in shallow troughs, where salt was collected, and were then close upon the edge of the Lake, are now fully half a mile distant from the present margin. Salt is collected along the shores in large quantities, and conveyed into Turkey. On crossing the Frontier a tax of ten paras (rather more than a halfpenny) per load is exacted; the value of a load in Turkey being about 1*s.* 3*d.* It would be interesting to ascertain whether the saltness of the water is increasing or diminishing.

Some authors have endeavoured to account for the excessive saltness of the Lake by supposing that it is attributable to the streams which flow into it from salt rocks on the north and east. This theory, however, cannot be maintained; because such streams are comparatively few and insignificant, and their effect would be neutralized by the large number of pure streams, some of considerable size, which flow from other quarters, especially those rising in the lofty Frontier-chain on the west.

My own idea on the subject is based upon the examination of the neighbouring igneous chain, which, it is evident, has been elevated at a very recent period. During this elevation, it is by no means difficult to conceive that large isolated bodies of salt water were detached from the then existing main ocean, and settled in basins, such as the Caspian and Aral Seas, and the Lakes of Urúmia and Van. Supposing that, after detachment, a rapid evaporation took place from great heat caused by igneous action at the bottom of these basins, the water would of course become more salt, and under certain circumstances rock-salt would be deposited. (See also p. 309.) Continual evaporation would tend to increase the saltness; and, if the freshwater streams flowing in did not equal the quantity of water so dissipated, a continually increasing saltness would take place, while the sea or lake would be gradually decreasing its limits. Such I believe to have been the origin and cause of the excessive saltness of the Lake of Urúmia. In corroboration of this theory, we have not only porphyritic and granitic eruptions on its shores, but considerable deposits of rock-salt in the neighbouring Plain of Khoï, which are described in the following Section.

Section from Selmás to the Plain of Khoï. Fig. 18.

At about $3\frac{1}{4}$ miles due north from the town of Dilman is a small artificial "tepeh," or mound, constructed upon the extremity of a gravel spur from the east, at the village of Moránjúk. This gravel is chiefly composed of angular and loose fragments of blue limestone. On quitting Moránjúk, the road turns to the N.E., and at the pass called Khonli Dereh, ascends over extensive and undulating calcareous marl hills, the horizontal stratification of which is partially concealed under a gravel-capping. On descending into the Plain of Khoï, the marls, *c*, fig. 18, make their appearance in powerful beds of light-blue and white layers, alternating with each other. The next lower rock is a deep-red, indurated, calcareous marl, *d*, which rises into a beautifully rounded dome, called Kárá Tepeh, on the north side of which these red marls are again overlaid by the white and blue beds, and these again by a thin layer of brownish-yellow limestone, *b*. From the foot of the Pass to the Dúzlak, or "Salt Hill," is a distance of $3\frac{1}{2}$ miles across a plain covered with salt efflorescence on the surface. The glare arising from it renders the short ride exceedingly painful to the eyes. The Dúzlak is a small and conspicuous hill in the centre of the plain, nearly circular in form, three-quarters of a mile in circumference at its base, and 150 feet high. It has a remarkable appearance in the distance, and is composed of a deep-red marl dome, *e*, rising from among superimposed beds of light-blue or grey marls. On examination, the red marl proves to be exceedingly friable, and to be associated with a fine-grained, exceedingly hard, red sandstone, impregnated with small crystals of salt; sometimes this sandstone is grey and of a fibrous structure, and the mineral forms clear stalactites between the layers. The blue or grey marls are capped by fine loose-grained sandstones, which pass into a coarse gravel, abounding with Corals in a beautiful state of preservation; some of these undoubtedly lived during the deposition of the gravel; but others have been decidedly derived from an old bed of crystalline yellow limestone, *f*, and are much rolled and worn. Large water-worn blocks of the limestone lie at the base of the hill. I am unable to state whether they have been transported from another locality, or whether they are projecting fragments of the rock *in situ*. I am inclined to regard them as *in situ*, because they do not elsewhere appear on the plain.

Immense excavations have been made into the blue marls for the purpose of obtaining salt, which valuable mineral here occurs—1st, in a state of powder; 2nd, in a solid mass of irregular blocks, firmly imbedded and locked with each other, hard and crystalline; 3rd, in transparent and very pure cubes. The second variety is the most abundant. The transparent cubes are only met with at the lowest parts of the excavations, which are now quite abandoned, owing to the slovenly manner in which they have been conducted, and consequently to the danger attending the working. The great wonder is, that the labourers are not frequently buried by the falling of the walls of the excavations. Some of the holes are 60 or 70 feet deep;

and, as any one is at liberty to dig how and where he pleases, it may be well imagined what a "warren" the Salt Hill is become.

At the base of the hill the hard crystalline limestone is completely filled with fossils, especially beautiful and perfectly preserved Corals, together with casts of shells, among which are an *Arca*, *Lithodomus*, and *Trochus*. The Corals agree in species generally with those from Guverjin Kalah, and many of them present a remarkable resemblance to species from the European deposits of Gosau.

Quantities of massive gypsum and crystals of selenite are imbedded in the sandstones and loose gravel. The surface of the Salt Hill is of rotten blue marl and sand, apparently derived from the melting of the mineral and the decomposition of the matrix, by atmospheric causes. Gypsum and selenite also lie strewed in great abundance on this decayed soil.

The Plain of Khoï would appear to be an horizontal deposit of the above-mentioned sandstone and gravel.

In accounting for the origin and saltness of the Lake of Urúmia, I have concluded that these are due to the recent eruption of the igneous rocks, p. 307. I believe that the red and blue marls containing the rock-salt (together with the associated sand and gravel deposits at the Dúzlak, in the Plain of Khoï) were in process of formation at the period when the igneous rocks were intruded from beneath the bed of the then existing ocean, carrying with them portions of the stratified deposits,—and that the intensity of volcanic action was such as to produce solidified rock-salt from the depths of the sea in the pure state here met with. By the same action, the sands saturated with sea water would be converted into such a rock as the saliferous sandstone of the Dúzlak. The portion of the liquid mass which remained after the disturbance unevaporated, from depth or other cause, constituted the modern Lake of Urúmia, and I imagine that similar salt-lakes were formed in a like manner, varying however in their saltness according to circumstances,—viz. depth, intensity of volcanic action, &c. In favour of this view, it is worthy of remark, that the most pure and perfect crystals are at the greatest depth, where of course the pressure from above and the internal heat must have been greatest; while the least compact salt is at the surface.

The above theory appears to me to be the most simple in accounting for the origin of rock-salt in this region, and for the intense saltness of the Lake of Urúmia. That the streams flowing from the neighbourhood of salt-deposits have no influence on the quality of the water of the Lake itself is evident, since they are drinkable, and at Shábáni, half a mile from the Dúzlak, the water, though brackish, is by no means disagreeable. That a vast amount of rock-salt exists beneath the Lake and surrounding plains is almost certain.

The isolation and elevation of the Dúzlak are not difficult to explain, seeing the proximity of the igneous chain, and the probability of its being a dome, forced up in the centre of the basin.

Section between the Plain of Khoï and Van. Fig. 19.

From the Plain of Khoï the road to Kotúr traverses a long narrow ravine up the course of the small stream, flowing from Kotúr to Khoï. The precipitous mountains on either side are variegated with every hue and shade of contorted calcareous marls or limestones; but the beds are utterly devoid of fossils,—undergo every degree of contortion,—and graduate insensibly into each other in colour, so that it is quite impossible to make out any regular order of stratification.

For the first two miles from the entrance of the ravine, the variegated marls occur on both sides; but at the Beacon, erected by H. E. Dervish Pasha, the Turkish Commissioner, the following descending section was observed:—

1. Dark-brown heavy ironstone-clay.
2. Light-blue or grey calcareous slates, varying through intermediate shades to dark-purple; of great extent, frequently in a decomposing state.
3. Highly indurated, deep-red, calcareous marls and clayslate, sometimes passing into serpentine; and compact limestone enclosing amygdaloid.
4. Compact limestone, varying from light-grey to dark-olive-green, containing small crystals of carbonate of lime.

About four miles from the Beacon is a solitary flat-roofed Caravanserai, close to which is a chalybeate spring, 67° Fahr., depositing calcareous tufa as at Derik. Above the spring is an horizontal bed of gravel-conglomerate, resting against the curved strata of red indurated marls. The extent to which tufa-deposits have taken place during the formation of the marls is very remarkable. The tufaceous layers are intercalated between, and partake of the contortions of, the various beds of marls; while they have all undergone similar changes from the action of heat. The tufa varies from the loose and friable state of its first deposition to a compact limestone, and even to yellow or white saccharoidal marble.

At seven miles from the Beacon is an eruption of igneous rocks, where the following interesting section occurs:—

3. Variegated and highly calcareous marls, with much travertin, in layers and in mass. Some of these marls or limestones effervesce yellowish-green with muriatic acid.
5. A thick bed of gravel-conglomerate; the pebbles are cemented in brown oxide of iron, and are converted into hard dark-green or black chert by the action of the underlying igneous rocks,—which consist of:—
6. (*a*) pinkish trap, containing much leucite and hexagonal prisms of mica;
   (*b*) finely grained greenish granite.

The travertin has been abundantly deposited during the formation of the gravel-conglomerate, as well as during the igneous eruption; since it occurs in a much altered state in the midst of the gravel, as well as between the gravel and granite, which it likewise traverses in broad highly crystallized veins.

The travertin is so largely developed, and is so intimately connected with the marls, that there can be little doubt of their being chiefly composed of it. The presence of iron has of course produced their variegated colours; and it is a coincidence, that the travertin deposits, which are at the present day forming at innumerable places in the ravine, derive their colours from the quantity of iron held in solution by the springs.

From the vast extent of the travertin deposits in this region,—and, in many instances (when acted upon by igneous eruptions, as in the ravine of the Kotúr stream, and at Derik), from their remarkable similitude to the nummulitic limestone of the south,—I am inclined to think that they have had considerable share in the formation of the earliest tertiary rocks of the Frontier.

It is remarkable that some of the friable limestone of Gúverjin Kalah,—and of the No. 7 bed of the Kirrind and Mahidesht section (fig. 9, 3 *g*), p. 276, Part I. of this paper,—cannot be distinguished from the altered travertin of Derik, &c. Supposing that the seas of the Nummulitic period abounded in travertin springs, would not the superabundance of calcareous matter sufficiently account for the extreme rarity of animal life, and hence of fossil remains?

At twelve miles from the Beacon, the small valley of Zerri branches off on the right bank of the stream. Here the variegated marls entirely cease, and are succeeded by a second eruption of igneous rocks;—viz. the same fine-grained green granite as before, traversed by veins of carbonate of lime,—a dark-coloured serpentine,—and a grey conglomerate of felspar and talc rock. The ravine now widens, and gradually expands into the pretty Plain of Kotúr, which is bounded on the east and south by igneous rocks.

On quitting the Plain of Kotúr, the road turns to the N.W., and passes through a series of red altered sandstones, containing thick beds of gravel-conglomerate, and resting upon a hard chert-rock, of pinkish-grey colour, which is frequently traversed by veins of a beautiful red felspar with talc.

It is not improbable, that the upper layers of gravel are identical in age with those so much altered and resting on the granite in the ravine between Khoï and Kotúr; and they possibly belong to the gypsiferous formation.

Turning towards the north, the chert-rock overlies compact blue limestone, in thin layers.

All the above beds are elevated and thrown downwards to the south, at an angle of 45°, by the mountain of Hallep Dagh, which is chiefly composed of very dark-green serpentine and fine-grained grey granite. Thin veins of light-green steatite traverse the serpentine. In one locality the serpentine mass overlies the blue limestone, which is at the point of junction much contorted.

At the top of the Pass between Kotúr and Sheráb Kháneh is a little freshwater lake, surrounded on all sides by small peaks and undulations of limestone.

From Sheráb Kháneh the road crosses a low limestone-ridge, covered with fine loose gravel, and descends into the somewhat lower plain of Seraï, which is bounded on the north by a low range called Kur Momedelán. On the south side the plain is bounded by a range of blue and grey limestone, with slates dipping in the same direction. From the plain of Seraï a short descent over limestone conducts to the little plain of Astajú.

The west extremity of this plain is shut in by a low range of hornblende and talc rock, which protrudes through variegated marls.

This range is crossed; after which, it curves in a westerly direction, bounding the road on the north; and finally joins the Kur Momedelán, which is composed of highly coloured and altered marls. The red marls are frequently converted into serpentine and jasper. These beds dip at an angle of 40° to the north, and repose on a grey rock of decomposing felspar and hornblende, as observed just before entering the plain of Ardchek.

In the plain of Ardchek is a small lake, the water of which is brackish and disagreeable. It has no outlet; but a few insignificant streams flow into it.

On the south this plain is bounded by an eastern prolongation of the great igneous range called Warrekh Dagh; on the north side of which is an outer ridge of white limestone. The north shore of the lake washes the base of the high range called Kizzulján Dagh, the jagged summits of which appear to be composed of some igneous rock, beautifully variegated by the numerous beds of coloured marls lying without visible order on its slopes.

The road continues to the west along the south side of the plain of Anzoub, passing the extremities of several low limestone spurs from the lofty and craggy range of Warrekh Dagh. The western continuation of Kizzulján Dagh, composed of white limestone, bends towards the south, and at length joins an important spur called Ak Kirpi Dagh, projecting from Warrekh Dagh. A precipitous descent down the escarpment of this limestone barrier conducts to the plain of Van (which is about four miles broad at this point) to the shore of the lake. At the distance of a mile from the lake a bold rock of compact grey limestone, 400 feet in height, rises abruptly from the plain, presenting a perpendicular face towards the west, and extending about half a mile in length from north to south. On the summit of this rock stand the Citadel and eastern wall of the City of Van. The foundation blocks of the Citadel are of the same limestone as that on which they stand; but the stone chiefly used in the construction of the more recent portion of the buildings is of soft reddish volcanic breccia; and I also observed many blocks of comminuted white shell-sand, in which is a minute species of *Mytilus*. The last is probably derived from the shore of the Lake, or from one of the Islands, and is of very recent formation. At the present day, however, no mollusca inhabit the Lake of Van.

Section from Van to Mount Ararat. Fig. 20.

At the third mile from Van, the road touches on the shore of the Lake at the "perek," or soda-basins (p. 320), and then, turning slightly more towards the N.E., it quits the Lake and crosses a low rising ground. At the highest point of this rise, six miles from Van, a few slate-rocks project through the red and blue marls of the Kuzzuljah Dagh, which here dips into the plain on the S.W. At the village of Derlashen the yellow compact limestone rises in a thin bed from beneath the marls. After crossing the Mermút Chaï, and an irregular plain surrounded by peaks of limestone and variegated marls, the summit of an easy limestone pass is attained, which overlooks the N.E. spur of the lake. At the foot of this pass, on the north side, a thin overflow of black basaltic lava covers up the limestone ; its lower portion is compact, but on nearing the surface it becomes highly vesicular, and is strewed with blocks and pieces of black scoriæ. The basalt borders the shore of the Lake in a low range, and it constitutes the N.W. side of the Khárpánák promontory, extending to near Mírik, but not crossing to the east of the road between Van and the latter place. At the entrance to Merek village, however, the basalt disappears, and its place is supplied by some conspicuous peaks of white limestone. The village is situated at the height of 1000 feet above the Lake; and in the cliffs the following descending section is observed :—

1. A confused and broken mass of compact white limestone; its position not satisfactorily made out with regard to the rocks of the section; the thickness very considerable. This is the limestone which appears in peaks above the village.
2. Altered red clays; thickness unknown, but considerable.
3. Grey volcanic tuff, containing regular layers of apparently water-worn pumice, and various volcanic products. In aspect it sometimes resembles a coarse grit, but is very light.............................. 150 ft.
4. Cream-coloured tuff, with larger lumps of yellow pumice, which easily crumble to powder; very light to the touch .... 40 ft.
5. Highly vesicular, heavy, brownish-blue lava; vesicles very large and quite empty. In passing downwards, the vesicles become gradually smaller, until they finally disappear, and the lava at last passes into a dark-blue compact basalt .... 100 ft.
6. Alternating gravel-beds and fine sand layers, of a delicate light-pink colour; unaltered by contact with the overlying basalt .... 250 ft.

The dip of the beds Nos. 2–6 is at 60° to the S.W., *i. e.* from the Lake.

From this single Section at Mírek it would be impossible to pronounce upon the age of any of the deposits. They may belong to the Nummulitic, to the Gypsiferous, or to even a later series.

From Mírek to the mouth of the Bend í Máhi Sú, at the extreme N.E. end of the Lake, the road continues along the shore, having a high basaltic range on the S.E., which sends down several spurs into the Lake. The whole of the mountains closing in the N.E. extremity of the Lake of Van are basaltic, and they present some bold and imposing scenery to the traveller.

On the north rises the lofty peak of Asúrúk Dagh, with its crateriform centre, having much the aspect of a volcanic cone cleft on its south side towards the Lake. Possibly from it issued forth the streams of basalt on the N.W. side of the Kharpanak promontory. I had no time to visit it. From the extremity of the Lake to Begiri Kalah is a distance of 6½ miles along an alluvial plain, through which flows the Bend í Máhi Sú.

Following up the course of the stream from the Kalah, the road traverses an open valley, ten miles in length, between high and imposing cliffs of black basalt and grey basaltic lava; the path is much obstructed by lumps of loose scoriæ. At one locality was observed a mass of altered white travertin, overlaid by vesicular basalt. Just previous to entering the spacious plain of Abághá (in which are the abundant springs of the Bend í Máhi Sú) the stream flows through low cliffs of columnar and compact basalt.

Immediately on entering the Plain of Abághá, upon the left of the road are some isolated rounded hills of white lava, enclosing glassy felspar, and capped by basalt. The contrast of opposite colours is very remarkable. Several patches of compact blue limestone likewise occur in the same vicinity.

The N.W. extremity of the plain is bounded by a high mountain-mass of black basaltic lava, called "Tendúrlí," an expressive name, meaning "ovens," because there is at the summit a small crater, which emits such heat, according to the universally current account, as to roast meat suspended over it. From this crater vast streams of black lava have flowed down the sides of the mountain, appearing in the distance as if petrified in their descent. Around the base of Tendúrlí, and extending from it five miles into the plain, is one vast sea-like mass of amorphous basalt, thrown up, rolled over, and doubled upon itself; the surface being traversed by enormous fissures which render it impassable.

The road winds round the S.E. extremity of this uninviting and sombre mass, and passes through a gap in a low blue limestone range. This shoots across the plain from the N.N.W., and is covered up on the N.E. by the lava-flow which has actually been forced up the slope of the limestone dome.

From this point, after a rough passage over scoriæ, the base of the lofty range of Kára Kalah Dagh is reached. This range consists of altered red marls, and has clearly checked the further flow of the lava towards the east. Near the summit of the pass over Kára Kalah Dagh the surface is thickly strewed with rounded pieces of yellowish-white pumice, varying to the size of half an inch. These must have been thrown out when either the crater of Tendúrlí or those of Mount Ararat were in an active state of eruption. The little plain of Kasley Gúl (which takes its name from a small lake in its centre) is surrounded by mountains of hard red chert and altered clays. A long pass over variegated marls conducts to the town of Bayázíd, which is situated near the summit and commands a fine view of the plains at the foot of Mount Ararat. On the descent, the blue marls, which rest on limestone, exhibit unequivocal evidence of there having been considerable volcanic agency at work during their deposition. Numerous layers of large rounded lumps of basaltic lava lie closely packed together in the marl matrix.

The descending order of stratification here is—1. Red marls. 2. Blue marls. 3. Blue compact limestone. The last constitutes the lofty range at the back of the town, and shuts out the view of Mount Ararat. It is thrown down nearly vertically towards the S.W., *i.e.* towards Bayázíd, and the marls have been shot off from it in the same direction. Upon these Bayázíd is built. A broad plain intervenes between Bayázíd and Mount Ararat. The two peaks of this great monarch of the Persian Mountains are apparently a solid mass of basaltic lava, similar to that of Tendúrlí, but, of course, on a much more gigantic scale. Immense streams have flowed into the plains at their foot, passing in their course over the extremity of a lofty range of limestone, and again overflowing it at its base.

A hollow cone, broken down at its S.W. side, is situated in the centre of the lava flood a great distance up the slope of the Greater Ararat, but far below the top of the saddle which connects the two peaks. The layers of the crater are distinctly seen in the interior, dipping from the centre, and an enormous stream of lava appears to have flowed from the fractured side of the cone. At the point where the connecting saddle meets the slope of the cone, there are apparently relics of several ancient and decayed craters.

There is another on the lower part of the Lesser Ararat.

The limestone to the east of Bázirgan contains numerous casts of fossils, apparently of the same species as those from the nummulitic rocks of Kirrind.

A severe illness prevented my making further investigations in this highly interesting district, which had, however, been previously examined by Russian geologists.

A violent shock of earthquake was experienced at Bayázíd, on the 19th Sept. 1852,—a sufficient proof that the internal fires, which in ancient times produced such elevatory movements throughout this region, are not yet extinguished.

Section from Bayázíd to Ardish. Fig. 21.

From Bayázíd the red and blue marls bear away to the west in a lofty range called Dizzenen Dagh. The road follows along the north base of this range for 3¼ miles, and then strikes across a rough plain of basaltic scoriæ. Here the vast lava-torrents of Ararat and Tendúrlí meet; and of such extent have been these flows of molten matter, that, if a line be drawn in a S.W. direction from the N.E. base of Ararat, over Tendúrlí to the extremity of the Kharpánák promontory, on the east shore of the Lake of Van, it will pass uninterruptedly over basaltic lava for 110 English miles,—a distance exceeding the greatest length of the two longest streams from the crater of the celebrated Skaptar Yokul in Iceland! If to these streams be added those of Suphan Dagh, on the north shore of the Lake of Van, separated from Kharpánák by only thirteen miles, we have an infinitely greater volume of melted matter flowing from the three craters of this region than has, I believe, proceeded from any known volcanic source.

In the direction of Dyadin to the N.W., numerous little peaks or "tepehs" of red and blue marls project their heads from the plain, having their bases surrounded by the lava-flood; they are in fact islands in a basaltic sea.

At the miserable Kurd village of Kundú, seven miles from Bayázíd, a low range of blue marls commences, and bears towards the N.W., having its S.W. base overflowed by the lava from Tendúrlí. The road continues for 4½ miles along the skirt of this range, over a quantity of rough scoriæ. At one locality, just before quitting this marl range, I observed a patch of brownish-blue trap-rock, containing olivine and amygdaloidal cavities filled with carbonate of lime, overflowing the marls.

The piled and confused mass of scoriæ which forms the eastern termination of the basaltic streams from Tendúrlí, has much the aspect of the terminal morain of some immense glacier. From beneath the N.W. side of Tendúrlí a red marl range, which passes to the east of Dyadin, first shows itself, overflowed by the basalt. A short pass over this range conducts to the basin of the Múrad Chaï (Euphrates). Near the summit, but below the basalt, is much brown fine-grained lava.

From the village of Dáoud (near which is a warm sulphur-spring) the Castle of Dyadin is seen, six miles distant, standing on a high basaltic cliff on the right bank of the Múrad Chaï.

Immediately on quitting Dáoud, a patch of loose white chalk-soil is passed; this further on changes to a bright-yellow volcanic tuff, containing much pumice and leucite.

A low pass of lava intervenes before descending to the main stream of the river. A somewhat compact black lava, with analcime and leucite, forms the top of the pass; this rests on a light-pink variety, with the same minerals. A thick bed of the above-described yellow tuff succeeds; and the base of the section consists of the same pink lava which occurs immediately above.

On the left bank of the river, at a short distance upon the left of the road, is a hot sulphur-spring, 134° Fahr. The water bubbles up with great violence from a small hole, and, in flowing out of a small natural basin, leaves a yellowish calcareous deposit, similar to that observed in other travertin-springs, but much less in quantity. It has a slight odour of sulphur, and is nauseous to the stomach, though tasteless. There are likewise several smaller springs in the same locality, having various different temperatures. The rocks around are of yellow travertin, having much resemblance to the deposit from the spring, but frequently compact and altered to a grey slaty limestone.

From this point the road follows up the west branch of the river, through high cliffs of cream-coloured and grey travertinous limestone, into the heart of the great chain of Alá Dagh, which forms the watershed between the waters of the Múrad Chaï and the streams which flow into the Lake of Van. The bed of the ravine is strewed with small volcanic pebbles, among which obsidian is not uncommon.

At rather more than midway up the ravine the travertin rocks cease, being forced through by a series of finely-grained granitic and trappean rocks, frequently capped by basalt. On the ascent of the lofty pass of Alá Dagh are numerous lavas, and at the summit is a very beautiful pink variety, unobserved elsewhere.

In the commencement of the descent of the ravine of the Ardish Chaï, conducting to the Lake of Van, we have again many volcanic rocks, among which may be noticed a peculiar heavy grey rock, enclosing small crystals of quartz, mica, &c., and several varieties of basalt, sometimes columnar, &c. Further down the ravine beds of travertinous limestone make their appearance. At about eleven miles from the foot of the pass is another hot spring, having a temperature of 165° Fahr., in fact near that of boiling water. The water is strongly chalybeate and slightly saline; the calcareous deposit from it is reddened by the presence of iron. The same peculiarity exists here as at other springs depositing travertin, *i.e.* there are older deposits of similar nature in the immediate neighbourhood, though at this peculiar locality they are not of great extent. From this point, however, in the descent are frequent patches of a yellow tufaceous limestone, overflowed by columnar basalt. Near Khóch Kúpri, where the ravine begins to open out into the plain of Ardish, at the junction of a large stream from the N.W. with the Ardish Chaï, a flow of amorphous basalt occurs, apparently derived from the east; it is slightly amygdaloidal, the vesicles containing carbonate of lime. Disseminated through the mass are numerous flat crystals of a transparent white mineral. Beyond this commences the soil of the plain, which consists of a light volcanic yellow sand, producing rich crops of wheat. About two miles further, a short descent over the same amorphous basalt conducts to the alluvial plain of the river at Irishat. The basalt abuts against the western extremity of a low range of white limestone, containing volcanic crystals. From beneath the basalt there issues the large stream which flows into the Lake of Van on the east of Ardish.

The Lake of Van.

It is not generally known that a remarkable rise has of late years taken place in the water of the Lake of Van; and, as this phænomenon comes under the consideration of the geologist, I give here the results of my observations and inquiries on the subject.

Mr. Layard, in his second work, "Discoveries in the Ruins of Nineveh and Babylon," p. 408, has briefly alluded to this phænomenon.

The Lake of Van was carefully surveyed by Lieut. Glascott, R.N., in August 1838, when travelling in company with Mr. Brant, H.B.M.'s Consul at Erzerúm, and the result was given to the public by the latter gentleman in the Journal of the Royal Geogr. Soc. vol. x. p. 402.

The form of the Lake is an irregular parallelogram, giving off a spur to the N.E. Its greatest length from Tadvan, on the S.W., to Arnis, on the N.E., is seventy miles; and its greatest width is twenty-eight miles, measuring from Vastan on the S. to Arin on the N. The water is salt and bitter, but without the intense saltness of the ocean. The only important streams which enter the Lake are two near Ardish on the N., the Bend í Máhi Su on the N.E., and the Angel Su on the S. These are all fordable, except the Bend í Máhi Su in some parts.

According to the statement of the natives on its shores, the water of the Lake, owing to some unaccountable cause, began gradually to increase in the year 1838 or 1839. For some time it fluctuated a good deal, but at the end of twelve months it had gained considerably upon the land wherever there was a shelving shore, the depth being increased nearly two yards. During the second and third years the rise continued, until the increased depth had reached ten or twelve feet. Many towns and villages upon the Lake were surrounded, destroyed, or deserted, and the effects are still apparent on the north shore, where it is less rocky than elsewhere. Having in three years attained its standard height at twelve feet, it so remained, slightly rising and falling until 1850, from which time the natives say there has been a considerable and gradual subsidence of the water.

The effects of this phænomenon are best seen at Ardish, a town formerly containing 5000 inhabitants, with a castle, two mosques, a Christian church, and several caravanseraïs. [See the original drawings Nos. VII. and VIII. accompanying the Memoir.]

In August 1838, Messrs. Brant and Glascott pitched their tents upon a flat piece of ground extending from the south side of the town some distance into the Lake; the town being then connected with the mainland by a broad piece of flat cultivated ground. In 1841 the whole town was completely surrounded, partially under water, and entirely deserted by its inhabitants. In September 1852, when the water had considerably subsided, Ardish was connected to the north shore by a narrow strip of mud*, about a tenth of a mile in length, across the most elevated part of which my horse plunged with the mud up to his knees. On both sides, the isthmus had every appearance of having been recently overflowed. Every one assured me that it had not only been covered, but that it had been a yard under water periodically every year since 1841. The most intelligent persons with whom I conversed attributed the periodical overflow to the rise of the two streams which here empty themselves into the Lake, one on the east, and the other on the west of Ardish, and which swell considerably on the melting of the snows in spring. For about four months the isthmus is impassable; but, as the streams subside and assume their summer level, the water gradually retires from it. All accounts, however, agreed as to the rapid encroachment

* As represented at (*a*), Drawing VII.

of the lake upon the town in 1838 and 1839; and that the inhabitants were driven out during the two years following; the foundations of the houses gave way, and fresh water failed them.

At the time of my visit the water reached up to the very base of the town and castle walls on the west and east sides, and within ten paces of the large mosque on the south side, beyond which Messrs. Brant and Glascott had encamped. There was, however, undoubted evidence of its having been much higher, for within the walls in various places were large pools of stagnant water; the ground in several parts was saturated with salt and overgrown with saline plants. The quantity of land gained by the lake is enormous. Before the rise a person could walk from Ardish to Mádgháwánk, the next spur to the west; but the lake has since extended upwards of a mile to the north up the embouchure of the Ardish Chaï; thus cutting off from the latter pretty village its supply of fresh water, and, as at Ardish, causing the desertion of its inhabitants.

A like fate befell many other villages along the shores. Iskella, a small fishing village, a mile and a half from Van, is now half deserted. The islands in the Lake, on the authority of the Armenian Bishop at Chijis Monastery, were in a similar manner gained upon by the rise of water. If this be the case, the phænomenon cannot be accounted for by an elevation of the bottom of the Lake; because the islands would be elevated, and not depressed.

An old man of eighty-five (Ismail Bey) told me he had heard his father say that a similar rise had occurred about 140 years previously, when the inhabitants were in like manner compelled to evacuate Ardish, which continued an island for forty years, after which the water gradually retired. Ismail Bey himself can just remember the people returning and rebuilding their dilapidated houses.

There is a tradition that the Lake of Van now covers what was formerly a spacious plain, studded with villages and gardens,—that the Bend í Máhi Sú and the two streams of Ardish met and formed one large river about midway between Ardish and Bitlis,—that a short way below their junction there was a large bridge (which is now sometimes seen at the bottom of the Lake by the boatmen),—that at some distance below the bridge the river suddenly disappeared through a large hole, near which was a powerful salt-spring,—that by some sudden convulsion the hole became closed, and the accumulated streams, having no outlet, gradually formed the Lake of Van. Ismail Bey failed to show how, as the streams are all fresh, the water of the Lake is salt. The tradition, however, is a curious one, and I give it as such.

Similar oscillations in the levels of lakes have been observed in America and other portions of the world; but I am not aware of any on so great a scale, and where the effects have been so felt by the natives on the shore.

The rise of the Lake of Van is probably due to some change of climate for a succession of years, such as the fall of a greater quantity of snow in the mountains, or a deficiency in the usual evaporation. This is undoubtedly the most reasonable explanation;

but it must not at the same time be forgotten, that climatic alternations in those regions are exceedingly regular and uniform; and moreover there appears no reason why the Lake of Urúmia should not be similarly affected as the Lake of Van, since they are only separated by a range of mountains. Such however is not the case, for the former has been subsiding while the latter has been rising. [See Note B. p. 325.]

Again, it is difficult to conceive how four small streams alone, supplied by melting snow, should have sufficient influence to elevate twelve feet such a large body of water as the Lake of Van; though they may have a local effect at their mouths.

Another solution which presents itself, is the existence of intermittent springs in the bottom of the Lake, bursting forth at long intervals. We are not, however, aware of results on so great a scale produced by such a cause.

We cannot hope to explain satisfactorily the phænomenon above-described until a series of observations shall have been taken of the rise and fall of the barometer, and the effect of climatic influence on the water of the Lake.

At many localities along the shores, and particularly about three miles N. of Van, are alkali-pits, called "perek." The salt water of the Lake is admitted into shallow basins at the commencement of summer, when by the rapid evaporation crystallization takes place, and a crust or deposit is formed. This in ten or fifteen days hardens, and is an eighth of an inch in thickness. The water is again allowed to flow into the basin, and the process is repeated several times. In about five months' time the deposit has assumed an aggregate thickness of from two to four inches, when it is broken up into blocks about two feet square, and transported to Van on arabahs, to be used in the manufacture of soap.

The "perek" is sulphate and chloride of soda, with a considerable mixture of carbonate of lime; it is of a cream-colour, and easily broken by a sharp blow of the hammer. An insignificant tax or percentage on the produce is levied by the government for leave to collect the perek; but I could not ascertain what quantity is annually obtained, nor the value of the deposit in a raw state.

Two Sections from Ardish, round the N.W. extremity of the Lake of Ván, to Jezíreh-ibn-Omár.

Figs. 22 and 23.

Proceeding west from Ardish, a marshy piece of ground is crossed to the extreme north point of the recently formed spur of the Lake, between that town and Madgháwánk. The low range projecting into the Lake to the west of Madgháwánk is of compact white limestone, in which are to be detected a few casts of Corals. Succeeding to this is a small strip of land, where the inroad made by the Lake is evident, since a path which terminates abruptly on the shore is seen commencing again on the opposite side of a little bay.

Another low limestone range intervenes before reaching the pretty

Christian village of Axaráv; upon this are strewed numerous flint-pebbles, derived from the limestone, and containing the *Operculina* of the Kirrind beds; from which we may conclude that this limestone is of the nummulitic age.

From the ravine in which Axaráv is situated a third limestone ridge is crossed to the plain of Kanzag, the surface of which is thickly covered by large and small lumps of pumice, with here and there a piece of obsidian, probably resulting from the last eruption of Suphán Dágh.

A descending section in the ravine leading to Kanzag shows—1. White limestone; 2. White clays, with *Pecten*; 3. Loose grey sandstone.

The small village of Dilán is situated on the north of the road, and is reached by a very steep ascent from Kanzag up the side of the mountain, over fine loose volcanic sand, mixed with pumice and obsidian. At Dilán basaltic lava from Suphán Dágh overflows this sand, as well as a patch of the white clay No. 2.

Another small plain and a low limestone spur intervene between Kanzag and the volcanic sand plain of Arin, at the S.E. foot of Suphán Dágh. A high solitary rock of travertin rises conspicuously from the centre of this plain, like some ancient ruin. A little further westward, the base of the basaltic lava-stream from Suphán Dágh is skirted for about a mile. It has identically the same appearance as the lavas of Mount Ararat and Tendúrlí, and there can be little doubt of all the three mountains having been erupted at the same period. A distinct crater exists at the summit, as observed by Messrs. Brant and Glascott. The former gentleman remarks*, that, although only 10,000 feet above the sea, the party who ascended the mountain were affected with extreme dizziness and nausea, and he ascribes these sensations to the fumes of sulphur emitted from the crater.

The little village of Arin is situated at the eastern extremity of a small salt lake, midway between the base of Suphán Dágh and the Lake of Ván. Mr. Brant remarks † that in 1838 "Arin is situated about one mile from its Lake;" but in 1852 the village was not more than a few paces from its edge, and the villagers have been in constant alarm of being driven out. They say that the water rose simultaneously with the Lake of Ván to the height of seven feet; but that since 1850 it has been subsiding. At Horántz, on the west side, the shore was covered 120 paces from its present margin. It may therefore be fairly concluded that the water of the Lake of Ván oozes through the narrow intervening sandy isthmus, and that in so doing the saltness is partially extracted. This will account for the very slight degree of saltness in the Arin Lake.

About four miles from Horántz, on the neck of the isthmus, there is a small village called Pargát, which before the rise was situated a good mile from the Lake of Ván. When the rise had attained its maximum height, the water stood four feet up the walls of the

* Journ. R. Geog. Soc., vol. x. p. 410. † *Ibid.* p. 405.

church, a part of which was carried away. The back of the building is still nearly two feet in the water.

Upon the shore of the Lake of Arin lie numerous rounded lumps of volcanic tuff and black scoriæ, measuring 6 inches in diameter. The tuff is white, with laminæ of mica plentifully distributed through it.

From Horantz the road follows along the basaltic base of Suphán Dágh over pumice-sand. At one or two localities is a conglomerate of volcanic products and white limestone pebbles in a white calcareous paste.

About a mile before reaching A'd-el-Jíwáz is a ravine exposing a deep section of gravel, consisting entirely of small rounded pebbles of obsidian and larger ones of white limestone. They loosely adhere together by means of a thin coating of yellow calcareous matter, originating from some extinct travertin spring. This gravel to the west passes into a true volcanic tuff, mixed with carbonate of lime, frequently stalactitic and of open structure, as exhibited at travertin springs. The range to the north of A'd-el-Jíwáz is a convincing proof of the influence which has been at work in depositing the limestone-rocks of this region. This range and the rock on which the Castle stands are nothing more than a travertin deposit on a magnificent scale; the stone sometimes assuming the character of a true compact yellow limestone*, and at others that of a common precipitate from a spring highly charged with carbonate of lime, and frequently containing pieces of reeds.

On the west of A'd-el-Jíwáz, the road is carried 200 or 300 feet above the level of the Lake, which washes the base of the travertin mountain. The rock is frequently cut in steps for the passage of beasts of burden, and is extremely slippery and dangerous. A narrow irregular alluvial plain, formed by the retiring of the mountains from the Lake towards the north, is then crossed.

The mountains bear round again to the S.W., and consist of red and blue marls, whose position with regard to the tufa-limestone was not clearly made out, though they appear to overlie it. Further westward, these marls are succeeded by a fine grey volcanic tuff and breccia, with long angular lumps of basaltic lava.

Beyond the gardens of Súhúr the beds alter their character, passing down into a dusky-red fine-grained tuff, alternating with coarse volcanic breccia, which latter rock obtains as far as Akhlát.

At several places a more recent conglomerate in a white calcareous matrix rests unconformably in patches on the grey tuff. Here and there are a quantity of loose gravel and numerous lumps of pumice. At Akhlát old town the inhabitants have taken up their abode in holes and chambers excavated in these soft volcanic rocks. Akhlát is celebrated for some fine tombs of the early Mahomedan Princes of the district. The stone used is the red tuff, which is heavier and more durable than the finely-grained grey variety reposing upon it. It is admirably adapted for the delicate and elaborate work which

* Containing indications of Corals and marine shells.

ornaments these tombs and the grave-yards of this locality. The fresh appearance of the designs is very remarkable.

From Akhlát to Tadván, the wide plain, rising towards Nimrúd Dágh on the west, is wholly composed of friable grey tuff, which produces a very light, rich soil for grain. Pieces of pumice are abundantly contained in it. When the Lake rose, the foundations of several houses at the village of Yám fairly melted away and disappeared. Near Zerákh the sand is thickly strewed with large lumps of pumice, black scoriæ, and obsidian, containing glassy felspar. The immense quantity of volcanic products here observable is astonishing ; and I was not long in discovering that other vents had been pouring forth their contents in addition to Suphán Dágh.

In the maps hitherto published, a curved bay is laid down on the south shore of the Lake of Ván, between Avatak and Narnigas. This is in fact a very picturesque crater [see original Drawings Nos. IX. and X.], much truncated, and having its wall towards the Lake broken down so as to admit the water in a deep bay into the interior of the crater. The ragged edge I estimated, at a distance, to be three or four miles in circumference. The concentric layers, apparently of sand, are distinctly seen in the basin, dipping outwards. It is not remarkable that this crater has hitherto escaped observation, as it is only visible to a person proceeding from Akhlát to Tadván,—a road seldom traversed. The highest point I judge to be about 600 or 800 feet above the Lake.

I am also under the impression that Nimrúd Dágh itself (which is laid down as a range running N.E. and S.W.) is the base of an enormous cone, rivalling Suphán Dágh; with this difference, however, that, while the latter is of solid basaltic lava, the former is of volcanic sand. The broken and precipitous edges of a cup-shaped interior, having the layers dipping outwards, are seen in some positions. I was informed that, on clambering to the top, a person looks down on the opposite side into a circular depression with a lake at the bottom. If I should be correct in my supposition that Nimrúd Dágh is an extinct crater, there can be little difficulty in understanding from whence the great quantity of sand at the western extremity of the Lake of Ván has been derived.

Continuing west from Tadván to the Bitlís Chaï, the same friable, light, volcanic, red sandstone appears at the surface as occurs at Akhlát.

The Kerkúr Dágh rises abruptly from the plain on the north of the road; its smooth sloping sides and remarkable crests for some time arrest the attention before reaching it. Viewed, however, from the S.S.E., it has the aspect of a volcanic cone less truncated than that on the south side of the Lake [see original Drawing XI.]. It is wholly composed of a white rock, which I take to be pumice and tuff.

On advancing to the S.W., it is perceived that the westerly continuation of Kerkúr Dágh is a similar cone, joined on to the other, but having its summit much more eroded and the crater filled up.

On entering the narrow valley of the Bitlís Chaï, the lofty mountains on either side consist of grey quartzose rock, underlaid by soft mica-schist. The beds dip away at a slight angle from the ravine, the trough of which is filled up with volcanic tuff and ash. The stream flows onwards to Bitlís through this soft and yielding rock, which in the descent becomes dark-coloured and columnar, presenting exactly the appearance of basalt. At one place, where it is quarried for building-stone, it overlaps the edges of the mica-schist. On the west of the ravine before approaching Bitlís, it alternates with, and is overlaid by, an open-structured calcareous travertin. The houses of the town, as well as the rock on which the old Castle of the Begs of Bitlís is built, are of the grey volcanic tuff.

Below the town the tuff gradually thins out, and afterwards only occurs in patches down the valley. Two miles from Bitlís there is a cold acidulated saline spring, very agreeable to the taste, and much resembling Sedlitz Water. In rising from the bottom, the water effervesces. There is no calcareous deposition from the spring at present; but a few feet below there is a bed of travertin which it has formerly produced; and a considerable thickness of an older travertin rock here spreads along the bottom of the valley for the distance of a mile.

The channel soon becomes narrower, and is confined between lofty ranges of micaceous slate, much contorted, and overlaid (I think, conformably) by blue compact limestone; both rocks dipping from the ravine. This order generally prevails to Sháhtek, ten miles below Bitlís.

In some localities eruptions of basalt have broken through and overspread the slates; this is particularly observable near an old caravanserai at the sixth mile. Large deposits of travertin also occur; and at one place there is a very awkward descent passing through a cutting made in this rock and extending to the stream in the channel below.

Further down the valley the igneous rocks are left behind, and the blue limestone appears to the almost entire exclusion of other deposits, and rises into lofty ranges. On leaving the Bitlís Chaï, this rock is crossed at Chelifteh Pass. At Werkhántz, on the S.W. of this Pass, we meet with *Alveolina*, which proves this limestone to belong to the Nummulitic Series. The descending valley or irregular basin of the Kesser Sú is a mass of contorted, soft, unfossiliferous gypsiferous marls and sands, resting on the skirts of blue limestone mountains.

Near Sert, in these marls, is an extensive deposit of massive pure white alabaster.

From Sert the road follows the course of the Sert Sú to the Tigris, skirting the N.W. base of the inaccessible Bohtan limestone mountains; it then continues southwards along the banks of the Tigris to near Jezíreh-ibn-Omár, and afterwards trends away to the S.W. The limestone is unfossiliferous, but undoubtedly of the nummulitic age; and, being removed from the immediate influence of the igneous rocks, it assumes its wonted aspect,—being of a rich cream-colour, compact, and crystalline, as at Kirrind and elsewhere on the west of the igneous chain.

Conclusion.—On commencing this report, it was my intention to have made some general concluding remarks. As, however, I have entered fully into the details of the subject, so far at least as a passing examination of many of the localities would permit, I prefer leaving it for the present; in the hope that, during my proposed second visit to the regions under consideration, various obscure points may be further investigated, and doubts cleared up,—more especially such as relate to the transition between the cretaceous and nummulitic rocks,—between the latter and the gypsum series,—and the connection which the blue limestones bear to all three.

In concluding, I trust that every allowance will be made for the numerous imperfections contained in this communication,—owing to the difficulty of the subject, in consequence of the extreme rarity of the "Medals of Creation,"—and to the haste with which the marches were made.

This report may be regarded only as a very rude sketch of a truly interesting region.

Note A. (See page 261.)

Since writing the memoir, the author has had an opportunity of conversing on the subject with Mr. Waterhouse, of the British Museum, who has kindly examined the natural casts of footprints referred to at pages 261, 262. Mr. Waterhouse has expressed a doubt of these footprints belonging to an animal of the Feline Order, on account of the great prominence of the claws; but he believes that they are certainly referable to some of the Carnivora. The Chetah mentioned at page 262, does, however, appear to be an exception to the rest of the Felidæ in this respect, and does possess a relatively long claw. The author by no means intends to imply that the foot-prints are those of the *Felis jubata*; there is no evidence of that animal having lived during the early tertiary period. —July, 1855.

Note B. (See page 320.)

Ismail Bey's tradition agrees to a certain extent with the accounts of ancient historians as regards the sudden disappearance of the rivers in the present bed of Van Lake, by means of a subterranean outlet. May there not be a communication by this means between the Lakes of Van and Urúmia, which would account for the fluctuations in their respective levels? An obstruction in such a channel would produce all the effects alluded to above.

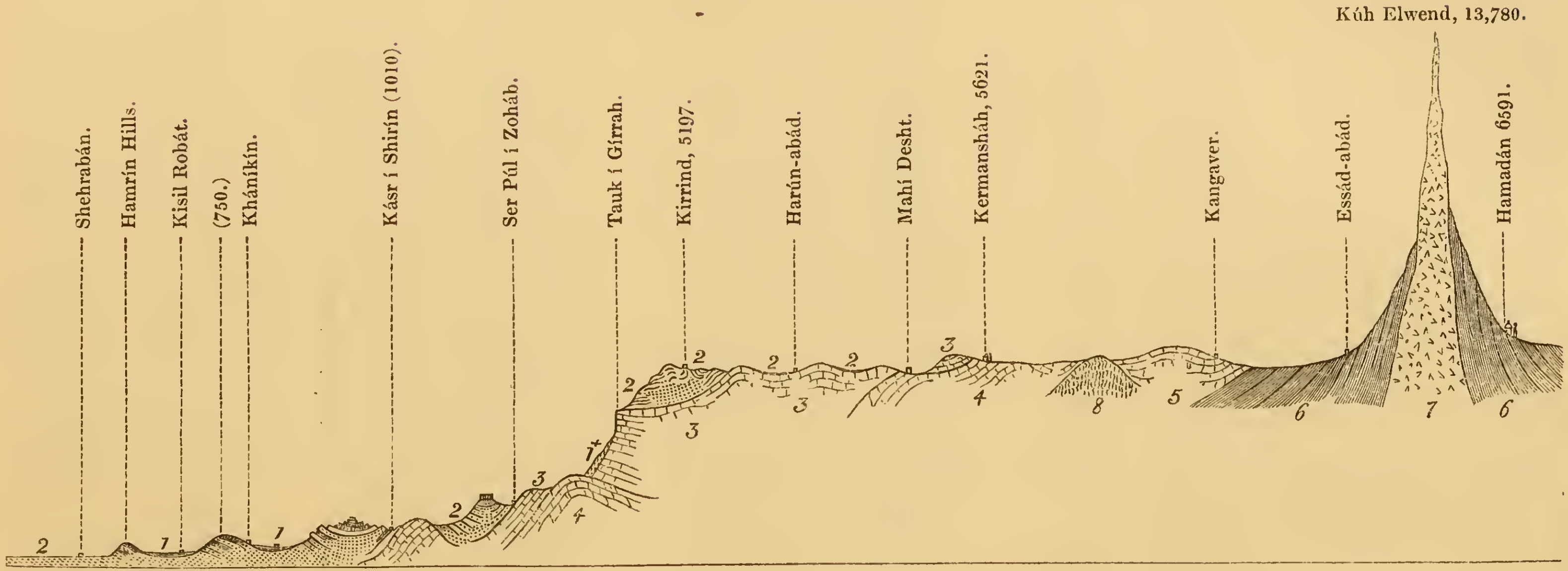
The Lake of Van is at an elevation of 5467 feet above the sea-level, as ascertained by Lieut. Glascott, R.N. (Journal R. Geogr. Soc. vol. x. p. 432); while that of Urúmia is 1367 feet lower. It should be observed that these Lakes are separated 80 miles from each other by the intervention of a lofty mountain range. —July, 1855.

Note C. (*Accentuation.*)

With regard to the pronunciation of the names of places mentioned in this Memoir, the á and í have the sound of a and i in French; the ú, that of the English oo.

Fig. 1.—*Section from the Plains of the Tigris to Hamadán.*

Length of Section, 210 miles.



1. Alluvium. 1*. Limestone-talus.

2. Gypsiferous series { *a.* Gravel-conglomerate. *b.* Red sandstone and variegated marls. *c.* Gypsum. } (These subdivisions are indicated by the varieties of tints in this woodcut and some of the following.)

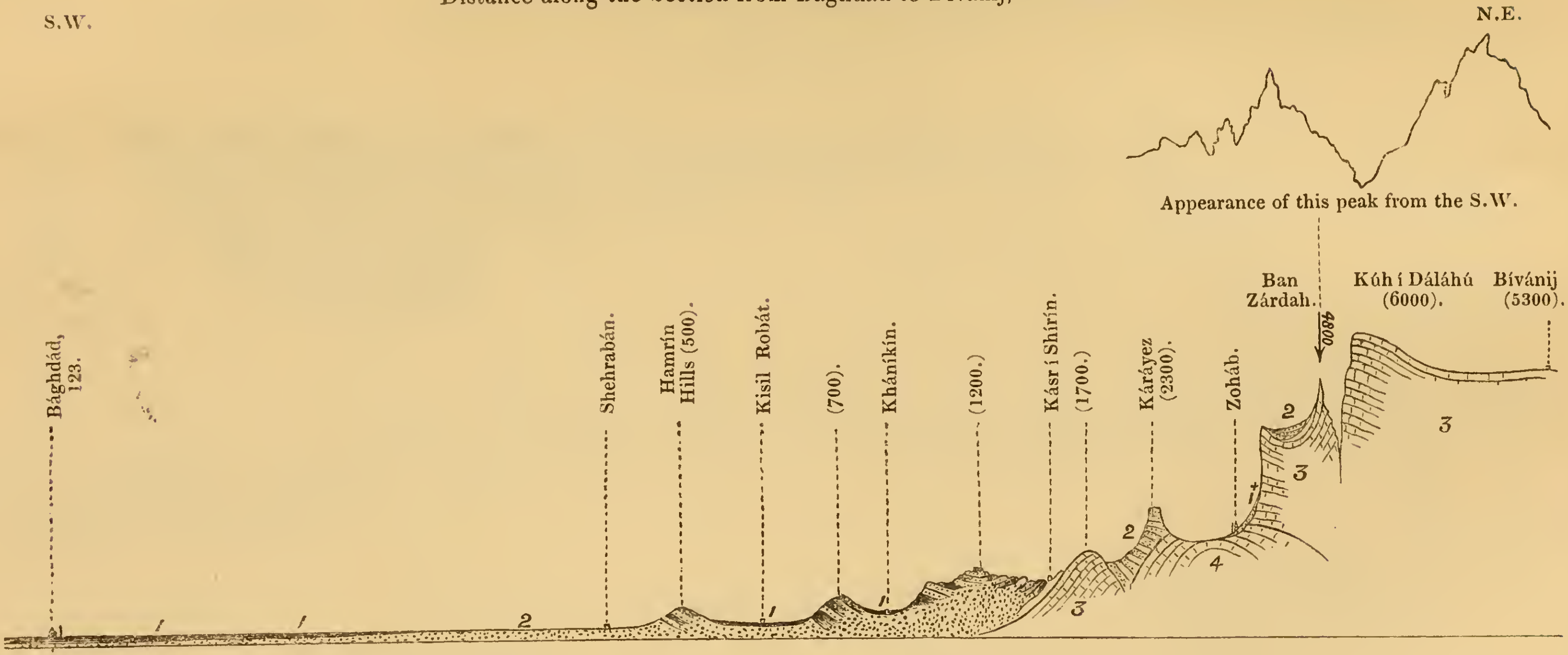
3. Nummulitic limestone. 5. Blue altered limestone. 7. Granite.

4. Cretaceous limestone. 6. Clay-slate and mica-schist. 8. Serpentine.

*** In this and the following Sections the heights that are given *in brackets* are approximations only to the true heights; those *not in brackets* are given on the authority of Mr. Ainsworth, Col. Rawlinson, Lieut. Glascott, Rev. Mr. Stoddard, and Prof. Parrot.

Fig. 2.—*Section from Bághdád to the Ban Zárdah.*

Distance along the Section from Bághdád to Bívánij, 145 miles.



1. Alluvium.
1*. Limestone-talus.

2. Gypsiferous series. { *a.* Gravel-conglomerate. *b.* Red sandstone and variegated marls. *c.* Gypsum.

3. Nummulitic limestone.
4. Cretaceous limestone.

Fig. 3.—*Section across the Valley of Giláláhú.*

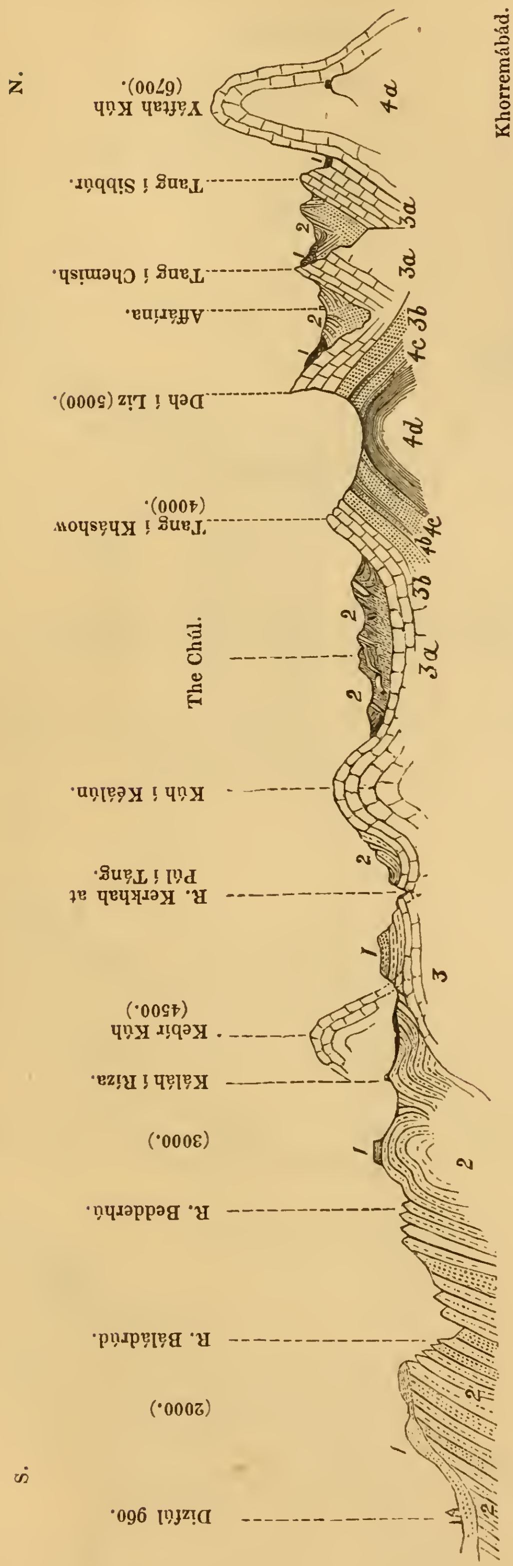
Length of Section, 20 miles.

1. Alluvial gravel.

2. Gypsiferous series
- *a.* Gravel-conglomerate.
- *b.* Red sandstone and variegated marls.
- *c.* Gypsum. (*The white bands.*)

3. Nummulitic limestone.

Fig. 4.—*Section from Dizfúl to Khorremábád.*



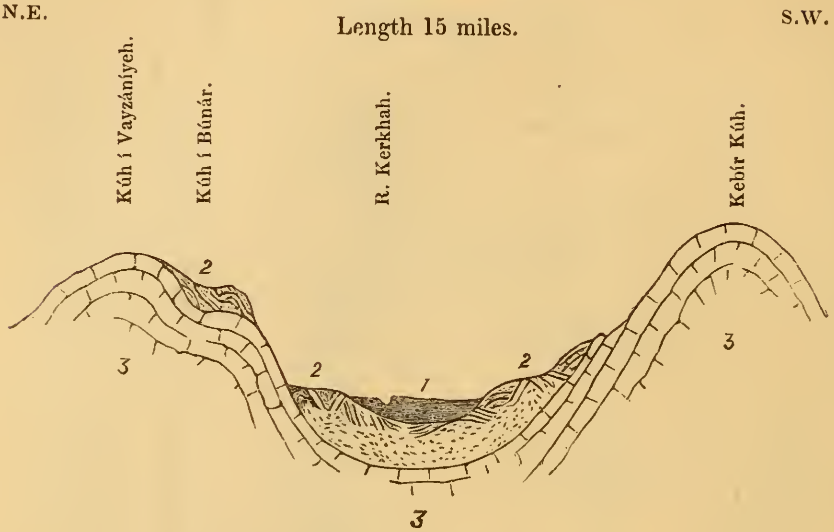
1. Alluvial gravel.

2. Gypsiferous series. { *a.* Gravel-conglomerate. *b.* Red sandstone and variegated marls. *c.* Gypsum. (*The white bands.*)

3. Nummulitic rocks. { *a.* Compact limestone. *b.* Red-chert-conglomerate.

4. Cretaceous rocks. { *a.* Limestone. *b.* Fine-grained sandstone. *c.* Iron-sandstone. *d.* Blue bituminous schists.

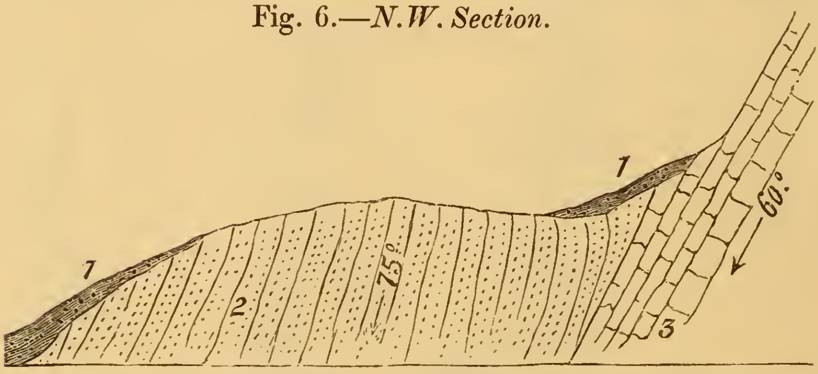
Fig. 5.—*Section across the Valley of the Kerkhah in the Písh Kúh, Lúristán.*



1. Alluvium and limestone gravel.
2. Red sandstone, variegated marls, and gypsum.
3. Nummulitic limestone.

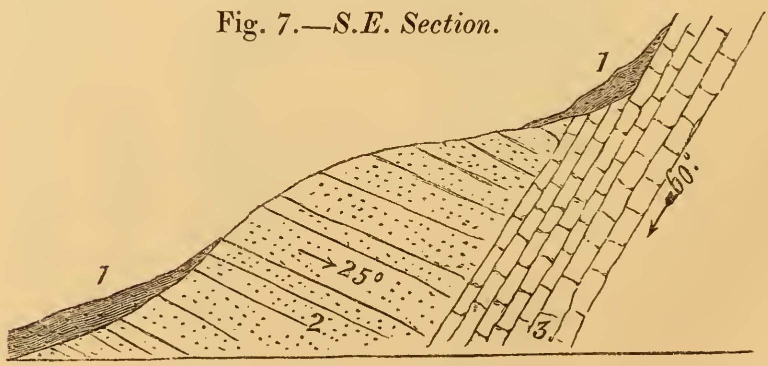
Figs. 6 & 7.—*Sections of the Gypsiferous beds at Kirrind.*

Fig. 6.—*N.W. Section.*



1. Limestone debris, and Alluvium. 2. Red sandstone and variegated marls.
3. Nummulitic limestone.

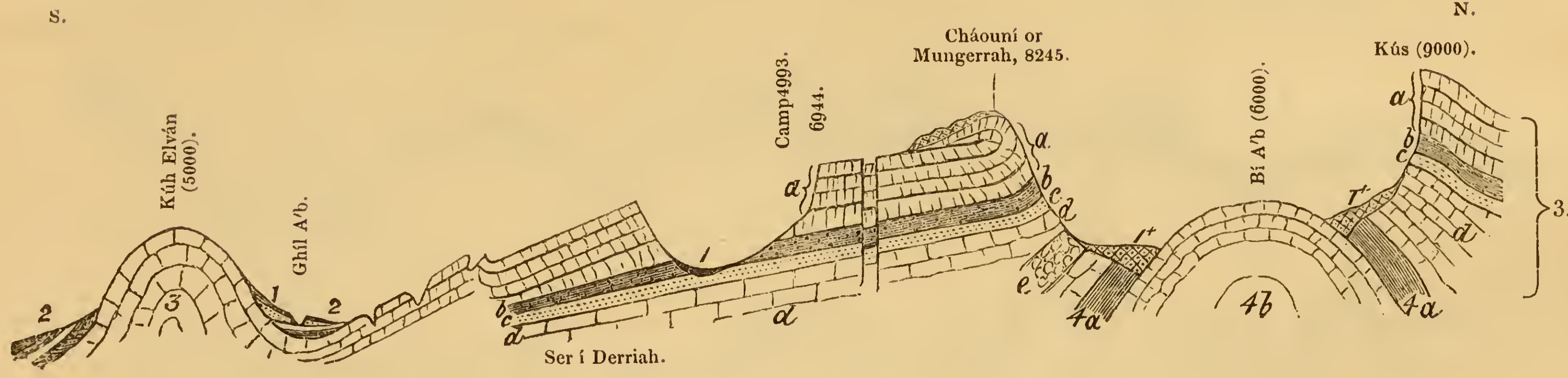
Fig. 7.—*S.E. Section.*



1. Limestone debris, and Alluvium. 2. Red sandstone and variegated marls.
3. Nummulitic limestone.

Fig. 8.—*Section through the Valley of Mungerrah and across the Bí A'b, Lúristán.*

Length of Section, 30 miles.



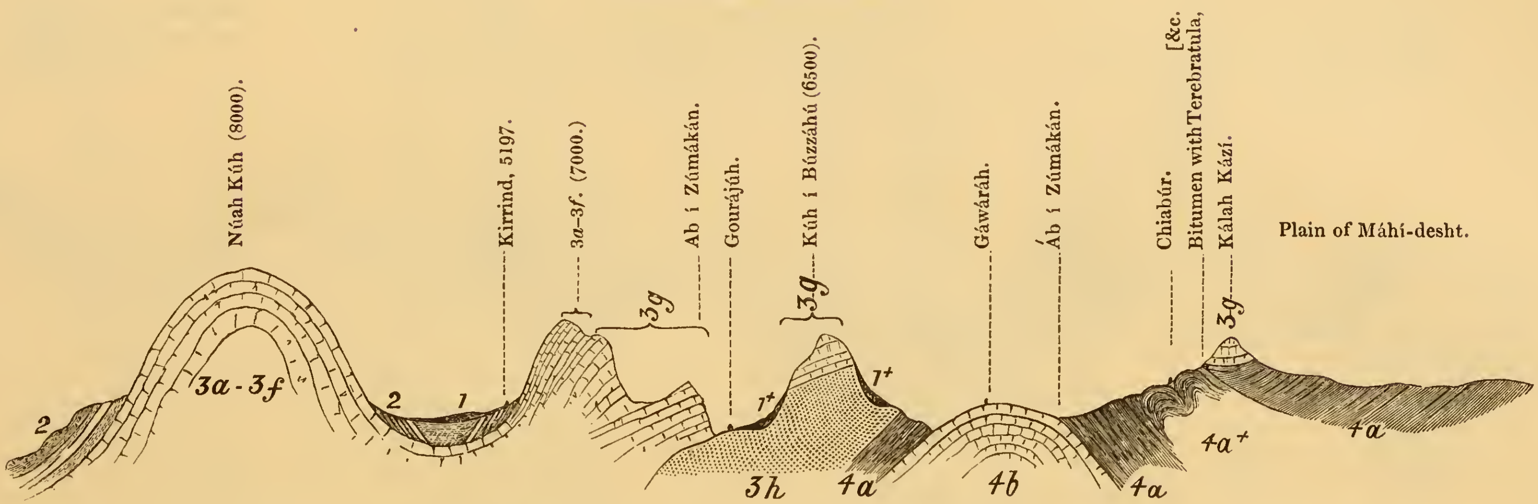
1. Alluvium.
1*. Limestone-breccia.
2. Gypsiferous series.

3. Nummulitic rocks.
- *a.* Compact grey limestones.
- *b.* Red-chert-conglomerate.
- *c.* Yellow and red sandstone.
- *d.* Grey limestone, with fossils.
- *e.* Blue nummulitic rock.

4. Cretaceous rocks.
- *a.* Blue shales.
- *b.* Limestone.

Fig. 9.—*Section from Kirrind to the Plain of Máhí-desht.*

Length of Section, 30 miles.



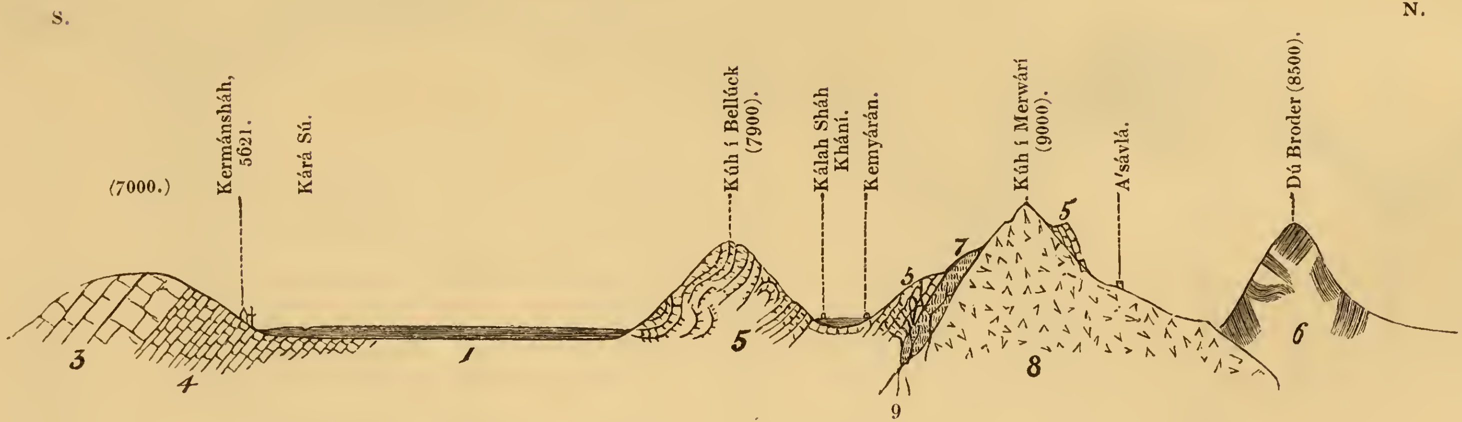
1. Alluvium and limestone debris.
1*. Limestone-talus.
2. Gypsiferous series.

3. Nummulitic series.
- *a.* Compact white marble.
- *b.* Compact white marls and limestone.
- *c.* Limestone and red sandstone breccia.
- *d.* Chert-gravel.
- *e.* Yellow sandstone.
- *f.* Yellow calcareous marl.
- *g.* Compact arenaceous grey limestone.
- *h.* Red marl with chert-pebbles.

4. Cretaceous rocks.
- *a.* Grey and dark blue bituminous shales.
- *b.* Cream-coloured limestone in thin layers.

Fig. 10.—*Section between Kermánsháh and Asávlá, on the road to Senná.*

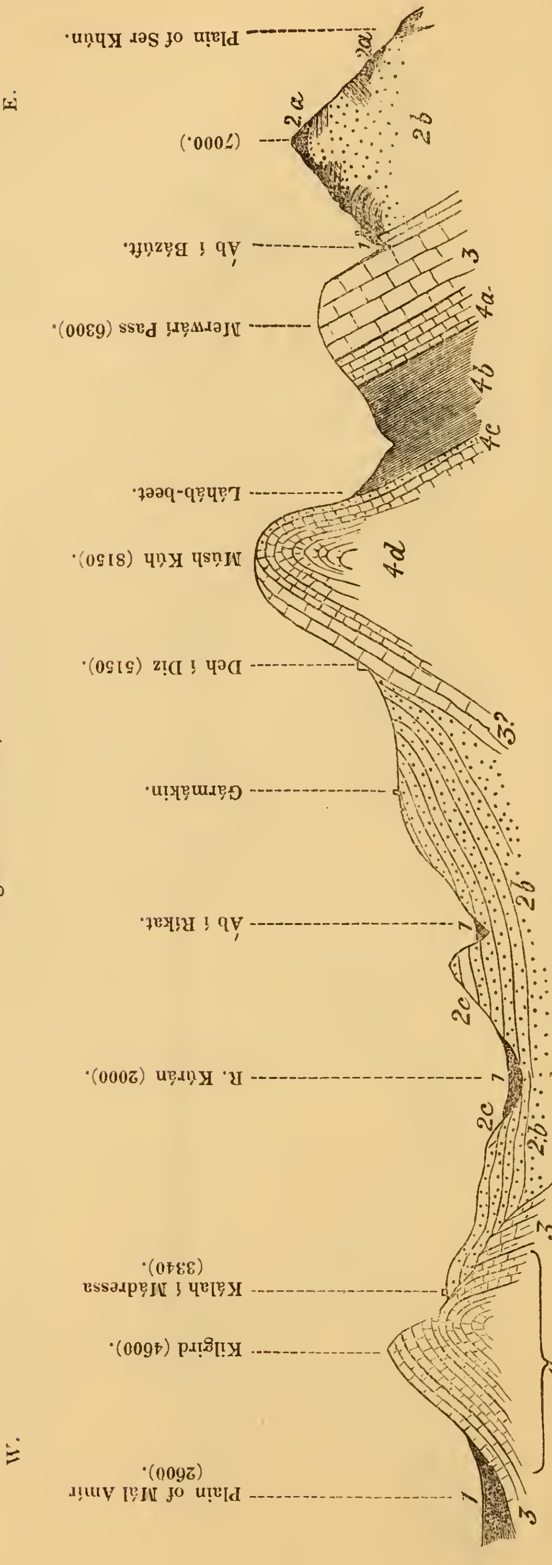
Length of Section, 50 miles.



1. Alluvium.
3. Nummulitic limestone.
4. Cretaceous limestone, &c.
5. Blue altered limestone, much contorted, and near the Serpentine converted into cherty breccia.
6. Clay-slates, much contorted.
7. Serpentine.
8. Granite.
9. Trap-veins.

Fig. 11.—*Section from Mál Ámir to Ser Khún, Búkhtiyári Mountains.*

Length of Section, 50 miles.

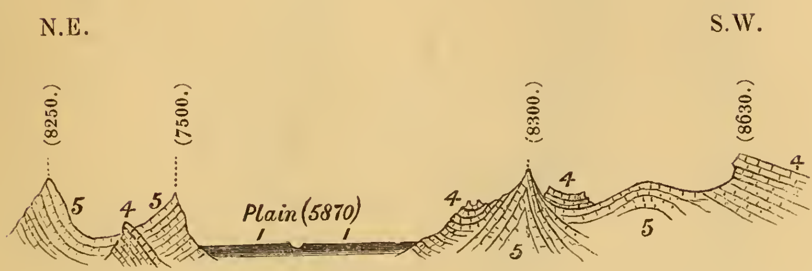


1. Gravel and alluvium.
2. Gypsiferous series. { *a.* Conglomerates. *b.* Marls and sandstones. *c.* Gypsum.
3. Nummulitic limestone.

3 ?. Clunch (without fossils).
4. Cretaceous rocks. { *a.* Limestone. *b.* Blue shales. *c.* Sphærulitic limestone. *d.* Limestone.

Fig. 12.—*Section at the South-eastern entrance into the Plain of Ser A'b í Ser, near Fayláán.*

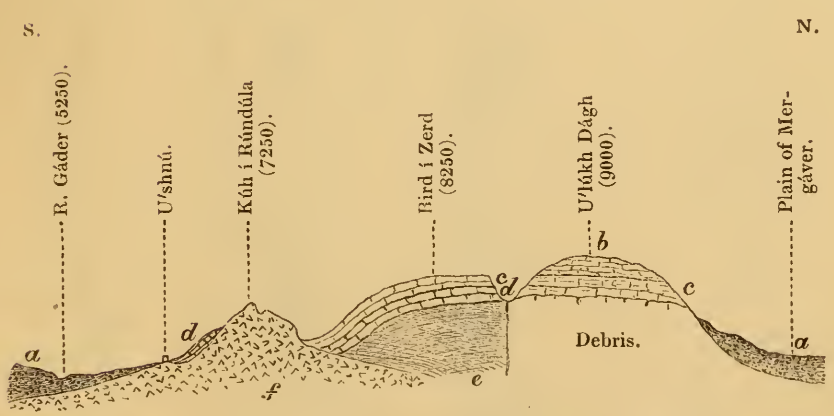
Length of Section, 10 miles.



1. Alluvium.
4. Yellow cretaceous limestone.
5. Blue, altered, and much contorted limestone (probably Lower Secondary).

Fig. 14.—*Section from Úshnú to Mergáver.*

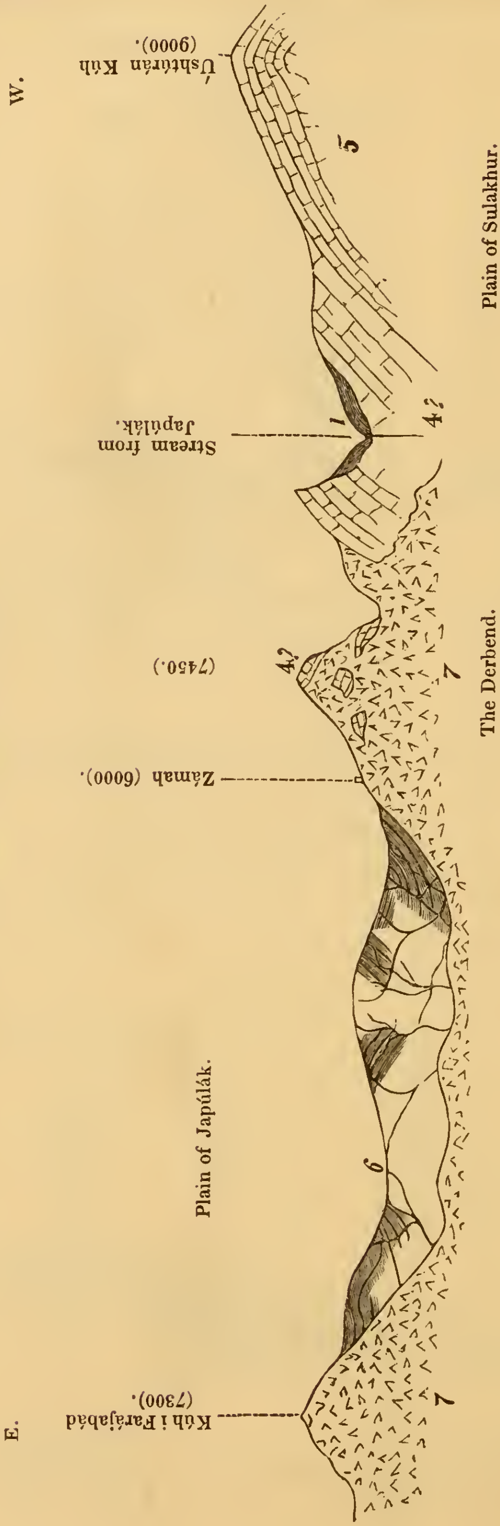
Length about 20 miles.



a. Alluvium and gravel.
b. Cream-coloured limestone with copper ore.
c. Blue argillaceous limestone.
d. Blue limestone.
e. Bluish-green altered shales.
f. Grey granite.

Fig. 13.—*Section from Kúh i Farájabád to Úshtúrán Kúh, Bákhtíyari Mountains.*

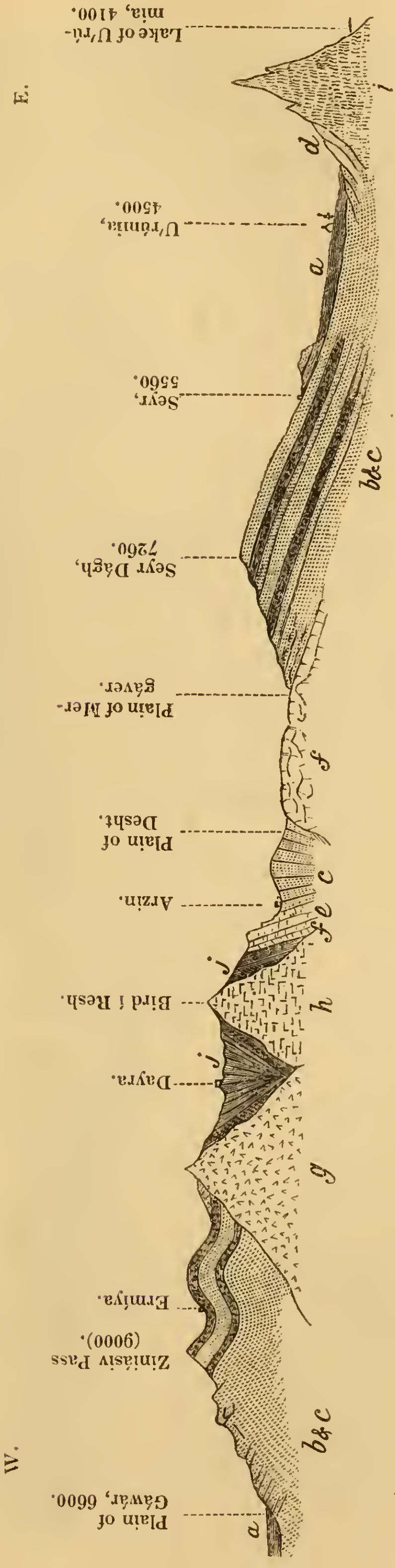
Length of Section, 30 miles.



1. Alluvium.
4. White limestone (Cretaceous ?).
5. Blue limestone (Lower Secondary ?).
6. Blue slates, with veins of quartz.
7. Granite.

Fig. 15.—*Section between Gáwár and U'rúmia.*

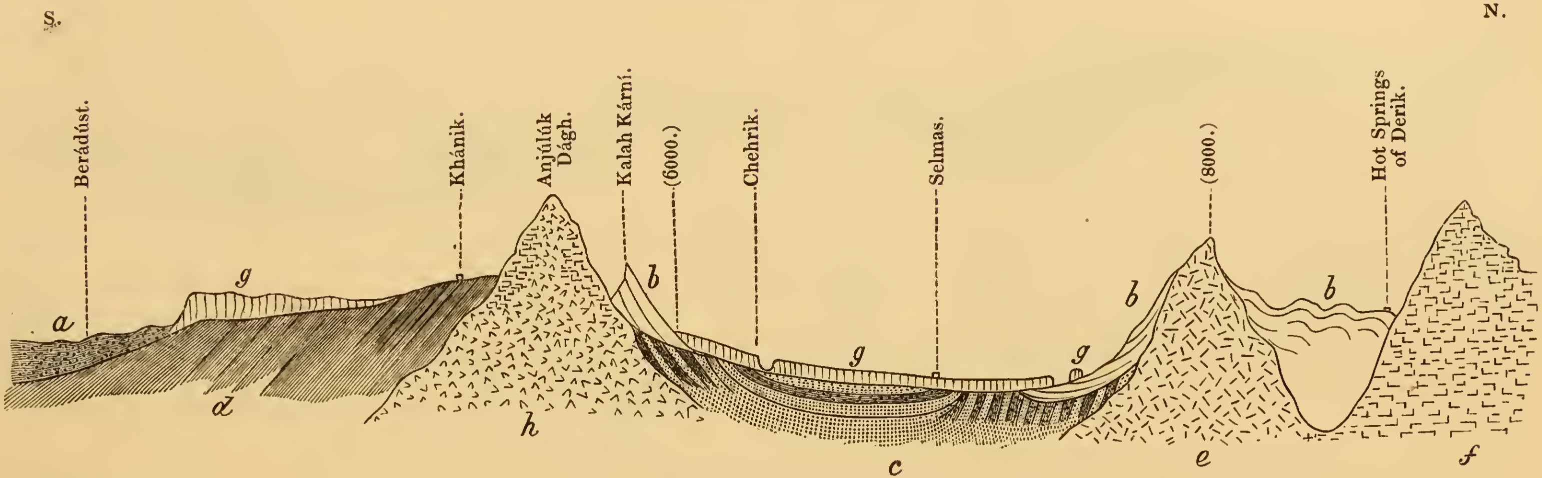
Distance about 50 miles.



a. Alluvium.
b. Gravel-conglomerate.
c. Red sandstones.
d. Gypsum.
e. Yellow limestone.
f. Blue altered limestone.
g. Granite.
h. Hornblende rock.
i. Serpentine and porphyry.
j. Blue schists with ironstone.

Fig. 16.—*Section from Berádúst, across the Plain of Selmás, to Derik.*

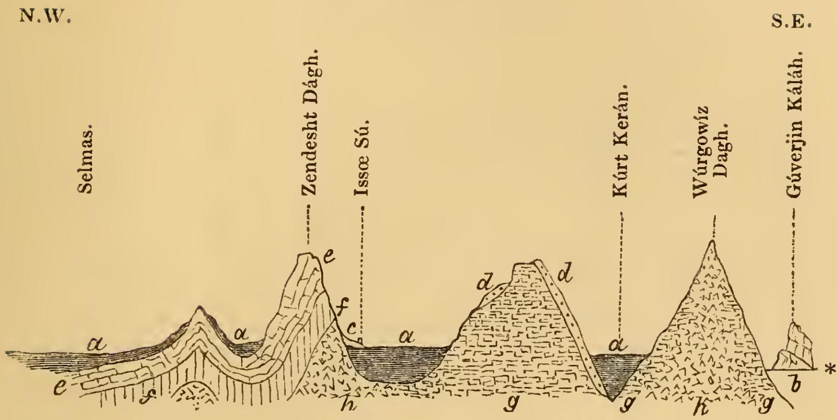
Distance about 25 miles.



a. Alluvium and gravel.
b. Travertin.
c. Gypsiferous sandstones and gravel-conglomerate.
d. Clay-slates.
e. Felspar rock with carbonate of lime.
f. Hornblendic rock.
g. Basalt.
h. Granite.

Fig. 17.—*Section from Selmás to Gúverjin Káláh.*

Distance about 20 miles.

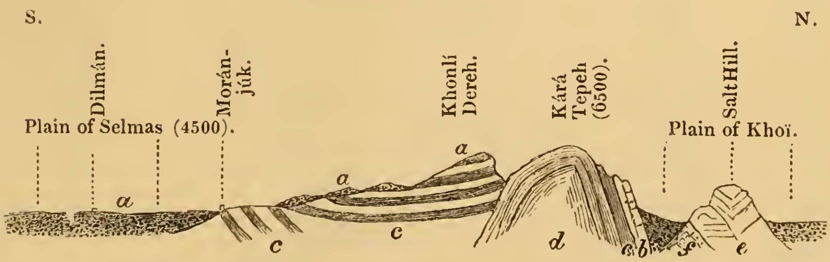


a. Alluvium.
b. Nummulitic limestone.
c. White limestone.
d. White chert with common opals.
e. Blue altered contorted limestone.
f. Compact red fluor with red jasper.
g. Hornblende rock.
h. Pink granite.

* Level of the Lake of Úrúmia.

Fig. 18.—*Section between the Plains of Selmás and Khoï.*

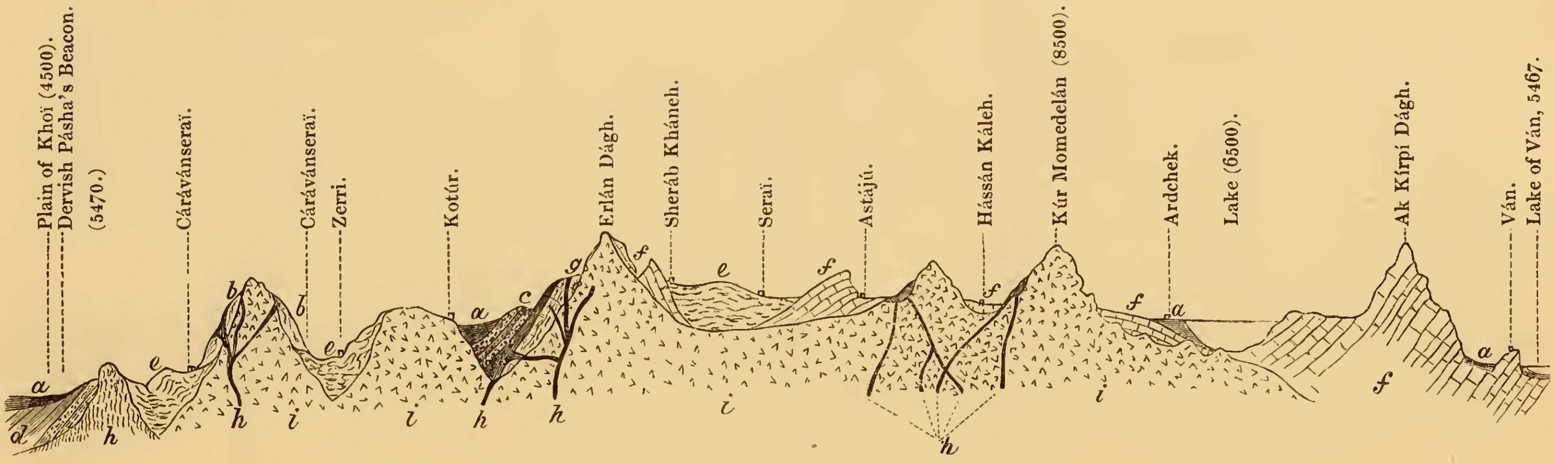
Length about 17 miles.



a. Alluvium.
b. Brownish-yellow limestone.
c. White and grey marls.
d. Indurated red marls.
e. Salt deposit (marls and sandstone).
f. Yellow fossiliferous limestone.

Fig. 19.—*Section between the Plain of Khoï and Van.*

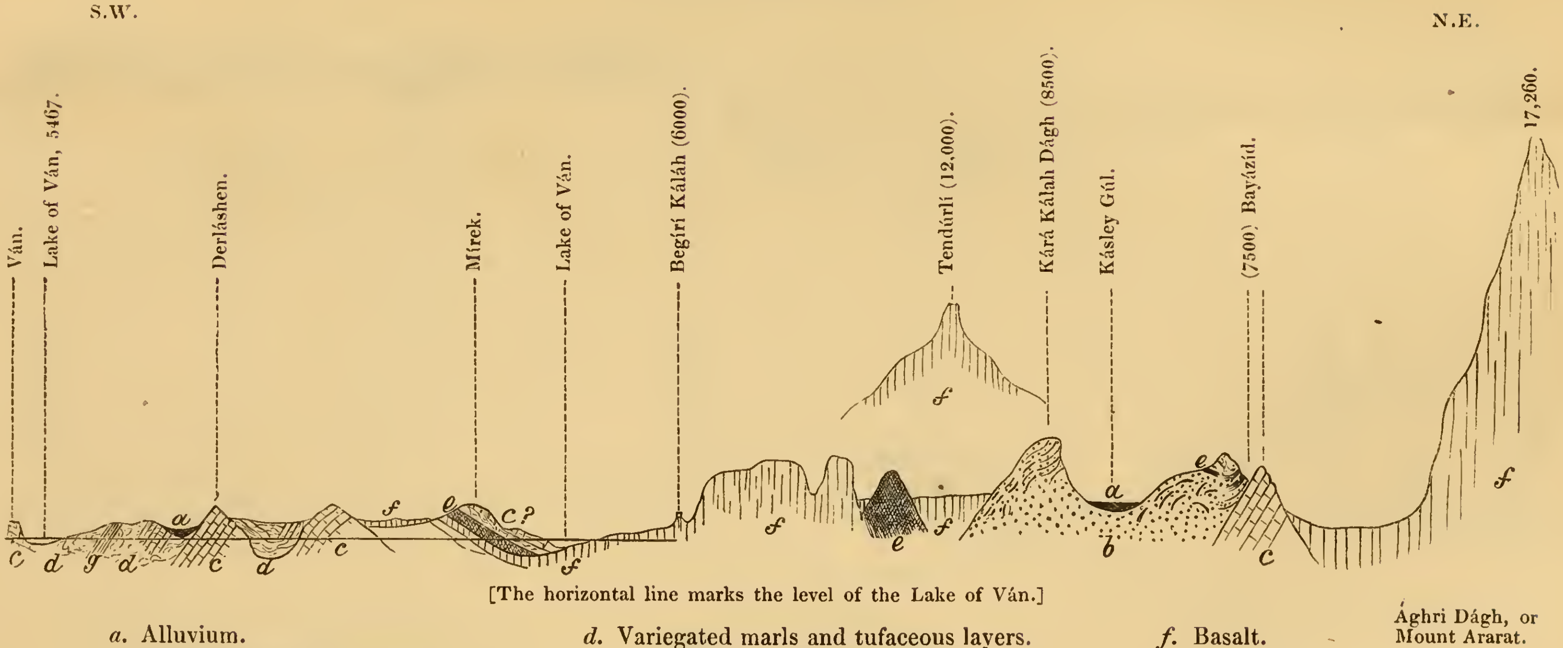
Length about 75 miles.



a. Alluvium.
b. Travertin.
c. Red sandstone and gravel-conglomerate.
d. Variegated slates, much metamorphosed, with marls, &c.
e. Variegated marls, with tufaceous layers.
f. Nummulitic limestone.
g. Contorted blue crystalline limestone.
h. Serpentine and steatite.
i. Granitic rocks.

Fig. 20.—*Section from Ván to Mount Árárát.*

Distance about 85 miles.

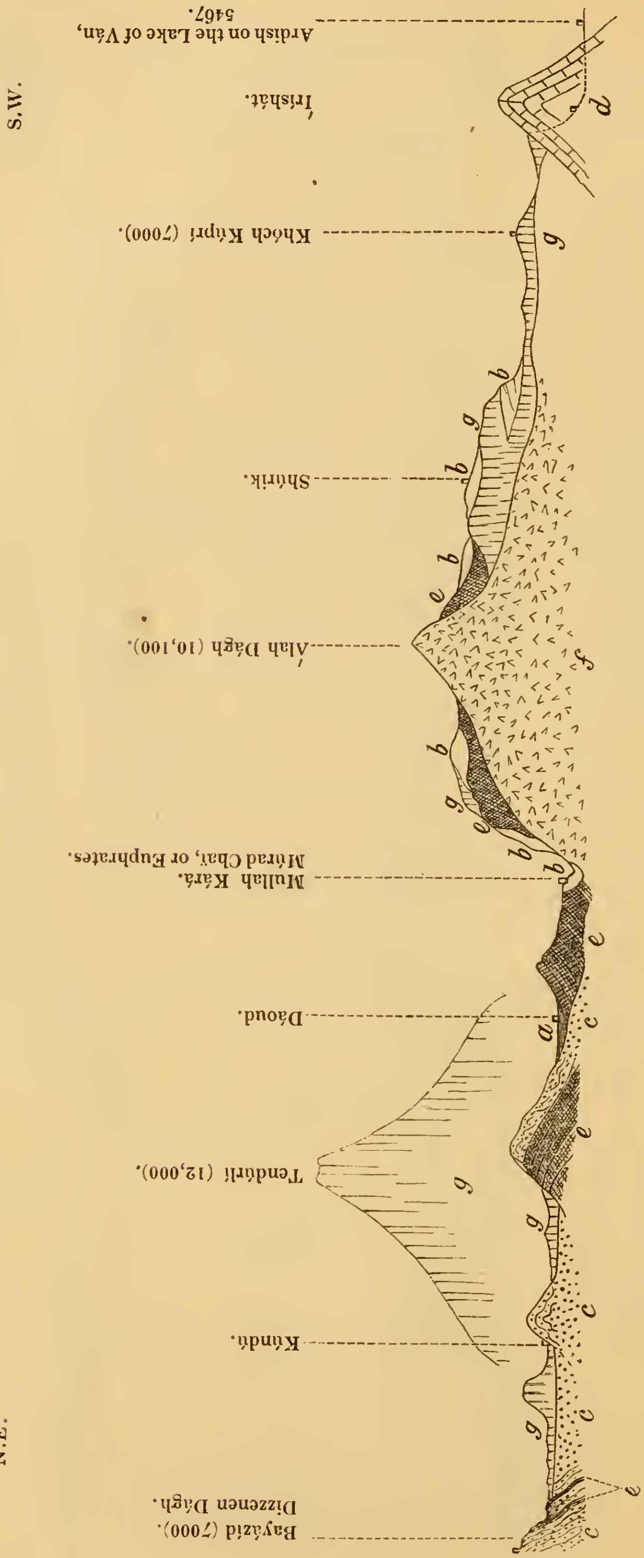


[The horizontal line marks the level of the Lake of Ván.]

a. Alluvium.
b. Variegated marls and sands.
c. Nummulitic limestone.
d. Variegated marls and tufaceous layers.
e. Volcanic lavas and breccia.
f. Basalt.
g. Blue slates.

Fig. 21.—Section from Bayázid to Ardish on the Lake of Ván.

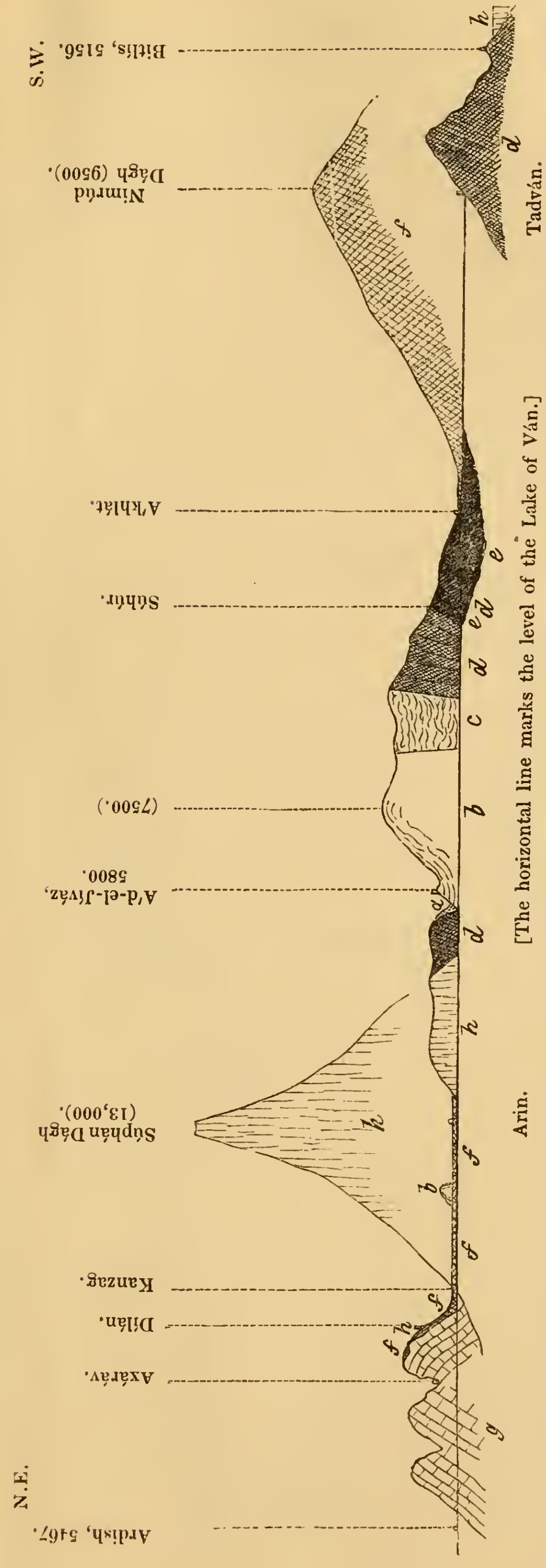
Distance about 55 miles.



a. Alluvium.
b. Travertin.
c. Red sandstones and variegated marls.
d. Nummulitic limestone.
e. Volcanic lavas and breccia.
f. Granite.
g. Basalt.

Fig. 22.—*Section from Ardish on the Lake of Ván to Bitlis.*

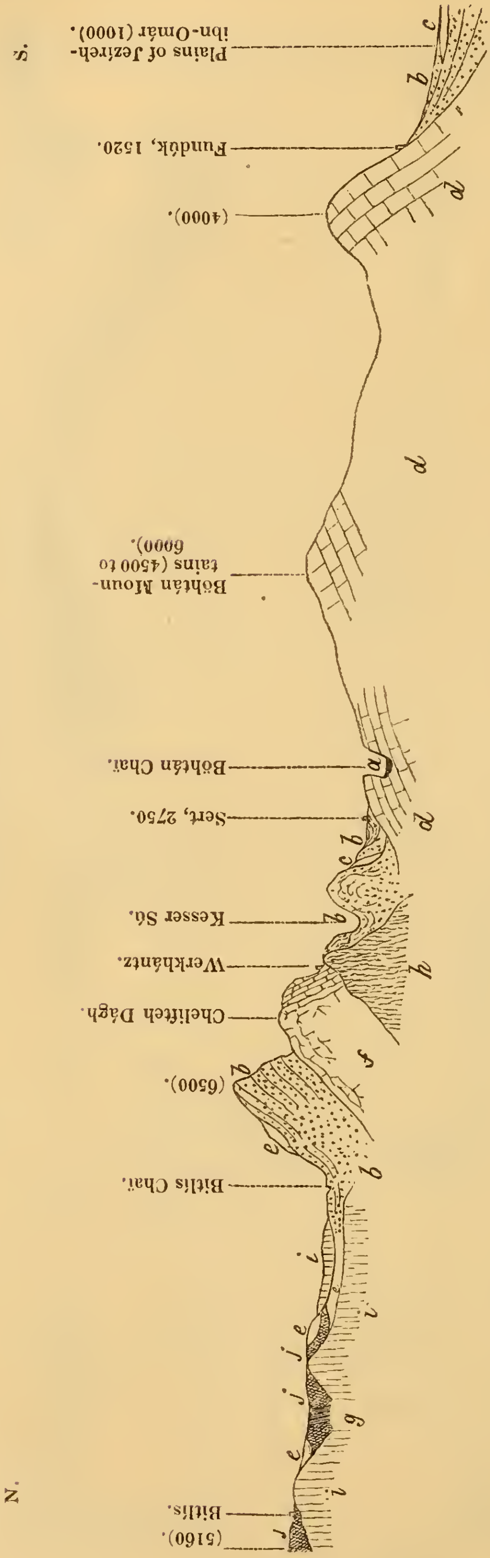
Distance about 75 miles.



a. Obsidian and limestone gravel.
b. Travertin.
c. Variegated marls and tufaceous layers.
d. Grey volcanic tuff.
e. Red volcanic breccia.
f. Volcanic sand and pumiceous lava.
g. Nummulitic limestone.
h. Basaltic lava.

Fig. 23.—*Section from Bitlis to Jezîreh-ibn-Omár.*

Distance about 75 miles.



a. Alluvial gravel.
b. Red sandstones and gravel.
c. Gypsum.
d. Nummulitic limestone.
e. Travertin.
f. Blue altered contorted limestone.
g. Blue schists.
h. Serpentine.
i. Basalt.
j. Volcanic tuff.

Drawn by S Hislop

On the Geology *and* Fossils *of the* Neighbourhood *of* Nágpur, Central India. By the Rev. Messrs. S. Hislop and R. Hunter.

[Communicated by J. C. Moore, Esq., F.G.S.]

[Read June 21, 1854*.]

(Plate X.)

[*Note.*—A full Abstract of this Communication appeared in the Society's Journal, No. 40, p. 470 *et seq.*, in consequence of unavoidable delay in the publication of the Memoir itself.]

PART I.†

(Geology of the District.)

Contents.

Physical Geography of the District.—The country to which the following paper refers is the western part of the recently acquired kingdom of Nágpur‡, lying, with the southern corner of the Ságar

* For the other Papers read at this Evening Meeting, see Quart. Journ. Geol. Soc. vol. x. p. 454 &c.

† Part II., containing the Palæontological Portions of this Communication, with Illustrations, will appear in a subsequent No. of the Journal.

‡ With regard to the spelling and pronunciation of Hindu names of places, the authors have furnished the following remarks in one of their late letters to the Assistant-Secretary:—

"Orthography in India is a very unsettled branch of learning. Those who first stereotyped in English characters the Hindu names of places were most unsuited for the work, and hence most unscientific is the system of spelling practised by the generality of our countrymen. We follow the Jonesian system, as it is adopted by such societies as the Royal Asiatic. By that every Hindu letter has an English representative, though that representative has more a continental than an English sound attached to it. The vowels are *a, á,—i, í,—u, ú,—e, ei,—o, ou.* They are in pairs, short and long; *a* unaccented having the sound of *u* in *but*, *á* accented the sound of *a* in *have*, *u* the sound of itself in *full*, its long being just the same sound more dwelt on, *i* the sound of English ē made long or short as it has accent or no accent. There is only one consonant that may occasion difficulty, that is a *d* written in italics. When so written or printed it is intended to have a sound somewhat like *r*. Thus we write Weiróga*d*, whereas it is commonly written Wyraghur. The *gh* for *g* is just a gross mistake, which destroys the etymology of the language to a person who does not know the original Hindu name. Silewá*d*á, as written by us, is usually represented Sillewarra."

GEOLOGICAL MAP
of the
WESTERN PART OF THE
NAGPUR TERRITORY.
Scale 20 British Miles to an Inch.
TABLE OF SIGNS.
Basalt, Amygdaloid, &c. (Locally associated with Freshwater Deposit lying between the upper and lower traps)
Sandstone & Shales (Locally Fossiliferous & sometimes accompanied by Coal Seams)
Granitic & other Crystalline Rocks
NARBADDA TERRITORIES
THE NIZAM'S TERRITORIES
NAGPUR
CHINDWÁDA
BANDÁRÁ
CHANDA
Hinganghat
Weiragad
Umred

and Narbaddá Territories, between 78° 15′ and 80° 35′ east longitude, and 19° 35′ and 22° 40′ north latitude. It is of a triangular shape, each side extending about 180 miles. Its northern side is formed by the table-land stretching from the Mahádewa Hills on the north-west to the northern extremity of the Lánji Hills on the north-east: the south-eastern side is constituted partly by the chain last mentioned, and partly by a line drawn from its southern base to the junction of the Wein Gangá and Wardhá, which latter river marks out nearly the whole of the south-western side. (See Map, Pl. X.) The limits as thus defined enclose an area corresponding with that surveyed by Lieuts. Norris and Weston in 1826, and amounting by their calculation to 24,000 square miles.

The city of Nágpur is situated very near the centre of this area. In the northern division, where the hills are both most numerous and most elevated, the direction of the ranges is east and west. In the southern, which contains a greater extent of level country, the course they take is generally north and south.

Chourága*d*, the highest summit of the Mahádewa hills, and the loftiest point in our district, rises to an altitude of 4200 feet above the sea: the usual height of the range, which entering the Nágpur territory from Gáwilga*d* passes by Dewagad towards Siwani, is not above 2000 feet, though in the east of the same chain, where it goes under the name of the Lánji Hills, some of the peaks attain an elevation of 2300 and 2400 feet. At Nágpur the country has fallen to a level of 1000 feet. On the west, however, it immediately rises by 200 or 300 feet in a succession of eminences, which run parallel to the Dewaga*d* range, until they reach the basin of the Wardhá, when they suddenly sink in precipitous descents as at Talegaum Ghat. Towards the east of the capital, the plain extends almost without interruption to the banks of the Wein Gangá, where the general level is about 900 feet above the sea. Still further east, on crossing the river, we find the country preserving its former flatness, except that occasionally it is diversified by ranges of hills running north and south, of which that encircling the Lake of Nawagaum is the most considerable. In the southern division of the territory there are few hills, if any, that rise above 2000 feet; while the champaign tracts, which abound on both sides of the Wein Gangá and Wardhá, fall, ere these rivers have effected the junction of their united streams with the Godávari, to 800 feet above the sea-level.

It will thus be seen that our district presents a watershed from north to south. The most important rivers which flow through it are the Kanhán from the Mahádewa Hills, which at Kámpti receives the Pech from the same upland tract, and the Kolár,—the Wardhá, which is joined by the Wanná from the hills west of Nágpur, and by the Pain Gangá from the Nizam's country,—and the Wein Gangá, the largest of all, which on its left bank is increased by the united streams of the Wág, the Son, and the Dewa, and by the Chulband, and on the right by the Kanhán and Wardhá, after its confluence with the latter of which it takes the name of the Pranhítá, and ere long discharges its waters into the Godávari.

History of the Geological Observations of the District.—The geological structure of the territory, whose extent and natural features have been thus briefly described, has for some time engaged the attention of scientific men in India. Dr. Voysey and Captain, now Colonel, Jenkins were the first who examined it. From the result of their investigations, as published in the Bengal Asiatic Society's Transactions, Part I. for 1829, it would seem that they were unsuccessful in their search for fossils. The lamented Voysey, indeed, who was the first in India to find shells in a stratum enclosed in trap, thought he had discovered, on the journey hence to Calcutta, which terminated his distinguished career, bivalves in a bed of limestone near Ráyepur within the Nágpur State, though on the east of our district*; but I have since ascertained† that the appearances, which he regarded as organic, are the consequence of the rock having been brecciated. The next observer within our field of investigation was Dr. Malcolmson, who in 1833 worthily following up Voysey's discoveries within the Nizam's dominions in 1819 and 1823, pointed out new localities for the formation in the same part of the country, and traced it into this kingdom to Chikni and Hinghanghát. At the former of these places, which is sixty miles south of the city of Nágpur, he met with *Unio Deccanensis, Physa Prinsepii, Paludina Deccanensis,* and *Melania quadrilineata*: at the latter, which is sixteen miles nearer the capital, he found an abundance of silicified wood. But though he lived in this neighbourhood for some years, he does not appear to have been aware of the existence of similar organic remains here; and, while with Voysey and Jenkins he enlarged on the *mineralogy* of Sitábaldi Hill, like them he failed to advert to the two rocks which are its most interesting features,—his own trap-imbedded stratum with Physas and Melanias towards the top, and an unfossiliferous member of the sandstone formation resting on gneiss at the bottom. In 1842 Lieut. Munro, of H.M.'s 39th Regt., brought to light in the sandstone quarries near Kámpti, nine miles N.E. of Nágpur, the impressions of ferns, which were forwarded to Malcolmson as having previously discovered the first vegetable remains in the sandstone of the Hyderabad country, by whom they were figured and described as resembling *Glossopteris Danæoides* of Royle‡. As this species of fern is now understood to be a *Tæniopteris,* it seems likely, that the comparison of the Kámpti specimens with it was incorrect, and that they belonged to a *Glossopteris,* whose species, owing to the fragmentary state of the fronds, cannot be determined.

In 1845 I procured a few fossils of the same kind from the Kámpti sandstone, and two years subsequently my esteemed colleague the Rev. R. Hunter and myself fell in with them in the

* Beng. As. Soc. Journ. vol. xiii. p. 856.

† The first person singular here refers to Mr. Hislop, by whom the memoir is for the most part written, with the exception of the description of the Plants and Insects of the Tertiary deposits, which is from the pen of his fellow-labourer Mr. Hunter. For a previous notice of the "Geology of the Nágpur State," by the Rev. S. Hislop, see Journ. Bombay Asiat. Soc. No. 18, July 1853, p. 58, &c.—Ed.

‡ Bomb. Br. R. As. Soc. Journ. vol. i. p. 249.

contemporaneous strata of Chándá, eighty miles south of Nágpur. None of these specimens, however, were preserved, nor was anything further done by us or by others to understand the palæontology of this part of India, until June 1851, when, walking with my fellow-labourer in the neighbourhood of our residence, two or three Physas in a deposit enclosed in a trap hill about a mile west of Sitábaldi, and two miles in the same direction from Nágpur, forced themselves on my notice. They were at once referred to the fossils which Voysey and Malcolmson had discovered in a similar situation, and the deposit in which they occur was identified with the freshwater formation that they had traced in several parts of the Nizam's territory, and at Chikni and Hinghanghát in this state. In a few days after, at the same spot, I found the first bone, and Mr. Hunter the first tooth; and, after a week or two, on Tákli Plain, about 2½ miles N.W. of Nágpur, I met with the first Fruit and Entomostracan. About the same time, from observing the traces of ancient vegetation on the soft clayey sandstone, used in the absence of chalk for whitening the writing-boards in our Mission schools, I was led to make inquiries about the locality from which it was brought, which ended in the discovery of *Glossopteris* and *Phyllotheca* and some seeds or seed-vessels at Bokhárá, six miles north of Nágpur. Ere long we were joined by our friend Capt. Wapshare, Judge Advocate of the Nágpur Subsidiary Force, who added many valuable vegetable remains to our collection; and it is to his able and generous efforts that we owe, among other rare acquisitions, the first palm and the first mulberry-like fruits. From the red shale of Korhádi, seven miles north of Nágpur, I procured tracks of Annelids, and more recently, in combination with them, the foot-marks of some Reptile: and towards the end of the year, in company with Lieut. Sankey of the Madras Engineers, I visited Silewá*d*á, twelve miles north of Nágpur, where the sandstone yielded a profusion of rich and most beautiful specimens of *Glossopteris*, and whence have since been obtained a variety of Exogenous stems, several species of *Phyllotheca*, and an interesting specimen, contributed by Mr. Hunter, of an allied genus, which by Lindley and Hutton is reckoned an *Equisetum*, and by Bunbury probably an *Asterophyllites**. A Mission tour, undertaken about the same time, conducted my colleague and myself past the freshwater formation at Pahádsingha, forty miles W.N.W. of Nágpur, in which was detected an abundance of fish-scales, dispersed through the stone. On our return, Mr. Hunter, among the seeds and fruits of Tákli, discovered the first specimen and the greater part of our fossil *Coleoptera*; while we received an accession to our collection of shells from Dr. J. Miller, then of the 10th Regt. M. N. I., who, while on an excursion with Dr. Fitz-gerald, had found the freshwater formation at Butárá near Machagho*d*á, eighty miles north of Nágpur, and also from Mr. Sankey, who had fallen in with it at Pilkápahad, twenty-five miles to the north-west. The latter-named officer, after discovering in the Kámpti quarries the first *Vertebraria*, a fine species of *Phyllotheca*, a long

* Quart. Journ. Geol. Soc. vol. vii. p. 189.

endogenous leaf, and an abundant kind of seed, all of which he liberally handed over to us, proceeded along with Dr. Jerdon, the Indian ornithologist, in the direction of Butárá and the Mahádewa Hills*, whence they returned with several new fossils belonging to our Eastern Coal-formation, and excellent specimens of the shells previously collected by Dr. Miller, agreeing in general with those of this neighbourhood. In a portion of the Butárá rock which they kindly gave me, I was struck with the appearance of a diminutive creature, which proved to be a second genus of the *Entomostraca*. Ere the first anniversary of the discovery of our earliest *Physa* had come round, several other localities had been ascertained for both the freshwater and sandstone fossils, and observations had been made on the remains of quadrupeds and shells imbedded in comparatively recent deposits. Since that, on our annual Mission tours we have become acquainted with a productive site for sandstone organisms at Mángali, sixty miles south of Nágpur, which has afforded a few unusual vegetable remains, a species of *Estheria*, scales and jaws of Fish, and the entire head of a Saurian; we have passed through districts abounding in laterite and iron-ore, and have increased our knowledge of the geological structure of the country generally.

General Geology of the District.—From the rapid survey which we have taken in the preceding historical introduction of the fossils that have been brought to light within our area, it is obvious that its palæontology, contrary to the common idea of Indian formations, is both varied and important; but, even in a lithological point of view, there are few tracts of equal extent that are worthy of more attention, and of all the portions of that interesting area, there is none for interest that can be compared with the vicinity of Nágpur,—its centre at once political, historical, and geological. We have only to take a few steps from our house and we reach the summit of Sitábaldi Hill,—the scene of as heroic a conflict as ever our countrymen gained in the East. The spot on which we stand consists of nodular trap (fig. 1). At the distance of a few yards from our feet, just under the brow of the hill, is a narrow stripe of green or yellow calcareous indurated clay, which, on close inspection, is found to contain a number of decaying casts of freshwater shells. Under this we perceive a bluish-green friable rock, which hardens first into a tough amygdaloid, and then, a little above the level of the plain, down to which it is scarped by the quarrymen, into a compact greenstone. Cropping out from under the foot of the hill may be seen a bed of soft variegated sandstone, and then, according as we look east or west, the prevailing rock covering the plain beyond is either gneiss or trap.

But let us extend the prospect to the horizon. As we stand with our faces to the north, the first glance that we cast on the distant hills shows that there is a marked difference among them. Behind us, on our left, and in front we follow a long sweep of flattened summits, with here and there a valley to break the uniformity; but no sooner do we look towards the right than we descry a series of round-topped hills rising up at intervals in massive strength. These

* Quart. Journ. Geol. Soc. vol. x. p. 55.

flattened summits are the tops of trap-hills, which stretch, in the orm we see, from our present position to the coast of the Arabian Sea; and these massive eminences are granitic hills which rise up in the manner that meets our eye, at various distances from each other, from the place where we stand to the Bay of Bengal. The intermediate hills and plains, which in front fill up the foreground, are formed of the dolomite and shale of Korhádi, and the sandstone of the basins of the Kanhán and Kolár.

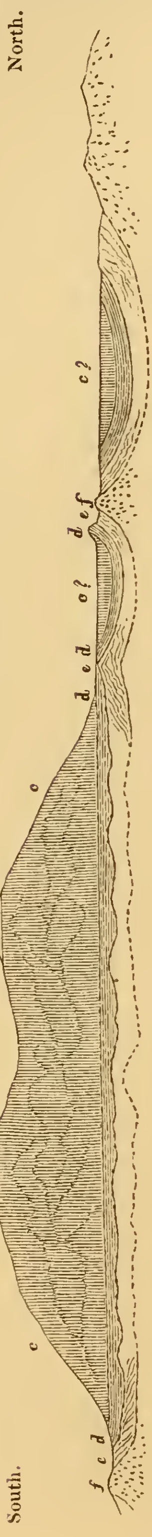


Fig. 1.—*Section through Sitábáldi Hill.*

a. Overlying nodular trap. *b.* Freshwater tertiary.
c. Underlying trap; vesicular for some feet under the freshwater deposit, then compact, but nodular at the sides.
d. Highest member of the Sandstone series, which most probably underlies the amygdaloid throughout.
e. Gneiss, into which much of the Sandstone has been transformed. *f.* Pegmatite.

From our elevated station we are thus enabled to command a prospect of twenty miles in every direction, and the formations that we can trace within that range make up an exact miniature of the geology of our whole area. Nay, were we to go down the hill and walk around its base, in the descent and circuit, which might all be accomplished in twenty minutes, we should meet with almost every rock that is to be found between Bombay and Katták.

The geology of our area must at one time have been extremely simple. Its principal feature was then sandstone, associated with shale and limestone. But now other two formations are discovered on the arena, and these seem on the surface as if they had been two huge icebergs, which approached each other in frightful collision, crushing the sandstone between them, and allowing the fragments to slide out at either end, and scattering them here and there over their own bulk. Or, to speak in language more precise, the sandstone formation, which once occupied the whole space that we have chosen for description, is now covered up by trap on the west, and broken up by granite on the east, leaving only a small diagonal stripe running through the centre, which, after being interrupted at the north-west and south-east, increases in these directions to a broad expanse, while a few detached portions, formerly continuous with it, appear in the body of the trap and granite. It is the juxtaposition of trap, sandstone, and granite in this neighbourhood which invests the geology of Nágpur with special importance, and which, when investigated by competent observers, may shed a flood of light some future day upon Indian geology in general.

Trap Rocks of the District.—The greater part of the trap within our area lies in the west in the shape of a parallelogram, one of whose corners has been encroached on by a projecting portion of Berár and the Betul district of the Ságar and Narbaddá territories. Its greatest length is 120 miles, and its breadth is from fifty to sixty. Its south-western side, on which the irregularity of figure is found, and by which it joins on to the great sheet of basalt in the Dakhan, is formed by the Wardhá. Its south-eastern side, commencing from Suit on that river, crosses the road from Nágpur to Chándá on the south of Chikni, and, passing by the north of the Mángali fossiliferous quarry, extends to Sákrá and Bhiwákund, after which it coincides very nearly with the political division between the Súbás (provinces) of Nágpur and Chándá, which stretches by Lingá, Jámgaum, and A'lasur Hills to the north-west of Bhísi. Here begins its north-east side, which skirts the small patches of sandstone on the west of Umret and Kuhi, and, running close by the city of Nágpur, meets with an eruption of granite, and then touches the sandstone basin of the Kanhán and Kolár, after which it again encounters plutonic rocks on its passage up the right bank of the Kanhán to Dewaga*d*. At this ancient Gond fortress, the upland tract of Multái, which constitutes the north-west side, joins that last described, and completes the parallelogram.

In addition to this, the main body of trap within our area, and connected with it, there is a smaller development of the same formation in the north. Stretching south and east from Dewaga*d*, it fills up the space between the Kanhán and the Pech, and, sweeping westward round the granite at Chindwá*d*á, and eastward by way of the summit of Kurai Ghát to Siwani and Chapárá, it merges, along with the Mathur range of hills, in the basaltic district that extends to the Narbaddá at Jabbalpur.

The above is, I believe, all the overlying trap within our area, with the exception of one or two isolated portions south-east from Suit, near Warodá and the confluence of the Páin Gangá with the Wardhá.

Granitic and schistose rocks.—The plutonic and metamorphic formation, the extent of which I shall now briefly indicate, lies chiefly in the eastern portion of our area. It is intersected by the Wein Gangá for the greater part of its course. The tract on the left bank of the river I have had little opportunity of exploring; but, from the cursory examination I have given it, I have reason to believe that granite and its allied rocks are there very largely developed, being only occasionally diversified by patches of sandstone and variegated shales, among which red shales predominate. On the right bank of the Wein Gangá, in the district near its junction with the Wardhá, the extent of the formation is not so great. It is observed principally in the channel of the Wein Gangá, though it may also be traced around the bases of the sandstone chains of hills, which it has been the means of upheaving. In both the districts under consideration the general strike of the strata is N. & S., corresponding with the direction of the streams and mountain-ranges, and in that last mentioned the dip is for the most part to the west. But it is on the north that the greatest development of granite and crystalline schists occurs. There we may perceive these rocks rising to the surface (though it would be hazardous to conclude that there are not others of a different character in the hollows covered up by the deep soil) from Nágpur north-eastward to the Lánji Hills,—a distance equal to the length of our trappean parallelogram, and with a breadth in proportion. This second parallelogram is applied perpendicularly, but unequally, to that previously described. Near the line of contact, *i. e.* in the district near Nágpur, the gneiss and other metamorphic rocks, like the hills and tributaries of the Wein Gangá, which run through it, had uniformly an east and west direction, with veins of the massive rock penetrating them at right angles to the strike.

This is the case with the crystalline formation north of the Kámpti quarries, which has communicated to the sandstone strata there and at Silewá*d*á a southerly dip. As the granitic eruption, however, is traced up the basin of the Kanhán, it is seen to bend round a little, and to give a westerly inclination to the sandstone at Bábulkhe*d*a, Tondakheiri, and Adássá. From the last-mentioned place it proceeds northwards past Sáner and Kelod, in a narrow stripe on both sides of the Kanhán up to Dewaga*d*. Beyond this we find it rising up around Chindwá*d*á, and running west into the shaly beds of Jámwahi and Hardága*d*. But returning to the neighbourhood of Nágpur, we discover parallel to the great body of the granitic formation on the north of Kámpti a range of quartz hills running in the line of the strata westward from Wáregaum to Gumtárá. The plutonic force, which has tilted up these, has greatly disturbed the limestone rocks at Korhádi, and given to the sandstone at Bokhárá, on the south of the Kolár, the same dip as we observe at Silewá*d*á and Kámpti on the north of that river.

Sandstone.—But let us now refer to the sandstone formation, which I have said exists in the central parts of our area, though only the wreck of what it once was. Its upper member, reduced in thickness by metamorphic agency, may be observed horizontally entering the trap-hill of Sitábaldi on the east side, and again emerging on the west. It is then wholly displaced by gneiss and granite towards the Nág River, after which it again becomes the surface rock for a short distance to the west, until it is a second time overlaid by trap. It remains thus concealed for sixteen miles, when it is seen on the north-west of Yahár at Nimji, whence it extends to Sátnawari on the south-west and Kotwalba*d*i on the north-west. At these villages it is a third time covered up by trap, nor does it in that direction rise again to the surface within our area, or indeed, I believe, anywhere beyond it. The division of this formation which proceeds to the north of Nágpur occupies a part of the basins of the Kanhán and Kolár from Kámpti on the south-west to Kelod on the north-west, being about thirty miles long and twelve broad. Its north-eastern border touches the great granitic tract, which stretches from Nágpur to the Lánji Hills, while its south-western boundary is constituted by the trap, surrounded by which two of its detached portions are found at Kutkheiri and Chorkheiri, near the source of the Kolár. Were we to follow the direction of these outliers, they would lead us to the sandstone hills beyond our area, that skirt the southern side of the trap chain of Gáwilga*d*, north of Elichpur. But if we suppose the sandstone continued north-west in the line of the Kanhán's course, we arrive, after crossing some miles of trap and granite, at the beds of carbonaceous and clayey shales, which, running under the trap-range of Mathur, appear on the north side, and form the base of the lofty development of sandstone at the Mahádewas. The largest body of this formation, however, lies to the S. in the basin of the Wardhá and Pranhítá, extending, with only a few slight intrusions of plutonic rocks at Segaum and the north-west of Chándá, and some outliers of trap indicated on the map, from the termination of the basaltic effusion at Jámgaum Hill and Suit, south-west into the Nizam's country by Kotá, until within a short distance of Badráchellam.

A very marked feature in the geology of the country between the Iri and the Wein Gangá is the occurrence of ranges of sandstone-hills, running for the most part north and south, corresponding in general direction with ranges of the same formation in the district of Kotá, described by Dr. Bell *. These hills, where they have fallen under my observation, rise from plains of plutonic rocks, by which the strata have been indurated and elevated, though still retaining their horizontal position. Such are the flat-topped chain which stretches on the east of Segaum, and that which terminates in the castle-like bluff of Perzága*d*. On either side of the Wein Gangá we meet with some isolated remnants of the sandstone formation. One of these, but very limited in its dimensions, lies on the banks of the Selári, a small stream which joins the Wein Gangá near the town of Pawani. Another farther down the river extends for some distance, first on the right bank and then on the left. In the district on the east of the Wein Gangá, a little sandstone proper is met with at Koká to the north-east of Bandárá, and on the banks of the Wág River near Ámbgaum, and on the east side of the Nawagaum Lake, from which it extends south as far as Mahágaum; while on the west of the lake there is an abundance of shale, which is also seen to cross the road from Nágpur to Ráyepur at Mundipár Ghát and Jamnápur near Sákorali. These argillaceous strata, which are red, green, and as partly at Mundipár even white, seem to be the same as the fossiliferous laminated clays at Korhádi. In addition to the dolomitic strata at Korhádi mentioned above, there are eminences of the same crystalline limestone running eastward among plutonic rocks from the Pech, on the west bank of which river higher up there is a small patch found along with a little outcrop of sandstone at Dudhgaum, surrounded by trap.

Laterite, &c.—In various parts of our area we meet with beds of laterite, covering the rocks already described. I have not found it

* Quart. Journ. Geol. Soc. vol. viii. p. 230.

on the west of Nagpur; but it is seen abundantly within the trap-district at Ságar N. of Dudhgaum, and at Pándaratalâw S.W. of Umre*d*. At Karanlá, E. of the same town, it overlies plutonic rocks, and from Pawani on the Wein Gangá it stretches in a broad belt sometimes over sandstone and at other times over gneiss and granite towards Weiraga*d*. South and west of this throughout all the province of Chándá it occurs more or less. I have already mentioned the fact of its resting on dolomite at A'mbágiri. At Máhonda on the Kanhán, straight east from Nagpur,—at Dharmapuri and Karbi in the basin of the Sur River, which flows from Rámtek into the Wein Gangá,—and again in the neighbourhood of Chándpur further up the Wein Gangá, the same formation is presented to view. But it is on the east bank of the river that its most extensive development is witnessed. Crossing the Ráyepur road at several places it unites on the north of it to form extensive tracts in the district of Lánji, and all around Hattá and Kámtá.

The superficial deposits that are superior to laterite are either red or black. The former is found in general where plutonic rocks, sandstone, or laterite prevail, though instances are not rare of the latter being met with in such situations. The "regur," or black soil, occurs almost universally where trap abounds.

Description of the Strata.—Having thus given some account of the extent of the formations within our area, as they appear on the surface, I shall now endeavour to point out in a descending order their thickness, nature, contents fossil or mineral, as the case may be, and age.

I. *Superficial Formations.*

1. *Black Soil or Regur.*—The regur is of no great depth in this district, seldom if ever exceeding 20 feet. In some places, as at Tákli village, it is seen to overlie a stratum of brown tenacious clay, which, like itself, is much mixed with "kunker." I have not succeeded in finding any organic remains in the regur except bones of oxen and sheep, of very doubtful antiquity.

2. *Red Soil.*—The red soil in our area is of greater depth than the black, frequently displaying a section of 50 feet. Like it, it seems to rest on a brown calcareous clay, at the bottom of which there is in general a layer of conglomerate. In river-basins it alternates with layers of loose sand and gravel, often imbedding existing fluviatile shells of the genera *Melania*, *Cyrena*, and *Unio*. In the district west of Nágpur, the rivers often expose a bed of sand and gravel cemented by a small quantity of lime, and in its consolidated state furnishing blocks of sandstone or conglomerate two or three feet thick. This stratum for the most part is unfossiliferous, but near the Kolár, about ten miles north of Nágpur, there occurs in it an abundance of *Paludina*, *Melania*, and *Cyrena*, which, though belonging to existing species, from the nature of the matrix have been much altered since the period of their deposition. Of some the cavities are simply filled with siliceous and calcareous matter, but in

the greater number of instances the shell has been completely absorbed, and employed as a cement in aggregating the particles of the rock. A similar deposit is seen at Nágalwa*d*a near Elichpur, to the west of our area; but there, in addition to the fossils just mentioned, it includes *Limnæus, Planorbis,* and *Unio.* On the banks of the Sarpan River, near Tondakheiri, 14 miles N.W. of Nágpur, there is an accumulation of the freshwater shells previously enumerated, with a considerable intermixture of a species of *Bithinia* and a few specimens of land shells—*Helix* and *Bulimus.* Mingled with these remains of *Mollusca,* there was a quantity of jaws, vertebræ, and other portions of *Mammalia,* which were not much petrified; but, I regret to say, they were accidentally destroyed before they could be examined*. In the bank of the Kanhán at Kámpti about 45 feet under the general surface I found the shoulder-bone of some mammifer, much increased in weight from the process of petrifaction. Bones in the same state have been discovered lying above ground, between Nágpur and Kámpti, which must have been washed out of the kankaraceous red soil.

Judging from the relation of the regur and red soil to the brown clay, I am inclined to regard these two formations as contemporaneous; and, from the evidence of the fossils contained in the latter, I would class both as Post Pliocene.

II. The *Brown Clay,* on which I have said both the red and black superficial deposits rest, averages, together with its underlying *Conglomerate,* a depth of 20 feet. The clay is not known to be fossiliferous, but in Tákli Plain there were found in the conglomerate apparently the tusks of a large mammal, which had been completely converted into stone, but they were so much affected by the weather as to fall to pieces on being removed. The formation containing them, I suppose, should be assigned to the Newer Pliocene, and will rank with similar deposits at Jabbalpur and elsewhere.

III. *Laterite.*—This formation seldom exceeds 10 feet in depth anywhere in our area. No fossils have yet been discovered in it here, but diamond-mines have been opened in it east of Nágpur. Malcolmson †, and after him Newbold, inferred the identity of the sandstone of Central with that of Southern India, from the existence of diamonds at Weirága*d*, a town about 80 miles S.E. of the capital. The inference, however, is drawn from erroneous premises, which would have been corrected, had these authors personally visited the spot. At Weirága*d* there is no sandstone near the diamond-mines; the only rock in the vicinity is quartzose and metamorphic. It has been too much taken for granted, in my opinion, that the diamond-conglomerate of Southern India is connected with the sandstone, within tracts of which it is sometimes found; and hence the arenaceous strata of the Peninsula have actually come to be

* Some fragmentary bones, from the banks of the Sarpan, imbedded in a sandy earth and associated with numbers of *Melania, Paludina,* and *Unio,* form part of the series of organic remains forwarded by Messrs. Hislop and Hunter. The bones, having been kindly examined by Prof. Owen, prove to have belonged to Ruminants of two sizes,—such as a Buffalo and a small Antelope.—Ed.

† Bomb. Br. R. As. Soc. Jour. vol. i. p. 250.

designated by the name of diamond-sandstone. Now, although the diamond-conglomerate has been found reposing on sandstone beds, yet there is no instance, that I am aware of, of the diamond having been extracted from any one of them; nor are there any data to prove that the conglomerate derived most of its materials from that source. On the contrary, Heyne * has shown that the pebbles at Kondápetta and Ovalampalli, near Kaddápá, are chiefly of chert and jasper-basalt, quartz, hornblende, and felspar. The first two have evidently been derived from the limestone of the neighbourhood, and the rest from igneous rocks. And these pebbles are not contained in a paste of sand, but, according to Heyne, of clay †. It is true the diamond-conglomerate may in one place overlie sandstone; but in another place, as at Kondápettá, it may rest upon limestone, while in a third, as at Bejwá*d*á, near Másulipatam, according to the statement of Captain Newbold, it may be found immediately above gneiss ‡. In short, I am inclined to concur in the verdict long ago pronounced by that experienced Indian observer, Dr. Heyne, when he remarked, "All the diamond-mines which I have seen can be considered as nothing else than alluvial soil" (superficial deposit). But if the matrix of the diamond be a surface-deposit overlying several rocks, I can perceive no propriety in attaching its name to one of these more than another. The matrix at Weirága*d* is a lateritic grit, and it is worthy of notice, that wherever the precious gem is sought for, whether in India or Brazil, there for the most part oxide of iron is diffused.

Having myself met with no fossil in this formation, I have nothing to offer by way of determining its precise age, but would content myself with remarking, that it must be posterior to the overlying trap, on which it is found occasionally, though in our district very rarely, to rest.

IV. V. and VI. *Trap and its enclosed sedimentary Formation.*—The next rock to Laterite in order of downward succession is the overlying trap, with which, however, for the sake of perspicuity it will be necessary to combine the freshwater formation previously alluded to and the underlying trap.

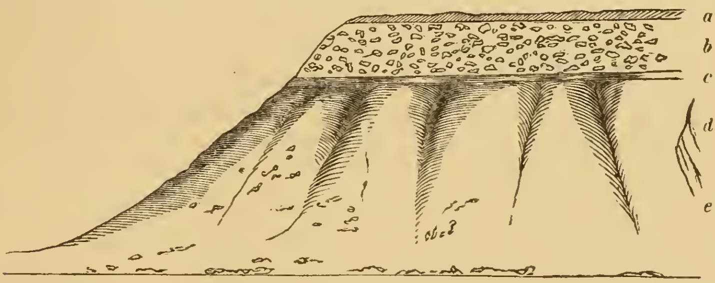
Trap, it was before stated, is the prevailing formation in the west of our area; but when that assertion was made, it was understood that this volcanic rock is of two kinds,—one overlying, and the other underlying,—and that between these two, and therefore seldom exposed to view, there is for the most part found an aqueous deposit. All three generally occur together. The exceptions are met with in the plains, on the outskirts of the trap-formation, where we not unfrequently observe the usually enclosed stratum resting immediately on sandstone without the presence of either the upper or lower basalt. In some of these instances it is probable that the overlying rock has been removed, and cases occur of its remaining where no underlying trap has ever existed. On the other hand, there are examples in similar border-localities of a single sheet

* Tracts on India, p. 97. † *Ibid.* pp. 96 and 105.
‡ R. As. Soc. Jour. vol. viii. p. 245.

of trap extending over sandstone without being associated with a second sedimentary formation or volcanic effusion.

Though the three formations are generally connected with each other, yet it is chiefly the upper one, viz. the overlying trap, that meets the eye over the face of the country. Leaving out of consideration the very few examples of denudation which have uncovered the freshwater deposit in the plains, and the equally rare instances of eruption which have there upheaved it on its edge, it is on the escarpments of the table-lands that we may be said to gain our whole knowledge of this department of Nágpur geology. In commencing our ascent of these steep hills, our attention is attracted by a number of blocks near the foot, which are easily distinguished from the masses of basalt among which they have fallen from above. As we make our way up over the hard, dark, vesicular rock, the blocks increase in number until we come to a friable greyish or bluish-green zone. We must now move slowly and look narrowly, for a few yards of upward progress may conduct us from the soft amygdaloid, where fragments are thickly strewed, to a nodular basalt, where not a trace of them is to be seen. Occasionally the freshwater formation is so thin that a very little earth or herbage may suffice to hide it from our sight. But generally the water from the brow of the hill in the monsoon collects into little rills just at the place where it leaves the nodular trap, and having now gathered enough of strength to make an impression on intervening barriers, it proceeds to plough up the soft deposit, and the still softer subjacent amygdaloid, leaving an interval between each streamlet, like a talus resting on the harder vesicular rock below (see fig. 2). The thickness of the overlying trap on Sítábaldi Hill and the tabulated summits in its immediate vicinity is from 15 to 20 feet, which agrees very exactly with the

Fig. 2.—*Sectional View of one of the Trap Hills near Nágpur.*



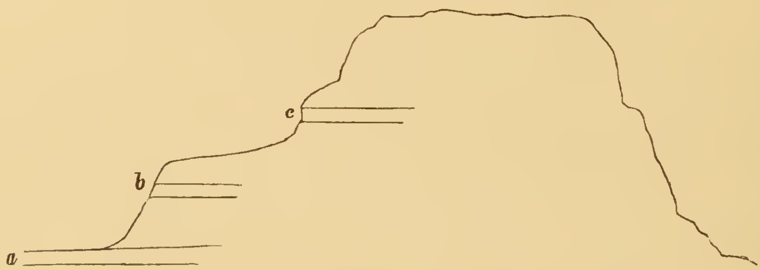
a. Surface soil. *b.* Nodular trap (15 to 20 ft. thick). *c.* Freshwater deposit. *d.* Soft amygdaloid. *e.* Hard amygdaloid.

thickness assigned to it by Dr. Voysey at Jillan. On the Western Ghats, however, according to Colonel Sykes, a stratum of earthy jasper, which is just our freshwater deposit, was found near Junar under a thickness of from 300 to 600 feet of basalt *. But it not unfrequently happens, that in leaving the plain and climbing up a

* Trans. Geol. Soc. 2 ser. vol. iv. p. 419.

trappean hill we may come upon the freshwater deposit at three distinct elevations. There is first the stratum which underlies the nodular trap generally throughout the plain, and which may be seen sometimes laid bare at the commencement of the ascent;—then, after passing over hard and soft amygdaloid, we come to another bed, overlaid by nodular trap; on gaining the top of this we reach a terrace, which conducts us to another ascent, where we find ere mounting to the summit a repetition of amygdaloid, sedimentary rock, and globular basalt. An example of this occurs at the hill of Gi*d*ad, 40 miles S. from Nágpur, the top of which has been

Fig. 3.—*Section of Gidad Hill.*



a. Freshwater deposit, as seen in the plain, of a white colour.
b. Freshwater deposit, of red colour, under the terrace.
c. Freshwater deposit higher up, brownish green in colour.

appropriated by the disciples of a Musalman saint, named Shek Faríd, to a mendicant establishment, which is supported by the donations of Hindus and Muhámmadans alike, from all parts of the Nágpur territory. See the accompanying section of the hill from east to west (fig. 3), where *a* is the deposit in the plain, white; *b* the same stratum of a red colour under the terrace; and *c* a repetition of it higher up, brownish green. Whether there was a fourth stratum above *c*, the quantity of brushwood and want of time prevented me from observing. That all these strata are one and the same, though they differ in hue, I have no doubt. When we become acquainted with the changeableness of this deposit within a space of a few yards, its different phases on the eastern declivity of Gi*d*ad Hill occasion no difficulty. Near Kátol, 40 miles N.W. from Nágpur, a similar appearance is presented. There a thick stratum of red clay lies at the foot of the hill, and we see its tendency to slope upwards and lean against the ascent; but we leave it behind, and come upon the amygdaloid, which emerges from under it. The amygdaloid is overlaid by a bed of red clay, which is surmounted by nodular trap constituting a terrace. Above this, before we reach the summit, we meet with a succession of amygdaloid, red clay, and nodular trap again. In ascending the ghat to Gawilga*d* Fort, which however is beyond the limits of our map, the same thing may be observed. The slope is so steep, that the road is carried in a winding direction up its face, and, although there are no terraces, yet, if I remember right, the traveller comes upon one deposit, which is there of a deep red clay as at Kátol, three or four times successively.

From the remarks now made it will be inferred, that the stratum in question is extremely varied. Not only is it of all colours and all mixtures of tints, but it is of all kinds of substance, and all forms of structure. At one place it is calcareous, at another siliceous, at a third clayey, and at a fourth a compound of all three. Here it is soft, and there indurated ; frequently the upper layer, which is next the overlying trap, is hardened, while the lower part remains unchanged. Here it is crystalline, there cherty, and elsewhere scoriaceous. In one spot it is full of fossils, in another and neighbouring locality it is utterly devoid of all traces of ancient life. In one part of a hill we see it six feet thick, but as we follow its line along the face of the escarpment we may witness its reduction to little more than an inch. I know not one constant feature that is characteristic of it. In judging of its identity a very useful guide to follow is its position between the nodular trap above and the vesicular trap below; but even this, as we have seen, fails us on the outskirts of the formation. Extensive experience, that enables us to combine several criterions that would singly be insufficient, is here, as in so many other cases, the only sure help towards arriving at a correct decision.

The greatest depth of the underlying trap, from its lower part being generally concealed, it is impossible to ascertain. It is obvious that according to its greater or less development the plain rises into a gentle swell or increases to the dimensions of a hill. Near Tákli, at the spot where almost all the fruits have been discovered, it is only a few inches thick, and a few yards from that locality it thins out altogether; whereas at Sítábaldi Hill, where it is observed to rest on sandstone, it attains a thickness of 100 feet; and in hills where its superposition on the sedimentary rock cannot be seen it must be a great deal thicker.

I have been thus minute on the appearances exhibited by the overlying and underlying trap and the deposit enclosed by them, in order that we may have a clear idea of their relation to each other. The conclusions to be derived from my description I need scarcely indicate. It is quite evident, that before either of the volcanic rocks was poured out in our area there had been deposited on the sandstone a stratum which must have been at least six feet thick. Over this there was spread a molten mass of lava, which hardened the surface of the stratum, and itself cooled into a flat sheet of globular basalt about 20 feet thick. After a period of repose the internal fires again become active, and discharge another effusion, which insinuates itself between the sandstone and the superior deposit; and accumulating in some parts more than in others, through force of tension ruptures the superincumbent mass, tilting up the stratum and scattering the overlying trap, or raising both stratum and trap above the level of the plain, either leaves it a flat-topped hill, or with boiling surge pushes up its summit gradually or by fitful effort. In these convulsions, the more recent trap, where it has not tilted up the deposit altogether, has generally encroached upon it, entangling some of its fragments, converting the greater portion of it into a crumbling vesicular rock, or producing miniature outliers of amygdaloid from materials susceptible of the change.

[*Fossils.*—As the detailed description of the fossils of this Tertiary formation and of the older Sandstone series will form the subject of Part II. of this Memoir, and be published hereafter, the fossils of the fresh-water deposit are here merely referred to in short.

From the collections made by Messrs. Hislop and Hunter and their friends from this deposit*, the authors mention the following organic remains:—

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.	Melania.	Limnæus.
Succinea.	Paludina.	Unio.
Physa.	Valvata.	

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 6 feet in girth.
——, endogenous.
Roots, six or seven kinds.
Chara, seed-vessels.

In concluding his notice of the Tertiary insects and plants, Mr. Hunter observes:—

Before quitting this part of the subject, it may be observed, that it would not be difficult to conceive with some degree of accuracy the nature of the locality in which the fruits grew. Going back to the tertiary epoch, we find Tákli part of a lake, extensive enough to be bounded at least on the west and south, and probably on all sides, by the horizon. We assume rather than can demonstrate the existence of islands, which break the uniformity of the sea-like expanse of waters. On the higher land of these are forests, mainly of exogenous trees, some approaching 6 feet in girth. More scattered, but yet sufficiently numerous to attract notice, are palms, exhibiting

* An extensive series of organic remains and of rock-specimens from the superficial deposits, the tertiary beds, the fossiliferous sandstone and shales, and from the crystalline rocks, has been presented to the Society by the Authors of this memoir. The fossils, however, have not yet been ully worked out.—Ed.

on their stems, when closely examined, protuberances of aërial roots, similar to those so frequently observed on the Wild Date of India. In the more shady valleys are leguminous and other plants, in great variety and profusion; and there may be seen occasionally climbing by numerous tendrils over the bushes, a cucurbitaceous plant allied to the *Luffa*, its tender stalk weighed down by a ponderous and probably 10-angled fruit. The *Nipadites* here and there fringes the marshy shores; and wherever the water is shallow there rise above it the reedy peduncles of Aroid plants, terminated at one season of the year by spikes of flowers, and at another either by long succulent purple fruit, resembling mulberries, or by large pericarps, that without minute examination might be mistaken for cones.]

Age of the Freshwater Deposit.—It has already been shown by my esteemed colleague, in his concluding observations on the tertiary plants (see above), that the body of water in which the strata containing the above-enumerated fossils were deposited must have been a lake. I shall now inquire at what period that lake existed. The determination of this question is attended with peculiar difficulties. In a temperate climate like Britain, the discovery of a large number of organisms fitted for a tropical abode at once demonstrates that the rock in which they occur cannot have been deposited subsequently to a remote tertiary period. Here, however, where we have a tropical heat at the present day, the evidence derived from such a source is much more equivocal.

Still I think there are sufficient dissimilarities between our recent and fossil floras to prove the great antiquity of the latter. While there is a general resemblance between the two, inasmuch as *Hedysareæ*, *Cassia*, *Luffa*, and *Nipa* are comprehended in both, there may be remarked on the other hand the total extinction of two genera, if not an order of endogenous plants, that once flourished luxuriantly here,—I refer to the mulberry-like and strobiliform fruits, which, though formerly so abundant, have at present no representative either in India, or so far as I know, throughout the world. We must therefore direct our thoughts to some period comparatively remote, when there was a greater uniformity of temperature over all parts of the earth. Of the more ancient tertiary floras, none corresponds with ours so well as that of the London Clay of Sheppey and Belgium. In both of these localities we find *Nipadites*, and in the former also the *Xylinosprionites* and *Tricarpellites* of Bowerbank, fruits apparently allied to those found at Nágpur.

Of all the animal remains we have collected, scarcely one seems to be identical with forms now existing on the surface of the globe. The nearest approximation to specific identity is in one of the *Cyprides*, and in the minute discoid *Valvata*; but whether the identity is complete, I am not competent to say. Supposing, however, that it were proved to be so, this fact would merely show that of all the living tribes inhabiting the waters, or the margin of our old-world lake, not one has survived in India, except a single species of *Cypris*, for the *Valvata minuta* is not now found here, nor indeed does any species of that genus appear to occur throughout Asia. But with these most diminutive exceptions, if exceptions they are to be called, the statement holds good that between our ancient and our modern fauna the agreement is not closer than generic. In the class of fishes, the resemblance even to that extent is true only of one order,—the Cycloidans; while the other order, the Ganoidans, which have left their horny and bony scales so abundantly in our rocks, have entirely disappeared from our rivers and tanks. Of the class Mollusca, while the genera *Planorbis* and *Ampullaria*, now so common in our pools, are altogether absent from this deposit, *Valvata* and *Physa*, so extensively represented in it, both in species and individuals, have disappeared from the plains of Central and Southern India. Of the six genera *Melania*, *Paludina*, *Limnæus*, *Bulimus*, *Succinea*, and *Unio*, which are common to both ancient and modern India, the differences between the recent and fossil species, especially in the *Paludina* and *Limnæus*, are very great. Of the former, we have nothing at all so large as the *P. Bengalensis* of the East, or even the *P. vivipara* of Britain. In the latter genus, none of our species appear to have belonged to the inflated type, but they are generally more on the model of the *L. glaber*, than that of the *L. stagnalis* of our native country.

Combining then these facts, on the one hand we have the total dissimilarity between every species of our ancient and modern plants, —the disappearance from our flora of several genera, if not of something higher—the difference in prevailing type between some of our fossil and existing genera of molluscs, and the removal of others entirely from our continents to regions most remote,—and lastly, a still more decided transference among the orders of our fishes,—data, which all point to the negative conclusion, that it is no newer tertiary that can be compared with our freshwater deposit. On the other hand we find generically, specifically, and individually an equality, to say the least, between our Ganoid and Cycloid fishes, and a resemblance between our flora and that of the London Clay,—proofs which, in my opinion, lead us on to the positive inference that among older tertiaries the eocene formation is that with which our freshwater deposit must be classed. Bronn, I perceive, assigned it to the era of the continental molasse. Whether or not the statements above made will be sufficient to show that this view is incorrect, it is not for me to say; at all events, the fossils, which we have contributed, will enable others to decide.

Extent of the Freshwater Formation.—The extent of this tertiary freshwater formation throughout India is very great. In Capt. Sherwill's recently published Geological Map we find it laid down on the west of Rajmahal on the Ganges. Following the same parallel of latitude, we come to Rae near Narwar, about forty miles south of Gwaliur, whence specimens of *Physa* were obtained by Mr. Fraser, formerly Agent to the Governor General in the Ságar and Narbaddá territories. At Ságar itself organic remains were first discovered by Col. Sleeman, afterwards described by Dr. Spry, and more recently investigated by Capt. W. T. Nicholls of 24th Regt. M.N.I. East of Jabbalpur, in the same territories, occur the sites Suleya, where Dr. Spilsbury procured *Physa* in 1833, Dhunra in the same vicinity, Narayanpur near Sohajpur, Mandla, and Phulságar, on the north bank of the Narbaddá, and as far up the river as Mohtura and Domadadar, in the Ramga*d* Raja's country,—at all of which localities the same indefatigable and successful geologist found shells, including an abundance of *Physa*, several specimens of *Unio*, and, if I may judge from the figures, of *Limnæus* and *Valvata*. None of them, however, are named*. North of the Narbaddá, near Mandla, univalve and bivalve shells abound in the marls and earthy limestone, as we learn from Capt. Dangerfield, who styles them "Buccinum and a species of Mussel" (*Physa* and *Unio*?)†. Leaving the Narbaddá, and coming to the Tapti, near its source, we find that Voysey, as has been mentioned by Malcolmson, in his memoir on this deposit, discovered shells, which he named "Conus and Voluta" (two forms of *Physa*?), at Jirpa and Jillan, which lie apparently on the north of the Gawilga*d* range‡. On the S. of the same chain of hills near Elichpur, are Muktagiri and Bairam, whence Dr. Bradley procured the excellent specimens of *Physa* and *Unio*, which I had the pleasure of sending to the Geological Society. Returning to Jirpa, we enter the district of Betúl, about 100 miles N.W. of Nágpur, which was explored by Capt. Ousley, who found shells at Chichundra and Murkha on the E. of the town, at Bharkáwá*d*á, Bheiawa*d*a and Jawará on the S., and at Badori, Kolgau, Gaikhám and Bakur, on the S.W. Passing over the localities within the State of Nágpur, to which sufficient reference has been made in the previous part of this paper, we arrive at the district north of Hyderabad, where, I am informed by a friend, *Physæ* have been extracted from one of the banks of the Godáveri at Nándur, and where also fossils were discovered near Hatnúr and Manúr by Malcolmson, and at Medkondá, Shiwalingapá, and Deglur by Voysey, who as early as 1819, when organic remains were almost unknown in India, met at these localities with shells, including, as he thought, "Turbo, Cyclostoma, Buccinum, Helix, and Turritella," some of which may be identified as *Physa* and *Valvata*. Not far from Deglur, on the S. side of the Manjará, Capt. Newbold obtained specimens of *Physa* at Munapilli§, and again from between Kulkonda and Digái, on the banks of the Bhima, he was presented with specimens of *Paludina deccanensis* by Capt. Windham. These are all the fossiliferous localities for our tertiary formation with which I have become acquainted, with the exception of Bombay, and Padpangali near Rajamundry, afterwards to be more particularly noticed. But besides these, there are many places where the same deposit occurs destitute of organic remains. For example, my friend Mr. Hunter and myself, on a mission tour, traced it almost without interruption from the vicinity of Nágpur, where the fossils cease, westward to Elichpur, a distance of 100 miles and upwards; and, while the material of the rock was sometimes a whitish lime, and at others

* Bengal As. Soc. Journ. vol. viii p. 708.
† Malcolmson's Central India, vol. ii. p. 329.
‡ Trans. Geol. Soc. 2nd ser. vol. v. pp. 570–1.
§ Bengal As. Soc. Journ. vol. xiii. p. 987.

a green or a red clay, we were uniformly unsuccessful in finding in it any kind of fossils. Similar differences are exhibited in the unfossiliferous stratum around Shiwani. At Garhákotá near Ságar, thence to Tendukheda on the Narbaddá, wherever Major Franklin met with trap, he "always found it in association with earthy limestone*." The experience of Capt. Dangerfield regarding its position was somewhat different, he having met with it in certain parts of Malwa, as "a thin bed of loose marl, or coarse earthy limestone," "near the bottom of the small hills and banks of the rivulets†." The country between the Wardhá and the trap region described by Col. Sykes has not been examined by any geologist, so that no site can be named in it for lacustrine formation except Jálná; but I remember noticing it on my first arrival in India, nine years ago, at many localities, though I have now forgotten their names. But when we come to the scene of Col. Sykes's efficient labours‡, we can trace it almost everywhere under the name either of "ferruginous clay," or "pulverulent limestone." The stratum of "red ochreous rock," varying in thickness from an inch to many feet, and in texture from friable to compact earthy jasper, occurs at Nandur and Jihur near Ahmednagar; at Kothul; in the scarps of the hill part of Harichandarga*d*, and a mountain near Junir; and at Sirur, Wángi, and Barloni, between which two last-mentioned places the bed is believed to be continuous. Finally it occurs abundantly on the Ghats, frequently discolouring the rivulets, and giving a ferruginous character to the soil, over a considerable area§. Pulverulent limestone is generally found in layers, varying from an inch to three feet in thickness, and covered by a few feet of black earth. Examples of it are met with at Jib and Islampur near Ahmednagar; at Karkamb and at Salseh, ten miles S. of the fortress of Karmali‖. Crystalline limestone, which occurs as an imbedded mineral in amygdaloid¶, and "great masses of mesotype**," which are found in a similar position, seem to me, if I may judge from the analogy of the district of Nágpur, to be instances of our formation somewhat transformed. The ochreous rock or ferruginous clay above mentioned was discovered by Newbold at Sindaghi, in the Southern Marátha country, which lies south of Col. Sykes's district, and it was described by him as "finely laminated bright red bole," from 3 to 6 feet thick††. And this is most probably the origin of the "red clay," which Newbold on analysis found to be the basis of the amygdaloid in which zeolitic crystals abound‡‡.

The strata of Bombay have been described in an able and luminous manner by H. J. Carter, Esq., of the Bombay Medical Service§§. In thickness they greatly surpass anything we meet with in Central India, reaching to between 40 and 50 feet, and they are peculiar in

* As. Researches, vol. xviii. pl. 1. p. 33.

† Malcolmson, vol. ii. p. 328.

‡ Geol. Trans. 2nd ser. vol. iv.

§ *Ibid.* p. 419.

‖ *Ibid.* p. 420.

¶ *Ibid.* p. 421.

** *Ibid.* p. 425.

†† Royal As. Soc. Journ. vol. ix. p. 33.

‡‡ *Ibid.* p. 35.

§§ Bomb. Br. R. As. Soc. Journ. vol. iv.

having a little carbonaceous matter covering some of the vegetable remains. The fossils themselves, however, whether animal or vegetable, bear a remarkable resemblance to those which have been brought to light at Nágpur. Thus we find among them a fresh-water tortoise,—the elytra of insects,—an abundance of *Cyprides*, one species of which appears to correspond with the *C. cylindrica* (Sow.), first found by Malcolmson,—a few indistinct impressions of shells like *Melania*,—fruits and seeds, though not of the same genera as ours,—ensiform endogenous leaves, like the Nágpur specimens,—cormiform roots, which differ from ours only in being larger,—and an abundance of dicotyledonous wood.

At Pádpangali or Pangádi near Rajamundry, not far from the mouth of the Godávari, there are found some outlying trap hills, which Gen. Cullen pointed out to Dr. Benza as fossiliferous. That gentleman visited the place, and described one of the eminences as consisting at its base of sandstone, which is overlaid by amygdaloid veined with jasper, then a limestone deposit with fossils, and finally a sheet of basalt. The fossils were stated by Dr. Benza to be partly marine, and partly freshwater; but, as his statement was made at a time when not much attention was paid to the distinction between these two classes of shells, it was supposed that it might be incorrect. I confess that I myself was guilty of this wrong to the memory of an able geologist. However, I took steps to discover the truth, and through my friend Lieut. Stoddart, employed in connection with the Godávari public works, I have ascertained, I am happy to say, that Dr. Benza is substantially right. His Oysters were real oysters, though his "Ampullariæ" most probably belonged to some species of *Physa*. "On only one of these hills," says my intelligent informant, "could I find any Oysters; but there, I must say, they were as plentiful as stones." At the foot of a hill opposite to this, Mr. Stoddart found several kinds of shells, and among them a *Physa* identical with a species common around Nágpur, which was in the same block with a *Chemnitzia*. There seems to be a great variety of molluscous remains at this locality, and it would well deserve a longer investigation than my kind friend was able to give it *.

Here then we have the best proof which similarity of position and specific identity of contained fossils can afford, that the deposit enclosed in trap at Pádpangali is properly contemporaneous with our freshwater deposit in Central India, although a majority of its organisms are truly marine. It is evident that it was here our great collection of fresh water, stretching either in one continuous sheet or interruptedly a distance of 1050 miles, in a direct line from Rajmahal to Bombay, and of 660 miles from N. to the neighbourhood of Pádpangali, discharged itself by an estuary into the sea. Whether this great expanse of freshwater was one or many lakes, cannot now be determined, in consequence of the disappearance of trap from many situations where once it must have existed, but I am persuaded that the more careful the exploration made in the great basaltic region

* A small series of fossils from Pádapangali sent by the authors comprises *Ostrea*, *Cardium*, *Venus*, *Chemnitzia*, and *Nerinæa*?—Ed.

of Western India, the more evident it will become that the intervals between the lakes, if any there were, must have been exceedingly small. This was the conviction left on my mind by travelling from Nágpur to Elichpur, and this I think will be the feeling produced in the mind of any one, by taking a glance on a map at any district, like Col. Sykes's, that has been surveyed, even without a reference to a lacustrine deposit.

Minerals in the Trap.—I ought now to describe the minerals contained in our overlying and underlying trap; but this has been so well done by Voysey, in his remarks on the structure of Sítábaldi Hill*, that it is unnecessary. One of the most common in the locality just named, though elsewhere rare, is a pitchy black substance, with a sloe-like bloom upon it, lining the amygdaloidal cavities. This Voysey appears to have called "Conchoidal augite:" my friend Dr. Carter supposes it obsidian. It occurs in bands lying one above another, which may be followed to a great distance in a horizontal direction. The intermediate spaces seem as if they had been successive effluxes of volcanic matter, running along beneath the freshwater deposit, and then under one another, each efflux being united or welded to the preceding one by a vesicular belt. Many of the minerals that are met with in the amygdaloid are derived from the tertiary strata. This is particularly the case with jasper, the veins of which, as may be learned from Benza's description of Pádpangali Hill, and as we perceive in numerous places in this vicinity, are situated just at the zone of the vesicular trap's intrusion on the superior deposit. Sometimes instead of being jaspidified, the entangled parts of the strata are converted into chert, at other times they are crystallized into ponderous masses of mesotype. In one locality the calcareous matter is diffused as strings all through the amygdaloid, forming seams of kankar, like those represented by Newbold†; in another they are scarcely enclosed within its substance, but remain in blocks at the lower part of the deposit, which are compact externally, but in the interior, where the heat has continued longest, are found to be an aggregation of crystals.

On the plain south of Gi*dad* Hill there is lying about a great abundance of spherical nodules, which on being broken up exhibit a structure radiating from a central point, so that they have been mistaken for *Alcyonites*‡. The fakirs, who have located themselves on the top of the eminence, have adroitly taken advantage of this natural phænomenon to exalt the name of the saint whose disciples they profess to be. These nodules, according to them, are so many fruits and spices of different sorts, which Shek Faríd converted into stone, the largest having once been cocoa-nuts, the middle-sized betel-nuts (*Areca*), and the smallest nutmegs. There is a resemblance of the nodules to the last two natural productions; but, as all alike display an acicular crystallization, it is difficult to trace the similarity of the largest to the fruit of the cocoa. Much light must be intro-

* As. Res. vol. xviii. p. 123.
† R. As. Soc. Journ. vol. ix. p. 33.
‡ Journ. Beng. Asiat. Soc. vol. ix. p. 625.

duced into this land before the inhabitants shall be convinced of the falsehood of the alleged miracle, and shall be able to understand that the seeming organisms are simple zeolitic concretions that have issued from the soft subjacent rock. Nodules of the same shape are found in the same formation at Sonegaum, near Kalmeshwar, fifteen miles N.W. of Nágpur, but, being purely calcareous, their interior consists of a confused mass of rhombic crystals.

The Age of the Trap.—Beginning with the more recent, as we have done in regard to the stratified rocks, we find that the amygdaloid or underlying trap has not only invaded the tertiary formation, but broken it up, and along with it the nodular basalt, by which it is capped. The amygdaloid eruption, then, is incontestably subsequent to the basaltic. But what age is to be assigned to the latter? It is evidently posterior to the freshwater beds on which it rests. We have thus an overlying effusion of nodular basalt, which has taken place after the tertiary strata, and an underlying intrusion of amygdaloidal trap, which has occurred after the basaltic effusion. Besides these two formations of trap, I know of no others in Central India, either more modern or more ancient. Capt. now Col. Grant, in his paper on the Geology of Cutch*, and Dr. Carter, in his memoir on the Geology of Bombay before quoted, have adduced ample proofs to show that in the districts which they have examined, there have been eruptions of volcanic matter subsequent to the amygdaloid; but in all the district through which my colleague and myself have been called to travel, no trap formation so modern has fallen under our observation. Nor has any more ancient than the overlying trap been discovered. It might be thought from the occurrence of isolated pieces of trap in the lower part of our freshwater strata, that while these were being deposited, there were sheets of volcanic rock already on the surface of Central India. But it appears to me that there are no such fragments whose existence may not be accounted for on the principle explained by Lyell in his 'Manual,' 4th edition, p. 446, and stated in a preceding page of this paper. Besides at Bokára, and some parts of Tákli plain, where the amygdaloid has not been intercalated under our tertiary formation at all, but where the latter, with its characteristic fossils, rests immediately and conformably on the sandstone, there is not a trace of volcanic matter to be seen. I am inclined therefore to doubt the occurrence of any trap in Central India older than our lacustrine deposit. In the southern portion of the Rajmahal Hills, M'Clelland† informs us that amygdaloid is found underlying the coal-strata of that district. The coal there is manifestly the usual so-called oolitic coal of India, and therefore we have amygdaloid disturbing the jurassic formation. But, if a stranger to the locality may be allowed to express an opinion, I would respectfully submit that the position of the amygdaloid is not conclusive against its comparatively modern origin. It is obvious that the most recent age attributable to an intruded rock, such as it is, cannot be exactly determined by ob-

* Trans. Geol. Soc. 2nd Ser. vol. v.

† Report Geol. Survey of India, Season 1848–9. Calcutta 1850.

serving what strata it has disturbed in one district; for it may have invaded an older formation in one locality, and yet, rising higher, it may have broken in upon a newer formation in another place; or, applying the principle to the case in hand, the very same amygdaloid which M'Clelland calls secondary trap, because it has been erupted among the oolitic strata of Rajmahal, may be tertiary trap here, if it is, as I believe, the identical effusion which has been intercalated between the oolitic and tertiary formations of Nágpur. But for the conclusive determination of this question, the district of Rajmahal with a tertiary formation found in connection with trap in its northern part, and jurassic strata associated with trap in its southern part, presents the most befitting arena.

Mode of its Eruption.—Before leaving the volcanic rocks, it is desirable to indicate the lessons which Central India teaches as to the manner in which they were formed. Now the first thing which strikes any observer of the great basaltic field of this country is the comparative absence of all cones or craters throughout. I cannot name a spot in all the tract with which I am acquainted, where I could say either the nodular basalt or the amygdaloid came up from below. The nodular basalt seems to have flowed along for immense distances, filling up the tertiary lake, and leaving an arid plain in its rear. Then the amygdaloid inserting itself between the sandstone and the freshwater bed seems to have flowed generally underground on the same scale of grandeur. Sítábaldi Hill, which is almost an outlier of the great basaltic region of Western India, being connected with it by a very narrow neck, would be a favourable place for ascertaining whether the underlying trap, which has there accumulated under the tertiary deposit to a considerable thickness, has been forced up vertically through the gneiss and sandstone, which appear around the base of the hill to be inferior to it, or whether it has been horizontally intercalated, as in the generality of places, between the sandstone and the tertiary. I am disposed to take the latter view; but, if the government quarry were only excavated a few feet lower, as Voysey long ago suggested, it would put an end to all doubt.

From the statements previously advanced regarding the trappean rocks of Nágpur, taken in connection with the same formation in other parts of the country, it is obvious there is no foundation whatever for the supposition that the great outpouring of basalt in India took place in the ocean. And, although I believe that the fresh-water in which it really was effused must have stretched over great areas without much interruption, yet the discovery in the tertiary strata of abundance of pulmoniferous molluscs, such as *Limnæus* and *Physa*,—of plants, such as marsh- or shallow-loving Endogens, buried with their roots and fruits almost entire and therefore not far from the spot where they originally grew,—not to mention the occurrence of an amphibious univalve like *Succinea*, and of land-shells like *Bulimus*, together with great quantities of seeds and fruit and timber, the spoils of the neighbouring dry land,—plainly shows that the water in that part of the lake was of no great depth. Indeed it seems obvious that in places not a few the water of the lake must have been so shallow as to allow the igneous rock which was poured out over its bottom to rise above its surface into the atmosphere. We must resort then to some other hypothesis than aqueous pressure to explain the horizontalness of our trappean-hill tops, and a cause adequate to the effect is the well-known law by which the surface of liquid bodies is reduced to the same uniform level. To this law volcanic matter is subject in spreading over an area either of land or water. If to this it be objected, that then we should expect the surface of the effusion to appear scoriaceous like modern lavas, it may be replied that naturally all such light materials in the lapse of ages would be worn away.

VII. *The Sandstone Formation.*

Under the amygdaloid, or, where it has not been intercalated, immediately under the tertiary freshwater strata, is found an extensive series of rocks consisting chiefly of arenaceous beds.

A. The upper member of this series is seen at the foot of Sítábaldi Hill, passing into gneiss, into which much of it, as well as most probably all the lower members, have been converted. Without enumerating all its localities, I may mention that a good section of it is presented by a rivulet skirting the Lal Bág, where the layer under the nodular trap has itself been rendered distinctly nodular. It may be observed in the western division of the city of Nágpur; and it stretches in some places under the amygdaloid, in others under the tertiary bed, but for the most part as the surface-rock, through Tákli plain to Bokhárá. At Nágpur and in Tákli plain the strata are of friable sand intermixed with kankar, and variegated with a deep irony-red and occasionally a purple colour. But it is at Bokhárá where we can understand it best. In one of the quarries there we find it as at Nágpur, only with less of the colouring matter. Going northward to another quarry, we see it on the way overlaid by the lacustrine formation before described, which is capped by a small rise of nodular trap. Arrived at the quarry, which is only about 100 yards from the first, we find the same upper member of the sandstone, now however no longer soft and crumbling, but so hard that the hand-millstones of the country, which resemble Scottish *querns*, are derived from it; and the ferruginous matter, instead of being diffused as blotches, is gathered into waving iron-bands more indurated still. At this place these upper beds, which are about 25 feet thick and very coarse, contain angular fragments of a finer sandstone which lies below. Near Bazargau the strata where exposed are pierced with irregular holes, which seem to have been caused by the action of rain and the atmosphere. At Kámpti, situated towards their top, and rising even to the surface through the soil, are imbedded huge blocks, some of them angular, but most of them rounded and waterworn, which contain almost all the fossils that have been procured from that interesting locality. At Silewá*d*á, towards their lower part there occur a considerable number of compressed stems of trees *in situ*, one of which, presenting its thin edge in the side of a quarry, may be traced for about 20 feet. A few inches farther down we come to the largest of the iron-bands, which consists of a conglomerate, about 6 inches thick, enclosing fragments of dicotyledonous wood converted into a kind of jet and impregnated with iron. Ferruginous bands are common not only at Silewá*d*á, but also at Bábulkhe*d*á and Tondakheiri. It is only, however, in the neighbourhood of Chándá that any one of them has been found to contain wood in a silicified state.

B. Underlying the iron-band we come to layers of a much finer kind, consisting of argillaceous sandstone, varying from white to yellow and pink, and generally containing specks of mica. These strata, which are used for pavement and carved work, extend downwards for about 15 feet, when they gradually become coarser until they are suitable for millstones. The entire depth of these layers after their change from fine to coarse has not been ascertained. Dispersed through them, as we saw was the case with the upper member, are occasional angular fragments, so that it is difficult to distinguish lithologically between the two, except that the inferior beds always contain less oxide of iron than the superior.

It is in the argillo-arenaceous strata that we have met with nearly all the fossils which the sandstone of Silewá*d*á, Bokhárá, Bábulkhe*d*á, Bharatwá*d*á, Tondakheiri, Bazargau, Chorkheiri, and Chándá has yielded; and there is every reason to believe that the imbedded blocks of Kámpti also, which have furnished so many vegetable remains, were originally derived from them.

Chorkheiri and Chándá are the furthest limits north and south from which I have procured fossils of the inferior member of the sandstone; and the fact, that the fossils are exactly the same, in addition to a resemblance in lithological characters, demonstrates that the strata are so also.

Between these two extreme points, however, under an outcrop of coarse sandstone of much the same character as the generality of our upper beds, except that it is not coloured by iron or pervaded by iron-bands, there are found at Mángali and its neighbourhood fossiliferous strata applied to the same architectual purposes as our ordinary lower strata, though they differ from them in being of a deep-red colour, finer and more sectile, and with a larger admixture of clay and mica. As the Mángali red slaty sandstone contains scarcely any organic remains common to the inferior layers about Nágpur, it is not without hesitation that I include it under the present head, and arrange its fossils along with those of the more typical strata.

[*Fossils of* B.—For the same reasons as stated above, p. 360, in the case of the palæontology of the tertiary deposits, the numerous fossils of this division of the sandstone series are here merely mentioned in short, their detailed description being deferred until the publication of Part II. of this Memoir.

These fine and coarse argillaceous sandstones, rich with plant-remains, have afforded,—

Labyrinthodont Reptile* (from Mángali).
Fishes ; Small jaws and ganoid scales.
Crustaceans ; *Estheria.*
Plant-remains.
Fruit and seeds ; numerous and undescribed.
Leaves ; Conifer, Zamites, Poacites, and Ferns (*Pecopteris, Glossopteris, Tæniopteris, Cyclopteris, Sphenopteris*).
Stems ; exogenous and endogenous.
Acrogens ; *Aphyllum, Equisetites, Phyllotheca, Vertebraria.*]

C. Between the sandstone quarries at Bokhárá and Korhádi, granitic rocks have lifted to the surface, with a dip of 30° to S.W., a series of red shaly beds ; and between these and Bokhárá another species of green argillaceous strata, lying somewhat more horizontal. The relation of these two to the sandstone beds, from the absence of any good exposure, I have not been able to ascertain ; but they would appear to underlie it. Besides the locality now named, these rocks are developed in the district north of Chándá ; and, as I have been told by Mr. Sankey, the green shale covers an extensive tract of country near Hardaga*d*, south of the Mahádewa Hills. It is probably the same strata that are found to lie on the west and north of the Nawagaum Lake, and to cross the Ráyepur road at Mundipár Ghát and at Jamnápur, near Sákorali. The red shale at Korhádi has yielded the following organic remains :—

Fossils of C.—A reptilian footmark of one-third of an inch long, and as much broad. Three or four specimens have been obtained, each exhibiting only one print, owing to the brittleness of the matrix. I am not sure that all the impressions are of the same kind.

On the same specimens that bear these footmarks are seen the tracks of wormlike animals. That the animals forming these tracks have been Annelids resembling Earth-worms will be evident to any one who considers the appearance of the furrows ; the way in which the head has occasionally been pushed forward, and then withdrawn ; the tubular holes by which the ground has been pierced, and the intestine-shaped evacuations which have been left on the surface. Fossil worm-borings have been found in the green shale of Tadá*d*i, N.W. of Chándá, seventy miles S. of Nágpur.

The only vegetable organism which has been discovered in the shale is a sulcated plant, which most probably belongs to the genus *Phyllotheca* ; but as a sufficient length of the stem has not been obtained to display the articulation, its precise character cannot be fixed.

D. Immediately below the red shale there are found beds of white marble at Korhádi, which have been greatly disturbed and dolomitized by the plutonic rocks above referred to. Similar strata, but pink and blue, occur in the channel of the Pech at Gokala, a little above Parshiwani ; and still higher up at Nawagaum it rises into a chain of eminences, which runs thence westward to Kumári. Following up the river still further, on its right bank we come to a patch of

* The *Brachyops laticeps*, Owen ; see Quart. Journ. Geol. Soc. vol. x. p. 474 ; and xi. p. 37, pl. 2.

the same crystalline limestone at Dudhgaum, where it is in the vicinity of trap. To the east of this, at A'mbájiri in Chándpur, it occurs again: but there, as in most of its other localities, the granite rises to the surface in the neighbourhood. Limestone is found also on the Lánji Hills at Kunde and near Bhánpur to the east of Hattá; but whether it is the limestone associated with sandstone, or just a calcareous phase of our freshwater tertiary formation, from not having visited the spot, I am unable to decide. It seems to be comparatively free from magnesia, in which it differs from the generality of the strata of which we are now treating. From the heat to which these have everywhere in our area been subjected in the process of dolomitization, we need not expect to discover in them any organic remains. Newbold thought that he had found in certain cherty veins of limestone near Karnúl myriads of spherical Foraminifera. We have also veins of chert in the Korhádi limestone, which exhibit appearances that might be mistaken for the same objects, but they do not seem to be really organic. The minerals most abundant in the dolomite are tremolite and red and yellow steatite, which last, when the surface of the rock is weathered, stands out in little prominences, as if it were a species of lichen.

The whole series of strata which we have designated by A, B, C, D we conceive to be only subdivisions of the same formation. They have been disturbed by the same granitic eruptions, and, where fossiliferous, bear a general resemblance to each other in their organic remains. But this mutual connection is more apparent when we compare the series within our area with strata beyond it. From Mr. Sankey we learn that the sandstone represented in the north-west corner of our map is succeeded in a descending order at Chotá Barkoi by bituminous shale with fossils and sandstone, and at Bhuwan, at the foot of the ascent to one of the Mahádewa or Pachma*d*i Hills, by indurated green clay-stone and green shale, and bituminous shale with fossils. Again below the sandstone in the south-east corner of the map, as we are informed by Dr. Bell, there occur argillaceous limestone, bituminous shale with fossils, and a few alternating layers of impure limestone and bituminous shale, until we come to a bed, eight feet thick, of laminated sandstone, &c. Situated, as our sandstone is, between these two extreme points, and appearing to be a bond of connection between them, we might *à priori* expect that the intermediate beds would be of the same age as those at the localities on either side; and this opinion is confirmed by the appearance of the sandstone near Nágpur, which shares with the sandstones of the Mahádewa and Kotá hills, the distinguishing feature, first noticed in this neighbourhood, of being pervaded by ferruginous septa. These dark-brown stripes, which in all their hardness protrude from the weathered surface of the enclosing rock, will be found, wherever they occur, a very good criterion for judging of the age of the sandstone. But besides identity in the arenaceous beds of our whole district, we can trace the same identity between the subjacent strata at Nágpur, Pachma*d*i, and in the Hyderabad country. On the south of the Mahádewa Hills there is the same green shale as here and at Tadá*d*i; and at Kotá, according to a private letter with which I was favoured by (the late) Dr. Bell, red clay, of greater thickness than any stratum that was passed through, underlies the other shales which he has enumerated in his sections*: and in localities farther south, Malcolmson states† that the shales on which the sandstone rests are blue, red, green, or pure white; by which last-mentioned rather rare colour we are brought in mind of some of the strata at Mundipár. And as we are told by Newbold‡, the sandstone of the Eastern Ghats frequently "passes into red and green argillaceous and siliceous slates and laminated marls." I think then, that, though inferring the identity of Nágpur sandstone with that of Southern India from the occurrence of diamonds at Weiraga*d*, Malcolmson's statement was wrong as to its grounds, yet it was perfectly correct as to its matter. The position of the shale in reference to the limestone seems to vary. At Korhádi it is the superior rock. Such also is its position at Bángnápilli according to Malcolmson§, and generally according to Newbold. In a section, however, of the Pass at Mudalaity, given by the latter writer, we have the following order: "compact light-coloured sandstone, 120 feet; limestone, 310 feet; shales, 50 feet; laminar and massive sandstone;—whereas by the section obtained by Dr. Bell‖ we find sandstone, from 50 to 500 feet, —argillaceous limestone, 9 feet,—and, after various unimportant argillaceous, bituminous, and calcareous strata, in all 4 feet, limestone, 1 ft. 9 in., laminated sandstone and shale, 8 feet, and argillaceous &c. strata as before, 11 feet 8 inches, we come to limestone, 23 feet, then argillaceous and calcareous beds, 25 feet, red clay, 27 feet, and limestone." Here it would appear that shale, sandstone, and limestone are interstratified.

Though there is no great development of carbonaceous beds in the district which is the more immediate subject of this paper, yet I should regard the communication as incomplete without some notice of the position of the Indian coal in reference to our sandstone strata. Bhuwan, in the north-west of our area, at the foot of the Mahádewa Hills, furnishes us with a common term of comparison.

[In the foregoing observations on the so-called Jurassic (or plant-bearing) formation of the Nágpur territory the authors recognize four members in the following descending order:—A. Thick-bedded, coarse, ferruginous sandstone, with a few stems of trees. B. Laminated sandstone, exceedingly rich in vegetable remains. C. Clay shales of various colours, and bearing worm-tracks and foot-marks. D. Limestone, generally altered and crystalline. At the time when this memoir was written, the authors thought it probable that the Bengal coal-deposits might be referable to the shales (C) of this series; but, having since had further opportunities of personal in-

* Quart. Journ. Geol. Soc. vol. viii. p. 232.
† Trans. Geol. Soc. 2nd ser. vol. v. p. 543.
‡ Journ. As. Society, vol. viii. p. 167.
§ Malcolmson *ut supra*, p. 541.
‖ See also Quart. Journ. Geol. Soc. vol. x. p. 374, and *note*.

vestigation, they find that the carboniferous beds of Umret and the Mahádewa Hills are true representatives of the Burdwan coal of Bengal, and are referable, not to the Nágpur shales (C), but to the Nágpur sandstone with plants (B). About six months since the authors were enabled to visit* the coal-bearing deposits at Umret and the plant-beds of Bhuwan at the foot of the Pachma*d*i or Mahádewa Hills, 120 miles north of Nágpur, some notice of which was given to the Society by Lieut. Sankey†. A few miles north of Umret there occurs a descending series of sandstone, coal, argillaceous, bituminous, and sandy shales, and sandstone. The shales here represent the plant-bearing sandstone of Nágpur. At the Mahádewa Hills the overlying sandstone (which, like that of Umret and of Nágpur, is characterized by iron-bands) is of much greater thickness than to the south. Under this sandstone of the Mahádewas come green shales and bituminous shales, equivalent to those of Umret. From the examination also of the fossil plants (*Vertebraria*, *Trizygia*, *Phyllotheca*, *Cyclopteris*, *Glossopteris*, *Pecopteris*, and *Sphenopteris*) plentifully occurring in all these localities, the same conclusion is arrived at, namely, that the shales of Umret and the Mahádewas are truly equivalent to the plant-bearing sandstone of Nágpur, which last, indeed, in some places has argillaceous modifications. The bituminous shales of Kotá, on the Pranhítá, appear to belong to the same series, and underlie the iron-banded sandstone, as in other localities. The Kotá shales have afforded fish-remains of a Jurassic type (*Lepidotus* and *Æchmodus*) ; and at one place, Mángali, between Kotá and Nágpur, the equivalent of the Nágpur plant-bearing sandstone has yielded the Labyrinthodont Reptilian skull, lately described in the Society's Journal by Prof. Owen. The extension of the bituminous and anthracitic shales in other localities, namely, Duntimnapilly, Singra, on the Bágin River, Umla Ghat, &c., is alluded to by the authors in their recent communication ; and they remark, that, on the south, north, and east of the Nágpur territory, the carboniferous shales are thus seen to hold the same relation with the overlying iron-banded sandstone ; and that, though it is difficult to comprehend the Burdwan coal-field in the comparison, as it lies in a basin and has no overlying formation, yet the fossils are very similar to those of the Mahádewas, Umret, and Nágpur, and bear evident proof of the contemporaneity of the whole.—July 1855.—Ed.]

Thickness of the Strata.—A. The highest beds as exposed in the quarries of Silewá*d*á and Bokhárá average about 25 feet of coarse sandstone with iron-bands ; below which there are 15 feet of argillaceous sandstone, B, with an abundance of fossils, and an undetermined depth of coarse sandstone beneath. These constitute what Dr. Carter, in an able 'Summary of Indian Geology,' which I have just received, calls the Panná sandstone. From outcrops of this subdivision of the sandstone series in other localities near Nágpur,

[* A notice of the results of this visit was read at the Meeting of the Society, June 13, 1855.]

[† Quart. Journ. Geol. Soc. vol. x. p. 55.]

the whole thickness of the highest beds may be reckoned at about 200 or 300 feet. At Kotá, as we have seen, it ranges from 50 to 500 feet, at Mudalaity 120 feet, and at the Mahádewa hills, according to Mr. Sankey, 2700 feet, which must be its greatest development. c. The depth of the shales at Korhádi and Tadá*d*i seems to be—green about 30 feet, red 50 feet. At Kotá, omitting interstratified argillaceous limestone and sandstone, all the argillaceous thin strata united amount to 29 feet, red clay 27; while at Newbold's section of Mudalaity, where the shales, usually reddish, underlie the limestone, they attain a thickness of 50 feet. d. The limestone which underlies the shale has been much disturbed by granite at Korhádi, so that we cannot fix its thickness precisely; but I should think it cannot be less than 100 feet—at Mudalaity it is 360 feet. Under this limestone, which is included in Dr. Carter's excellent paper, along with shales and coal under the name of Kattrá shales, there occurs, as Newbold has shown in Southern India, and Franklin in Bundelkhand, another series of sandstone rocks, for which Dr. Carter proposes the name of Tará sandstone; but, as most probably, owing to the intrusion of the granite, this member of the formation does not occur in our neighbourhood, I have nothing to say regarding it.

Character of the Formation.—There can be little doubt that the upper strata are lacustrine. The occurrence in them of such an immense collection of terrestrial vegetation, intermingled with *Poacites*, taken in connection with the total absence of Fucoids and other marine plants, shows very plainly that they must have been deposited in fresh water. And, as no river could have covered the extent of surface which these beds occupy, we are bound to conclude that, like the tertiary rock previously described, they must have been formed in a lake, a conclusion which the discovery of *Estheria* (or *Limnadia*), with their two valves entire, and congregated together as they are found in their usual haunts, fully justifies. Again the abundance of worm-tracks and borings in the red shale of Korhádi and the green shale of Tadá*d*i renders it more than probable that the strata at these localities constituted the margin of an ancient lake and not of a sea or even of a river. Of the origin of the dolomitic beds it is impossible to give any certain account, owing to the transformation which they have undergone, though we may suppose they follow the analogy of the other members of the formation. The character of the upper strata at Elichpur, as would appear from the fossils discovered by Dr. Bradley, is exactly the same as at Nágpur. The *Lepidotus* which has been found at Kotá, from its association with terrestrial vegetable remains, has been pronounced to have been probably an estuary or inshore fish; but, as the genus also occurs abundantly in the freshwater strata of the Wealden, it may be perceived that the strata at Kotá are not of a different origin from those in our neighbourhood. This supposition is rendered more likely by the fact, that, while no marine vegetation is said to have been detected there, a piece of the shale which Dr. Bell kindly sent me bears the impression of a bivalve exceedingly like a *Cyrena* or *Cyclas*. Dr.

M'Clelland seems to suppose that the Burdwan coal-measures were deposited in a sea, for in the last plate of his Survey already referred to he has figured a fossil which he has called *Fucoides venosus*; but any person who compares the plant there represented with the *Glossopteris* figured in his plate XV. under the name of *G. reticulata* will, I believe, agree with me in considering both plants generically, if not specifically, the same. I infer, therefore, that there is no evidence whatever to prove that our sandstone, or the shale at Kotá, or the Bengal coal-measures, were deposited in the sea; but on the contrary every reason to believe that they were all formed in a large body of fresh water.

Age of these Strata.—The coarse iron-banded sandstone above, and the more fissile strata lying conformably below, which are undoubtedly of one and the same era, require first to be considered. For the sake of clearness, however, I shall refer to the latter member alone, as it has afforded most of the fossils, and furnishes the best data for comparison with the rocks of other localities. Some of the seed-vessels which it has yielded bear no very distant resemblance to those of the Stonesfield slate; *Asterophyllites? lateralis,* to use the provisional name proposed by Bunbury, and the forms of *Pecopteris,* show its near connection with the carbonaceous shales and sandstones of Scarborough; *Phyllotheca, Glossopteris,* and the narrow fronds of *Cyclopteris,* if M'Coy's figure* be truly of that genus, mark out the relation to the coal-beds of New South Wales, while *Tæniopteris magnifolia,* and sulcated stems in all respects corresponding with *Phyllotheca,* testify to the agreement with the Virginian carboniferous strata. These coincidences, some of which, as in the so-called *Asterophyllites?* and *Tæniopteris magnifolia,* seem to amount even to specific identity, along with the remarkable relations which the distant localities exhibit among themselves, form a network of proof, which in my opinion binds down all the various series of rocks to about the same epoch,—an epoch which the known position of the Stonesfield and Scarborough strata show to be Lower Oolitic.

Whether the Mángali sandstone is to be reckoned contemporaneous with these,—whether the two different kinds of strata there—the coarse thick-bedded upper and the fine fissile lower—are to be reckoned the equivalents of our A and B, is a question which observation in the field and a comparison of the respective fossils do not enable me to answer. The massive sandstone at Mángali, as has been said, is destitute of iron-bands, and the inferior argillo-arenaceous strata are much redder than ours; and especially the organisms of the lower strata at the two places are very dissimilar. Here they are all vegetable, while there they are almost exclusively animal. Only one of the fossil plants at Mángali appears to us to bear a resemblance to anything found in this vicinity. At the same time, if any inference is to be derived from the succession of the rocks there, it is in favour of the idea that they are the counterparts of our A and B. And that they cannot in age be far removed from them, is proved by a comparison, not of the Mángali fossils with others in this

* An. Mag. Nat. Hist. vol. xx. pl. ix. fig. 3.

territory, but of both these with those across the Atlantic. Our investigations in the resemblances of the sandstone fossils show that the Nágpur fossiliferous strata are connected with the Richmond carboniferous formation by *Tæniopteris magnifolia*, while the Mángali fossiliferous strata are still more closely linked to it by the discovery of what appear to be *Aspidiaria*, *Knorria*, and the interesting groups of large and small *Limnadiadæ*. Here, then, we perceive that the lower beds at both of these Indian localities bear a relation to the Virginian coal-measures, characterized by an apparent specific identity of fossils; and, though the genera of which the species seem to be identical are not the same in both cases, yet it is obvious from the sort of *ex æquali* argument which we may be permitted to use, that these lower beds must stand pretty closely connected with each other. But I do not wish to push to an extreme reasoning on a point which the progress of investigation here may soon elucidate by finding the strata under consideration in juxtaposition. Meanwhile I consider myself warranted in asserting, that our Mángali rocks cannot at all events be older than the Jurassic, if under that term the Lias is also included. Indeed the head of the Labyrinthodont tends to communicate to them a Triassic aspect; but, if the Jurassic character of their abundant flora be taken as the real indication of the age of these rocks, we arrive at a conclusion which brings out the interesting fact, that the family of Labyrinthodonts, instead of being confined to the Coal and Trias, survived (in the East) until the period of the Lower Oolite.

Regarding the age of our shale C, which there is every reason to believe underlies the coarse and fine sandstones A and B, I have little to say more than that it cannot be much older than these. The occurrence of worm-tracks, as well as of faint traces of *Phyllotheca*, will not allow me to consider it anything but part of the same Jurassic formation. But as I have endeavoured to show that the coal-measures of Burdwan are equivalents of our plant-bearing beds, and therefore belong to the Lower Oolitic group, it will be necessary to make a few remarks to establish the correctness of this view.

On the age of the coal-measures of Bengal two opinions have been submitted to the public within the last four years:—one in 1850 by Dr. M'Clelland in his "Geological Survey," and the other in the course of the present year by Dr. J. Hooker in his interesting "Himalayan Journals*."

Dr. M'Clelland's sentiments, which in 1846 were very decided as to the true Palæozoic character of our Eastern coal†, seem to have remained the same at the period of his more recent publication on the subject; for we find him in his "Survey," while admitting the

[* This portion of the paragraph on the "Age of the Sandstone" has been remodelled since the reading of the Paper, so as to introduce the necessary references to the opinions published by Dr. J. D. Hooker in his most interesting work on the Himalayas.—June 14 and Sept. 6, 1854.]

† "There cannot, however, be a doubt as to its belonging to the true coal-formation, from the nature of the coal itself, as well as of the beds with which it is associated."—Secretary of the Calcutta Coal Committee on the Coal of the Great Tenasserim River, in Committee's Report, p. 138. Calcutta, 1846.

Oolitic age of some bluish-white indurated clays at Dubrajpore in the Rajmahal Hills, nevertheless placing the shales, sandstones, and seams of coal of Burdwan, and of Mussinia and Kottycoon in the Rajmahal Hills, as an intermediate formation, which he styles the "Coal-measure," between the Inferior Oolite mentioned above and what he supposes to be the "Old Red Sandstone." After deducting specimens of *Fucoides*, which I cannot, with the aid of his figures, distinguish from those of *Glossopteris*, there are seven genera, to which he refers as "Indian coal-measure fossils." Of these, four, viz. *Sphænophyllum*, *Poacites*, *Calamites*, and *Pecopteris*, he says, are "common to the coal-measures of Europe." In the conclusion which would naturally be drawn from this statement I cannot concur; and hence it is necessary to review the grounds on which it is made. The three genera not mentioned are *Zamites*, *Tæniopteris*, and *Glossopteris*. Of these, the first two are held to be well nigh characteristic of the Jurassic period, while the remaining genus, though unknown in Europe, must, from the circumstances in which it is shown to occur, now be acknowledged to be equally a Mesozoic plant. And with regard to the four genera specified, I do not suppose that Dr. Royle will assent to the identification of his *Trizygia* with *Sphænophyllum*; and, if any specimens of the genus *Calamites* had been preserved for description, I have little doubt they would have proved to belong to our "non-tuberculated class of opposite sulcated jointed stems," which abound in formations above the true coal-measures. The genera *Poacites* and *Pecopteris* I have found in our "Jurassic" strata, and a specimen of the latter here is so like one figured by M'Clelland that it is difficult to resist the conviction that they do belong to the same species. If to the evidence now adduced there be added that afforded by the occurrence of the peculiar plants *Vertebraria indica*, *Trizygia speciosa*, &c. at Burdwan and Bhuwan, I think little probability will remain of the Bengal coal-formation being Palæozoic.

Dr. Hooker, in commenting on the opinion of Dr. M'Clelland, which he supposed to be in favour of the Oolitic age of the Burdwan coal-field, at the commencement of his first volume endeavours to prove that no inference can be deduced from the plants discovered in those strata. In his second volume, however, he puts forth an opinion of his own, which, though not formally enunciated in regard to the Burdwan series of rocks, may be gathered from his remarks on the carbonaceous shales near Punkabarree. On these shales there were "obscure impressions of Fern-leaves, of *Trizygia* and *Vertebraria*, both fossils characteristic of the Burdwan coal-field, but too imperfect to justify any conclusion as to the relation between these formations*. And then, in a foot-note, it is added, "these traces of fossils" (including a fragment of bone as well as vegetables) "are not sufficient to identify the formation with that of the Siwálik Hills of North-West India; but its contents, together with its strike, dip, and position relatively to the mountains, and its mineralogical character, incline me to suppose it may be similar."

* Himalayan Journals, vol. ii. p. 403.

It may appear presumptuous in me to impugn the view of one who, from personal as no less than hereditary claims, is entitled to the utmost respect on the subject of vegetable remains. I feel, however, that the learned author has been led away by his distrust of the evidence afforded by fragments of plants to rely on the more uncertain indications of mere lithological phænomena. Do strike, dip, &c. furnish us with such strong testimony on the question of age, that for their sake the Punkabarree shales are to be denied a place with the Burdwan beds which have Ferns, *Trizygia*, and *Vertebraria*, and to be ranked with the Siwálik rocks, which, I believe, have none of the three? Or, if the carbonaceous strata at both places are allowed to be contemporaneous, are both to be classed as Miocene or Pliocene, when the Bhuwan shales, which like them exhibit "impressions of Fern-leaves, of *Trizygia*, and *Vertebraria*," immediately underlie sandstones whose numerous fossils, not to mention those of Burdwan itself, are decidedly not more recent than Jurassic?

It only remains to add, that the age of the dolomitized limestone cannot be expected to be determined by the evidence of fossils; but, as in other localities, it is not unfrequently found to alternate with the shale c, it may be set down as nearly coeval with it;—thus making the whole series of rocks from A to D to correspond with the lower members of the great Jurassic formation,—reaching perhaps from about the position of the Scarborough strata downwards into the Lias.

VIII. *Plutonic and Metamorphic Rocks.*—At the end of a paper which has already extended to such a length, it would be unbecoming to say much on this part of our subject. We have in the city of Nágpur, and many localities to the east of it, the usual combinations of gneiss and quartz-rock, mica and hornblende schist, with massive granite. The peculiarity of the last-mentioned rock in the streets of the capital is, that it is generally a pegmatite, consisting of flesh-coloured crystals of felspar with quartz, disposed so as often to take the appearance of graphic granite. But very frequently it occurs with the felspar compact, in large white masses, which then have much the appearance of a pure dull porcelain. In Nágpur the most common rock is gneiss, passing into mica-schists. The former rock, when fresh, is quarried, though not extensively, for building; and when disintegrated, for the repairing of the roads. But for both of these purposes respectively trap, in the two conditions mentioned, is preferred. Masses of white quartz appear here and there in the city, some with crystals of black schorl, and others with scales of gold-coloured mica. The range of plutonic hills on the west of Kámpti, which is indeed only a narrow prolongation of the great granitic district in the Wein Gangá basin to the east, has been thrown up by an eruption of granite corresponding nearly with the course of the Kolar. The massive rock which lies in the channel of the river, unlike that of Nágpur, is generally grey and very micaceous. Above it, forming the N. base of the range, lies mica-schist, passing into granular schistose quartz, which is overlaid by a stratum of dark-grey, glistening, resinous quartz, and then by a considerable thickness of white quartz with scales of mica. This constitutes the ridge of the range for about its entire length from Waregaum to Gumtara, and with its snowy-whiteness attracts attention from a great distance. At the northern base of the range, between the quartz and the dolomite of Korhádi, there are interposed some beds of granular quartzose rock, which has very much the appearance of being an altered sandstone; in which case it might be the representative in this part of the country of the "Tará sandstone." But throughout the field of crystalline limestone at Korhádi there are many eruptions of granite, which just rise to the surface without any intermediate metamorphic rocks at all. In some of those instances the granite is garnetiferous, and at its junction with the dolomite the latter, besides its usual ingredients of steatite and tremolite, is intermingled with mica. At Halyadoba, N.E. of Umred, chlorite-schist with garnets is quarried for pavements; it abounds along the course of the Amb River. At Shegaum various plutonic rocks rise from under the sandstone, and extend northwards to Karsingi. The first which appears in the north street of Segaum is syenite, in which the felspar and hornblende greatly preponderate over the quartz. About 300 yards to the north this is succeeded by another kind of syenite, in which red felspar is combined with a small proportion of quartz, and a large quantity of a green mineral (epidote or diallage?). This rock (euphotite?) seems to be massive, and, if we may judge from the fragments of it lying on the surface, is the prevailing rock for some miles. In an adjoining plutonic area, a little to the north, there is an extensive development of pot-stone at Jámbul Ghát. The rich dark kind that possesses a small metallic lustre has hitherto been reserved by Marátha authority for the manufacture of idols; but the lighter-coloured varieties, which are more common, occurring also at Dini near Rampaili, and at Biroli on the Wein Gangá, near Tharora, have been long used for fashioning into vessels. Steatitic schists of a pure white tint, with a few imbedded garnet crystals, occur at Kaneri, on the Chulband river, and at various other localities east of the Wein Gangá. In many parts of this river's course, and in the Lánji Hills, hornblende rocks, both schistose and massive, abound. A coarse kind of corundum occurs at Dali Ghat, on the road from Nágpur to Ragepur.

Metals.—Small quantities of gold are found near Lánji in the sands of the Son river, a tributary of the Wein Gangá. In some fragments of quartz-rock on Nimá Hill, west of the Pech river, Col. Jenkins found galena. Where this rock is associated with dolomite, as at Kumári, it contains manganese. But the principal ore which it yields is iron; this may be obtained in immense quantities in the province of Chándá, both on the east and west of the Wein Gangá. Near Dewalgaum, only three miles from the east bank of this navigable stream, which communicates by the Godávari with the Bay of Bengal, at Masulipatam, in the midst of a level country covered with jungle, there is a hill named Khandeshwar, consisting of strata tilted up at an angle of 60° or 70°, the dip being to the north. The summit of the hill is about 250 feet above the level of the plain, 100 feet being gradual ascent through jungle, and the remainder an abrupt wall of naked rock. The iron-ore is for the most part specular, though many specimens possess polarity, and seem to be magnetic. It is on the surface of the slope that it is most valuable; but the whole mass, from an unknown depth under ground to the highest peak above it, is richly laden with metal. This single hill might furnish iron for the construction of all the railroads that shall ever be made in India, and with its abundance of fuel and cheapness of labour, and convenience of situation, it is admirably adapted for an export trade to every part of the country. But besides this locality, there are others in the neighbourhood which could each contribute an unlimited supply of the same indispensable metal. Among these may be mentioned Lohara, Ogalpet, and Metápár, Bhánápur, Mendá, and Gunjáwahi, which are all on the W. of the Wein Gangá; and at all of which places the ore seems to occur in quartz, and is sometimes granular, but for the most part compact. Unimportant crystals of it are scattered through the pegmatite of the capital. Notwithstanding that the specular ore is so abundant, there are many districts on the north of those already named where the hydrous oxide, in the shape of the heavier lumps of laterite, are selected for smelting by the poor natives, whose tools are anything but adapted for contending with the hard masses of the metamorphic matrix or gangue.

Age of the Plutonic and Metamorphic Rocks.—These evidently do not all belong to one and the same epoch. Col. Jenkins observes that at Nayakund on the Pech, to the north of Nágpur, he met with "a grey granite, composed chiefly of whitish felspar in very large crystals," a mass of which "was distinctly traversed three or four times by granite-veins, accompanied by as many heaves." The granite of the veins was smaller-grained and redder the more recent it was, and, to the best of that officer's recollection, was destitute of mica. Without, however, more extensive artificial sections of the rocks in this neighbourhood than have ever been executed, I fear it will be difficult to fix the respective ages of the different eruptions. A cursory view of the question would lead to the supposition that the micaceous granite is more ancient than the pegmatite; but, in areas where both are presented in the vicinity of each other, the soundness of this view may be questioned, or at all events it appears to be impossible in the present state of the country to have it confirmed. The pegmatite of Nágpur city, which we have said is associated with gneiss, mica-schist, and quartz with mica and with schorl, is evidently a very recent eruption, for it has not only converted much of the very highest member of the jurassic sandstone into gneiss, but it has completely upheaved it. That the eruption, therefore, was posterior to that formation, there cannot be the slightest doubt. But it has sometimes occurred to me, though the observations of the most eminent Indian geologists are opposed to the thought, that this pegmatitic outburst may be subsequent even to our trap.

The section (fig. 1) at page 350 may throw some light on this doubtful point. In this section we have the overlying trap (*a*) occupying the two summits of Sitabaldi Hill, under it the tertiary freshwater formation (*b*) and the intruded amygdaloidal trap (*c*) which has encroached on it. At the foot of the hill is the upper sandstone (*d*), which has been metamorphosed to a great extent by the gneiss (*e*), or rather by the pegmatite (*f*) beneath. On the north part of the hill the gneiss comes to the surface; but a little further north it is, together with the sandstone, overlaid by trap. This trap, which agrees with that overlying the tertiary beds in being nodular and poor in minerals, resembles in the very same respects the amygdaloid where it constitutes the superficial rock on the ascent. Proceeding in the same line, we find the trap cease and the sandstone upheaved. After this interruption the trap is again seen to be on the surface. Now the question arises: what is the reason that the trap is not found where the granite has thrown up the sandstone? The most obvious reply is, that once it was there, as it is seen on either side, but that by this eruption it was removed; in which case the plutonic rock would be of more recent origin than the volcanic. But, as there is the alternative of the latter never having been spread over the position of the former, and as this alternative is favoured by the examination of other localities, I content myself with merely submitting the case for determination, merely stating that my latest observations lead me to believe that the trap is of later age than the granite. At all events the section undoubtedly shows that the pegmatite and some of its accompanying gneiss are of an age subsequent to the upper sandstone. And yet in a layer of conglomerate contained in the red shale of Korhádi we meet with pebbles of undulated mica-schist very like that which occurs in the present day between Surádi and Korhádi. Rocks of this character, then, whether we are right or wrong in suggesting their connection with any still existing, did exist before the deposition of the red shales.

Conclusion.—In tracing the geological history of this district from the facts that have been brought forward, we are made to feel that the early epochs are involved in the utmost obscurity. While in many other countries the records of what took place in Palæozoic times have been preserved in successive strata of the earth's crust, in the Dakhan they have been wholly obliterated. It is not until we come down to the Jurassic era that we meet with archives whose characters can be read. Then we find that Central India was covered by a large body of fresh water, which stretched southward into the Peninsula, and eastward into Bengal, while on the north and west it communicated by some narrow channel with the sea. On the shores of this lake earth-worms crawled, and small reptiles (frogs) crept over the soft mud. In its pools sported flocks of little Entomostracans resembling the modern *Estheria*, mingled with which were Ganoid fishes and Labyrinthodonts. The streams which fed it brought down into its bed the debris of the plutonic and metamorphic rocks which then constituted the greater part of the dry land, and which were covered with an abundant vegetation of Ferns, most of them distinguished by the entireness of their fronds. Low-growing plants with grooved and jointed stems inhabited the marshes; and Conifers and other Dicotyledonous trees, with Palms, raised their heads aloft. Meanwhile plutonic action was going on, and strata, as they were formed, were shattered and reconstructed into a breccia; and finally an extensive outburst of granite elevated the bed of the lake and left it dry land. The sea now flowed at Pondicherry and Trichinopoly, depositing the cretaceous strata which are found there.

At the end of this epoch Central India suffered a depression and was again covered by a vast lake, communicating with the sea, not towards Cutch as before, but in the neighbourhood of Rájámandri, to which the salt water had now advanced. When the lake had during its appointed time furnished an abode to its peculiar living creatures and plants, it was invaded by an immense outpouring of trap, which filled up its bed, and left Western and a great part of Central India a dreary waste of lava. But these basaltic steppes were ere long broken up. A second eruption of trap, not now coming to the surface, but forcing a passage for itself under the newer lacustrine strata, lifted up the superincumbent mass in ranges of flat-topped hills. Since then, to the east, water has swept over the plutonic and sandstone rocks, and laid down quantities of transported materials impregnated with iron, and some time after there were deposited in the west a conglomerate, imbedding bones of huge mammals, and above it a stratum of brown clay, which immediately preceded the superficial deposits of the black and red soils.

I have to acknowledge my great obligations to Lieut.-Col. Alcock, of the Madras Artillery, and Drs. Leith and Carter, of Bombay, for assisting me in obtaining access to books (or extracts from them), of which I should otherwise have been deprived.

The map (Pl. X.) of the district described is coloured geologically from an excellent political map given in Rushton's Bengal and Agra Gazetteer for 1842. The formations between Chindwá*d*á and the Mahádewa Hills are laid down from a sketch obligingly furnished to me by Mr. Sankey.

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Notices of Meetings.

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- H. Paddington.—Examination and analyses of Dr. Campbell's specimens of copper ores obtained in the neighbourhood of Dargeeling, 477.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

March 7, 1855.

The following Communications were read :—

1. *On the* Gold-fields *of* Ballarat, Eureka, *and* Creswick Creek, Victoria. By M. Henrique Rosales.

[Communicated by W. W. Smyth, Esq., F.G.S.]

During the voyage to Australia I carefully studied the Government Reports on the gold-fields; and on my arrival I was greatly disappointed to find that the same regulations were still in force, which entirely precluded the establishment of a regular gold-wash work. I had five men, miners and others, bound to me for two or three years; and all that remained for me to do was to follow the example of others, and try my luck in the gold-lottery, for success under the present system of claims is a mere chance.

We first entered the gold-field of Eureka; but finding that, from the exhaustion of the shallow works, there was only deep-sinking, we proceeded to Creswick Creek, about twelve miles north of Ballarat, where between November and March I have sunk many a hole, some of which proved blanks, others were too poor to pay.

Ballarat*, Eureka, and Creswick Creek, although not one gold-

* [See also Mr. Wathen's paper on the Victoria Gold-fields, Quart. Journ. Geol. Soc. vol. ix. p. 74; and Mr. Selwyn on Mount Alexander District, *ibid.* vol. x. p. 299.]

field "in law," belong to the same auriferous tract, geologically speaking.

[On a MS. sketch-map accompanying this memoir, the author has laid down the principal water-courses and ranges for several miles round Creswick Creek, and also Eureka, but not the intermediate country, on account of the distance.]

In the following description I shall confine myself to the auriferous region of the "Ranges," for the basalt which hems it in on the east and west may be regarded only as a frame to the picture.

The general character presented by the gold-fields is an undulating surface, with steeper slopes where the slaty rock protrudes, and gentler slopes in the low lands, where the soil is composed chiefly of quartz debris, and is covered by the monotonous vegetation of the gum-tree. The features of the gullies and hills are so much alike, that when the traveller has seen one portion he knows the appearance of all. This tract is watered by creeks, which in summer generally dry up entirely unless they spring from the basalt: near Creswick Creek all the springs flow from that rock; and you can tell their position from a distance if you see a tea-tree. The basalt forms plateaux, not thickly timbered, but producing excellent grass; hence most of the squatters have picked out this ground for their "run." The general aspect of the vegetation enables you to draw the boundary of the basalt; for on this rock the "white gum-trees" are predominant, whilst on the auriferous ground the "stringy bark gum-trees" are almost exclusively seen.

The general geological character of this tract is "quartz-schistose," which is covered in the plains by drift or alluvial soil. "Quartz-schistose" is the misapplied term employed here to signify an indefinite succession of strata of clay-slate and of argillaceo-arenaceo-micaceous slates, interstratified apparently, as regards their strike, with quartz-veins of all sizes. These veins, however, appear to traverse the slates on their dip (figs. 1 and 2), as at Black Hill near Ballarat, where the quartz-veins are regular lodes.

Figs. 1 & 2.—*Quartz-vein in slates at Black Hill, near Ballarat.*

Fig. 1.

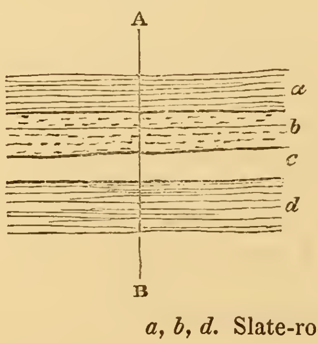
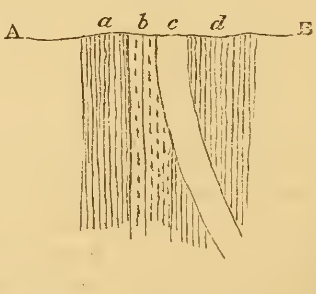


Fig. 2.



a, b, d. Slate-rock. *c.* Quartz-vein.

The strike or bearing is, as far as I have observed, generally north and south, dipping very commonly 85° and more to the east, but sometimes curved, and sometimes to the west, as towards Spring Hill, Creswick Creek.

It is these quartz-veins which form the matrix of the gold.

Quite unconformable to the slaty rocks is a conglomerate of pebbles of white quartz with a rust-coloured cement. This (the "iron-cement" of the diggers) is the only solidified rock belonging to the alluvial soil, and is found at varying distances, 10 to 20 feet, from the bottom of the alluvium, being sometimes only 1 or 2 feet thick, at others as much as 12 feet.

Where the slate-rock is covered by drift-deposits, it is generally decomposed into silicate of alumina; but not so much disintegrated as to prevent your distinguishing the "pipe-clay," which has been formed of the clay-slate, from the sandy pipe-clay ("sandstone bottom" of the diggers) resulting from the decomposition of the arenaceo-micaceous slates. Where the strata are decomposed but unmoved, the strike and dip are a sufficient index to distinguish a "true" from a "false bottom," *i. e.* whether the digger has reached the slate, or has still to penetrate more of the alluvial deposits. For want of observation of this kind, some holes have not been "bottomed" at once, whilst one at Bendigo penetrated 200 feet down into the slate in a vain search for another bottom. Although the "pipe-clay" consists principally of silicate of alumina, it retains sufficient potash mechanically mixed with it to render brackish the water which filters through.

The drift or alluvial deposit sometimes includes two "bearing beds" (charriages), containing gold. The lower of these—beginning from the base of the whole—consists of large quartz-boulders, sometimes of 4 or 5 cubic feet volume, which always indicate the run of the auriferous ground; and these are covered by gravels, sands, and clays, without any regular order of superposition.

From the absence of basaltic boulders, and from my observation of basalt overlying the auriferous detritus at Clark's Diggings, I consider the gold-bearing beds to be older than the eruption and flow of the basalt, although this is followed up by the detrital beds of more recent date.

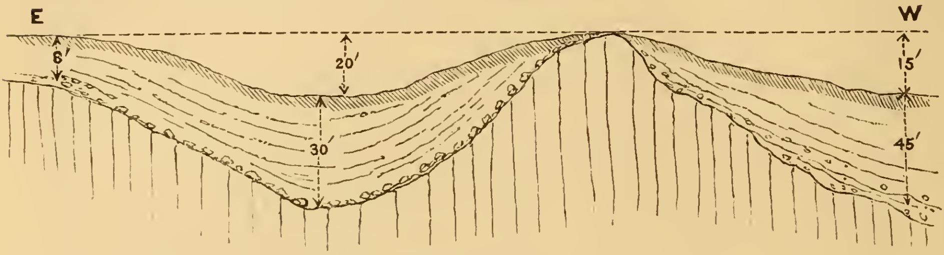
Hence results the important fact, that the gold may sometimes be found beneath the igneous rock.

The alluvial deposits may thus be divided into,—

I. Older than basalt ..	A. Before the eruption of basalt and the "charriage" of basalt-boulders.
II. Newer than basalt..	B. Contemporaneous with charriage of basalt-boulders.
	C. Newer beds covering the basalt-boulders, but older than the formation of the existing valleys.

At Creswick Creek the "charriage" seems to come from the east and south-east; but my endeavours to trace it have been foiled in approaching the Ranges, where it splits up into many branches. When thus tracked up, the bed of the charriage shows signs of having been disturbed, as for instance on "Flour-bag," Creswick Creek, where the auriferous layer sometimes crops out on the top of a hill, and is separated from the next depression by a ridge of slate,

Fig. 3.—*Superficial auriferous deposits at Flour Bag, Creswick Creek.*



whilst on both sides it is found at a depth of 30 and 45 feet below the bottom of the existing gullies, which run nearly north and south. See fig. 3.

A great portion of these inequalities of the gold-charriage are so covered by the more recent alluvium, that the relief of the present surface does not in the least correspond with that older bed. In direction also, or strike, it differs entirely from the modern water-courses, as for example at Creswick Creek, where the auriferous run crosses the flat formed by the present creek, and proceeds to "Flour-bag," "White Hill," the "New Rush" (a place which I opened, and which has turned out the richest in this locality), "Hard Hill," "Little Hard Hill," "Iron Hill," and down to "Large Point." In practice it is therefore useless to put down a hole according to the relief of the soil, although I am informed it is not so at Forest Creek, on the Bathurst side.

The inequalities above described I am inclined to ascribe to a disturbance at the period of the eruption of the basalt, although I must admit that I have not observed proofs of it in the slaty rock, and I should infer that its beds had been raised and sunk like wedges in the direction of its cleavage.

Thus far I have only spoken of one gold "charriage;" but in Ballarat, I believe, we may distinguish two:—1st, the deep bed, with boulders of moderate size; 2nd, the shallow bed, with large boulders.

The deep bed of Ballarat is formed of several "lines" (as the diggers say), or ancient water-courses, of no great width, which, although they crop out on the Ranges, attain a depth of 120 and 130 feet, and have acquired for Ballarat its great celebrity.

The course of this "deep-sinking" charriage is as follows:—1st line, the Eureka, which I believe will join with that near Pennyweight Flat; 2nd, the New Chum, Canadian, Donald's Flat, and Gravel Pits, this being the furthest point at which deep-sinking has proved the "run of the line." My impression is, that it would be found proceeding further to the north-west, under the basalt.

The shallow bed is found across Pennyweight Flat, Golden Point, and Ballarat Flat, whence I believe it would pass, like the other, under the basalt. It is distinguished from the former by its insignificant depth, its width, sometimes amounting to a full half-mile, and its much larger boulders ; and, whilst in the former the gold runs in gutters, here it occurs in patches.

In conclusion, regarding the future prospects of the gold-field, the diggers will continue, as at present, to follow up the alluvial beds, until after a time they are prevented by the great expense of labour required to reach them ; and then the gold regulations will have to be altered, and companies may be established and go to work in a proper way. It is only then that the deeper beds and the auriferous veins can be fairly opened on with due prospects of success ; but how many changes must take place before this ! Laws, wages, roads, &c., all must change !

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2. *On the* Geology *of part of the* Peel River District *in* Australia. By Frederick Odernheimer, Esq.

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

Near the Dividing Range of Australia, to the east and to the west, igneous rock and metamorphosed sedimentary rocks prevail, together with breccias and conglomerates, composed of both of the preceding kinds. At a greater distance from the Dividing Range, slates, shales, limestone, and grits, belonging, as it appears, to the older carboniferous system, predominate ; these are much traversed by, or sometimes regularly interstratified with igneous rocks, and are overlaid at some distance from the Dividing Range by coal-bearing beds, the age of which is yet a matter of controversy.

In the Peel District, of which I shall exclusively speak in the following remarks, true granite occurs but rarely. By becoming much charged with hornblende, it passes into syenite, and this latter, assuming a fine-grained or compact structure, passes into diorite. Porphyritic rocks appear in different places, and have either a granitic base-, felspar- and hornstone-porphyry (felsit-porphyr of the Germans),—or a syenitic or dioritic base. Serpentine is also vastly developed, especially on the Crow-land, or east side of the Peel. Trap or basalt is of less frequent occurrence in the Peel District, and is partly in the form of veins, partly intruded between the strata of sedimentary rock and forming beds parallel to the strata.

In contact with the igneous rocks is a great extent of metamorphosed sedimentary rocks, especially silicified slate. The silicification of the sedimentary rocks is a remarkable and very obvious fact, and will nowhere be found to greater amount than in this locality, and all along the Dividing Range ; only in rare cases some insulated masses of soft slate are observed, enveloped in the metamorphosed rock. Not only has the slate partaken of the silicification, but the limestone also has undergone the same change. In close connexion with the silicified rocks are found over a vast area brecciated rocks, either assuming the character of siliceous-slate-breccia, or of a compound of dioritic and siliceous rock, approaching on one side to diorite, on the other to siliceous slate. The limestone in the same region is also commonly brecciated, containing angular fragmentary particles and masses of siliceous rock, which increase sometimes in such a degree as to supplant the limestone in part or completely. Hence one and the same bed of limestone may be found in one place pure, further on passing into a brecciated limestone with fragments of siliceous rock, and still further into a siliceous breccia with enclosed fragments of limestone, which diminish at a greater distance, and even disappear altogether, when there only appears a siliceous breccia containing more or less calcareous matter. The fragments of limestone in the siliceous breccia are highly crystalline, and all traces of fossils are generally wanting.

Associated with the silicified slate quartzose hornblendic rock occurs to a great extent. Near granite a metamorphic rock resembling gneiss and mica-schist has been observed in a limited area.

The silicification seems to be most developed near the serpentine, the altered rock being there in a great measure intersected by quartz veins, or so highly charged with silex, that layers of pure quartz appear interlaminated with the silicified slate. Also near serpentine cavernous chalcedonic masses occur, and opal.

There can be little doubt, that the igneous rocks were intruded when the slaty rocks and limestone were just in the process of being formed, and the two masses have influenced each other in their composition. Even the igneous rocks, syenite, diorite, and porphyry, are much more overcharged with siliceous matter than I ever before had the opportunity of observing. The brecciated rocks, so extensively distributed, show equally the mutual influence of igneous and sedimentary rocks. The silicified slates are sometimes much contorted and twisted, especially near serpentine.

The breccia passes sometimes, but not commonly, into conglomerates with rounded particles of rock, which, however, are to be distinguished from the superficial conglomerates, composed of consolidated drift of more or less recent date.

At a greater distance from the Dividing Range and the high spurs which descend from it, and which for the most part diminish rapidly in height, there occurs a great extent of soft slate, interstratified with more compact beds, from half an inch to several feet in thickness, and charged, as it appears, with dioritic and siliceous matter, but rarely assuming the character of grits or sandstone. True diorite is also observed interstratified with slate, sending out in some cases veins into the latter rock, and causing a silicification of the nearest layers to a small distance. In the same manner felspar-porphyry (felsit-porphyr) and syenite occur also in beds in the slate, without visibly disturbing the latter. Brecciated rock appears in large layers near the Dividing Range, but these are more rarely met with at a greater distance. The slate contains also small beds of limestone, which increase in some localities to large masses. Where the soft slate predominates, and also in rare spots nearer the metamorphosed rocks, traces of fossil plants (*Lepidodendron*) have been observed in the slate. The limestone, where it is less metamorphosed (silicified and brecciated), contains plentiful remains of Corals, which are especially observed on the corroded surface, and generally charged with siliceous matter. Shells are of rare occurrence in the district of my immediate researches. The determination of the species of those fossils I must leave to better authorities at home.

In the area of the greatest development of igneous and metamorphosed rocks on both sides of the Peel River, and higher up to the Dividing Range, is the locality of the gold-bearing quartz-veins in this district. These veins are either parallel to the general strike of the rocks (N.N.W. to S.S.E.,—north 30° west to south 30° east), or transverse to the strike (E.N.E. to W.S.W.,—east 25° north to west 25° south). The veins are generally of small size, and seldom exceed one foot in thickness; they occur for the most part in dioritic rock, and in dioritic and siliceous breccia, but appear to be the richest in true diorite. As far as actual trials have shown, the veins are in general not very regular, being often cut off and shifted, or they lose themselves in small strings in the direction of the strike as well as in that of the dip, widening again at a short distance. In those few veins which are opened by trenches and shafts, the occurrence of gold is confined to the decomposed upper parts or outcrops, especially where these appear disintegrated and partly drifted. Where the veins become more compact at a greater depth, gold is not visible, but iron-pyrites are observed in more or less quantity.

I may not be justified by those few instances to form a decided opinion on the formation of the gold, but these very instances leave no doubt in my mind that the gold is derived from auriferous iron-pyrites. The upper parts of the gold-bearing quartz-veins, which have been tried, showed a high degree of decomposition,—the uppermost portion must have undergone a hydro-chemical process; the quartz appears in loose and often complete crystals newly formed, among which the gold is interlaced with more or less crystalline structure. This crystalline outcrop of the veins has generally been partly drifted. The more compact portions of the outcrop show also some gold as a coating on the surfaces, or in chinks in the mass itself, but not reaching far down, where the vein is less crystalline and cavernous. In favourable occasions, however, this decomposition has gone on even to a considerable depth; but the most auriferous quartz-veins confirm the observation, that gold appears chiefly at the outcropping. Auriferous iron-pyrites in those veins where they occur in sufficient quantity and richness must be looked for in future mining operations. I had the opportunity of studying, in many localities, the decomposition of the upper parts of veins, and I am led to the opinion, that the appearance of gold is most naturally accounted for by such decomposition. Hydrated oxide of iron is abundantly spread over those parts where gold occurs, and the source of this iron oxide can be traced to the pyrites in the lower parts of the veins, to which the decomposition has not reached.

This opinion of the formation of the native gold does not interfere with the theory of the relatively new origin of the gold-bearing quartz-veins themselves, but only has reference to the nature of the distribution of the *gold in the veins.* At an early period after the formation of the veins, the decomposition of the upper parts may have gone on at a much quicker rate, assisted by hot-water springs; but the appearances at present seem to imply that this decomposition is still being carried on, although in an imperceptible manner. The barren quartz-veins belong to the same system with those bearing gold, but are generally more compact, very rarely containing iron-pyrites; and their close structure allows of no decomposition.

A great deal of the drift-gold is to be referred to the gold-bearing quartz-veins. But the decomposed and disintegrated surfaces of rocks containing iron-pyrites, such as hornblende-rock, syenite, diorite, porphyry, and breccia in the Peel District, which contain pyrites abundantly, although in small specks, are also to be regarded as a source of gold. In several diggings here and in the Bathurst District (especially at Barandong on the Macquarrie, near Wellington) gold is found without any trace of quartz-pebbles, and can only be referred to the rock itself.

For the formation of a rich gold-field, however, the gold from these two mentioned sources must have undergone a concentration by drifting in water, in a strong stream moving heavy boulders and depositing the gold in favourable situations, and partly cleaned from the admixture of earthy materials. The formation of the drift-gold is so well known, that there appears very little left to be said about it. I will only remark, that the newest alluvial soil is observed to be perceptibly richer near gold-bearing quartz-veins; showing that the disintegration, if not the decomposition, of these veins is still going on.

Besides gold, ores of copper and of antimony have been observed. A high and remote hilly country of the "Peel River Land and Mineral Company's" estate still remains to be minutely examined, and I look for new discoveries there. Chromate of iron is found in large masses in serpentine. Red oxide of iron (*hæmatite*) is of frequent occurrence. Magnetic and titaniferous iron is disseminated in minute particles in the rock, and abundantly met with in the deposits of drift-gold. Traces of precious stones—zircons (hyacinths) and corundum (sapphire)—have been recognized*. I am very attentively looking out for them, as for other discoveries, and I hope to be able to give, in future letters, some farther observations, based on accurate chemical assays, especially of the iron-pyrites contained in the quartz-veins and in the rock.

Cann's Plains, Peel River, New South Wales,
September 8, 1854.

* [See also Mr. G. M. Stephen's paper on Australian Gems, Quart. Journ. Geol. Soc. vol. x. p. 303.]

3. *On the Occurrence of* OBSIDIAN BOMBS *in the* AURIFEROUS ALLUVIA *of* NEW SOUTH WALES. By the Rev. W. B. CLARKE, M.A., F.G.S.

[Abridged.]

IN Mr. Darwin's 'Geological Observations on the Volcanic Islands visited during the voyage of H.M.S. Beagle' (p. 38), that author describes and figures a volcanic bomb of green obsidian from the plain between the Rivers Darling and Murray, and which he received from Sir T. L. Mitchell.

The explanation given by Mr. Darwin appears to be satisfactory as to the origin of that individual specimen, and it is confirmed by the parallel examples cited from M. Beudant. Sir T. L. Mitchell's specimen would seem either to have been drifted from a very long distance, or, which is more likely, from the known habits of the aboriginals, to have been dropped by one of them, who probably found it in the trap-hills of the Lachlan to the north-eastward. This specimen was unique as to Australia, until recently.

During the last two years, several similar specimens have been found in the auriferous detritus of the western and northern Gold-fields.

The first which I met with was found in the cradle of a gold-washer on the Turon River, who dug it from a depth of 30 feet below the surface. This was a small, irregular, roundish substance, 0·6 inch in diameter, having a specific gravity of 2·7 at a temperature of 66°. It was undivided, and more like those examples described by M. Beudant than the figure given by Mr. Darwin. A similar specimen, but of a rude elliptical form, $\frac{1}{2}$ inch diameter in the major axis, and having a sp. gr. of 2·57 at a temperature of 63°, was found in the washing-stuff of the Uralla, or Rocky River, County of Hardinge, New England District.

From the same locality were derived two other specimens, which I have examined. These are perfectly round, having diameters respectively, including the rim, of $\frac{1}{2}$ inch and about $\frac{3}{4}$ inch. These, except in shape and in the extension of the cells over the rims as well as in the nucleus, agree with Mr. Darwin's figure. Their colour is also bottle-green, and they are translucent; the surface appearing black in the thicker portions, as in Mr. Darwin's specimen. But this blackness does not arise from any difference in the composition; it is merely the effect of greater opacity. The external concentric rings are evident in all three. The specific gravity of those from the Uralla is, respectively, 2·42 and 2·51 at a temperature of 63°. The smaller very much resembles a button without the shank; and, from this appearance, the diggers call them "button stones." They appear as if they had been cast in a mould; but there is no reason to doubt the imputed origin.

The alluvia of the Uralla, which rises in granite and flows through rocks of that class for many miles, consist of mud and sand (surrounding "boulders" of granite, in the decomposing exfoliative surfaces of which gold is visible), derived from decomposed granite, together with fragments and pebbles of granite, quartz, altered schist, grit, and an enormous amount of coarse garnets, spinelle rubies, white topazes, blue and black tourmalines, some oxide of tin, native white iron highly magnetic, cornelian, sapphires, chalcedony, &c.

The river rises near the summit of the Dividing Range, in the midst of a kind of plain or plateau, and winds amidst the rugged blocks of hornblendic granite, until it descends to a somewhat lower level where it forms flats with deep water-holes, in which the detritus is accumulated. The ranges above this lower stage are nearly on a level with the plateau at the head of the river, and these ranges are crested by basalt, which has issued from and overflowed the granite. The gold-washings are at the height of 2800 feet above the sea, by my barometric observations, and the crowning basalt has an elevation of 3085 feet.

The contour of the country and its geological structure render it probable that these bombs above mentioned had their origin in the outburst of the trap.

About four miles further south are the relics of quartziferous schists and their associated grits, which have been transmuted by the intrusion of various trappean, porphyritic, and trachytic rocks; and, though no direct crater is traceable, there is evidence of powerful igneous action*. As the detritus is all local, and there is no easily-assignable crater, it seems most satisfactory to conclude that these bombs are connected with the trap-eruption of the neighbourhood. This seems also in accordance with the facts mentioned by Mr. Darwin respecting the structure and products of Ascension, where such bombs are frequent, and basaltic streams cover other igneous products, some of which are trachytic.

Whether this explanation is sufficient or not, the facts themselves are interesting; for these singular bodies have been found in three localities in Australia, at intervals of 455 and 205 miles apart,—the distances from the Murray and Darling Plain to the Turon, and from the Turon to the Uralla. That they could have had only one point of origin is scarcely to be supposed, if they are really of sub-aërial volcanic origin: in two of the three localities, at least, there is presumption of such action; and in both of these localities the bombs were imbedded in gold deposits.

* This district and the geological phænomena are described in my Report to the Government of New South Wales on the "auriferous character of the country between the heads of the M'Leay and Gwydir Rivers," No. VII., dated Armidale, 14th Feb. 1853.

4. *On the Occurrence of* Fossil Bones *in the* Auriferous Alluvia *of* Australia. By the Rev. W. B. Clarke, M.A., F.G.S.

In a pamphlet published by me at Sydney in 1851 *, I mentioned the fact, that the gold-alluvia of New South Wales contained osseous reliquiæ of extinct animals, and I quoted a private letter from San Francisco, dated 23rd February 1850, showing, that bones of extinct animals have been also found in the gold-alluvia of California†. The inference was, that, in this respect, there is a resemblance in the alluvia of the two countries. These facts were, I believe, first mentioned by myself; for, though it was known long before, that the alluvia and caverns of New South Wales contained numerous remains of extinct animals, no one had before ascertained, that in some localities these remains had been accumulated in the bottoms of creeks contemporaneously with gold, before much of the materials forming the present banks of those creeks had been deposited. In 1853 I received direct information from Professor John B. Trask, of California, confirming the facts stated in the private correspondence above-mentioned, as to the manner in which the extinct mammalia of that State have been exhumed by the gold-diggers north of the Consumnes and the Tuolumne. He bears testimony also to their occurrence in that district, in his "Report on the Geology of the Sierra Nevada" (p. 11), 1853.

Interesting to the Society as, I presume, such well-authenticated facts must be, the following section of one of the auriferous localities on the Turon River, New South Wales, will illustrate them; especially as this locality is on the plateau or table-land above the river, at the head of a creek descending to it. It will be seen, that the diagram (p. 406) offers some points of resemblance also to that which illustrates the occurrence of auriferous alluvium with Mammoth remains at Berezof, at p. 478 of Sir R. Murchison's 'Geology of Russia and the Ural Mountains.'

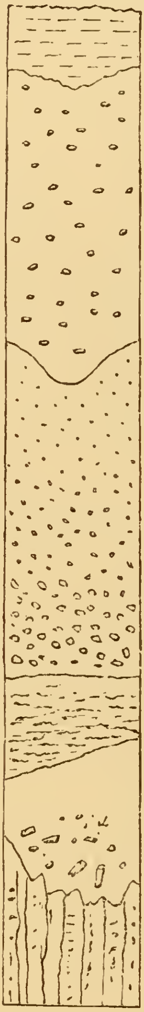
The bones are partly decayed, the interior cavities filled with greenish clay, effervescing with acids, which also surrounds the larger fragments. They appear to have been partially decomposed before they were imbedded in the gold-bearing stratum. They adhere strongly to the tongue, and in some instances are easily pulverized by pressure. Their presence would imply, that the gold in this deposit was collected at a comparatively recent date. As the bones appear to be similar to those which are found in the banks of the creeks on Darling Downs to the northward, where shells of living species, now inhabiting the same creeks, are attached to the bones, the period of the accumulation of the gold on Wattle Flat was certainly at no very ancient geological period.

* "Plain Statements and Practical Hints respecting the Working of Gold in Australia."

† [For a Notice of the Gold District of Upper California, see Quart. Journ. Geol. Soc. vol. x. p. 308.]

But as they occur on the plateau or table-land above the Turon, that river has had nothing to do with the accumulation and deposit. They must owe their transport to some cause of wider operation than a river.

Section of Wattle Flat (a dead level), head of Oaky Creek above the Turon River, New South Wales.



Bed	ft.	ft. in.	Description
6.	1 to	1 6	(No. 6.) Whitish-grey, felspathic, sandy marl, externally like chalk.
5.	5 ...	7 0	(No. 5.) Sandy clay, with ferruginous patches and pebbles of ironstone; also cubes of black pyrites.
4.	5 ...	7 0	(No. 4.) Highly micaceous, marly, and sandy clay, with small pebbles.
3.	1 ...	1 6	(No. 3.) Brown unctuous clay, with small shingle of ironstone; trap and red quartz breccia.
Gold and Bones. 2.	1 ...	2 6	(No. 2.) Buff-coloured clay, with pebbles of trap, ironstone, and quartz. This is the "washing-stuff" of the diggers, and contains gold. The position of the bones is seen in the sketch.
1.	....		(No. 1.) "Bed" or underlying rock, a decomposing, ferruginous, siliceous trap, filled with minute cubes of black striated pyrites.

The occurrence of fossil remains of extinct gigantic animals of living genera is now known to be a much more general phænomenon in Australia than it was supposed to be. Besides at the Condamine, Wellington, and Boree, and Mount Macedon in Victoria, I have lately had evidence of their existence in various other places, such as at the head of the Coodradigbee River; on the Murrembidgee; on the Turon; at Mudgee on the Cudgegong River; on Terabeile Creek, a water of the Namoi basin, where they occur in enormous abundance beneath the alluvial soil at Galandaddai, near Melville Plains, at a depth below the surface varying from 15 to 100 feet; at Dart Brook in the Basin of the Hunter; on Paterson River; and as far north as the head of the Dawson River; besides some places east of the Main Chain between Darling Downs and the Moreton Bay country. They are thus found throughout a range of eleven degrees of latitude, and at heights varying from 100 feet below, to 1600 feet and upwards above the sea-level. Mr. Stutchbury has reported other localities besides those enumerated, in the same range of country.

It is not probable that the destruction of all the animals of which there are relics was at one time; but it does appear that their entombment in alluvial deposits at such varied elevations, if by one catastrophe, would imply the march of waters over the whole of this part of the continent of New Holland. And, there are geological reasons for concluding, that as in California, so in New South Wales, a great part of the now dry interior was under water at the time when these gigantic creatures were buried; and it is probable their destruction at last was connected with the final outbreak of igneous forces which changed the horizon of considerable tracts, draining by disruption many local reservoirs, and introducing a state of things incompatible with the existence of animals which required conditions of life which only now obtain in an inferior degree. In California, "volcanic tufa" covers the "diluvial drift" which contains the remains of gigantic mammals; and in the interior plains of New Holland, black soil, the disintegrated spoils of numerous trappean overflows, covers up wide tracts of alluvial deposits, in and below which are found the relics of *Macropus*, *Diprotodon*, *Nototherium*, Crocodiles and other Saurians *, and, as recently discovered by Mr. Stutchbury, the remains of Fish †.

Whatever be the epoch of the last trappean eruptions (and there is no real datum upon which to found a belief in the absence of the secondary and older tertiary formations) in New South Wales, this however is certain, that in some localities gold has been drifted (though apparently not very far) and deposited contemporaneously with the now fossilized remains of animals that lived close up to the historic period, if not within it; but at the same time it must be observed, that the disintegration of the auriferous rocks from which the gold was accumulated commenced long before, and in the case of still existing gold-bearing veins and beds has not yet been completed.

If the occurrence of volcanic bombs (as illustrated in another paper ‡) in the auriferous alluvium of the Turon, on which the bones are found, as well as of the Uralla River, be considered with reference to igneous agents as causes of surface phænomena, as well as of destruction of animal life, it will be seen that, though the distance of the Turon is 160 miles from the Uralla, and there is no topogra-

* See Rev. W. B. Clarke's Report to the Government of New South Wales, on the Geology of the Basin of the Condamine River, (No. 10) 14th October 1853.

† See Mr. Stutchbury's Twelfth Report from South Brisbane, 1 January, 1854.

‡ See above, p. 403.

phical connexion between them, there is probably a connexion of another kind, which is of far more importance to the elucidation of the past history of New Holland, and this connexion seems indicated by the discovery of actual *volcanic* products, and the association of gold and animal remains.

[Specimens of the various strata on Wattle Flat, collected by Mr. Johnstone, Assistant-Gold-Commissioner at Sofala, accompanied this communication. Amongst them are fragments of mammalian bones.]

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5. *Notes on the* Geology *of* New South Wales. By the Rev. W. B. Clarke, M.A., F.G.S.

[In a Letter to Sir R. I. Murchison, V.P.G.S.]

[Abstract.]

The author alludes to the regular succession downwards of—1. Coal-bearing beds; 2. Rocks with "Lower Carboniferous" or "Devonian?" fossils, and with Coal-plants and Coal; 3. Metamorphosed grits and fine conglomerates, derived from granitic and porphyritic rocks, occasionally fossiliferous, and sometimes enclosing calcareous beds. This porphyritic grit and conglomerate the author regards as being referable to Von Humboldt's *Lozero* of Mexico, which underlies the *Grès houiller* of Quanaxato*. On the western flanks of the southern part of the New England County there are conglomerates, referable to the base of the Carboniferous rocks of the flanks of the Liverpool Range, which are associated with Devonian? fossils and altered grits and shales full of *Lepidodendron*. 4. The great north and south schistose formations, in which the author has found fossils which he assigns with some doubt to the Silurian epoch†. The schists have been broken through, after being metamorphosed, and before the deposition of the superjacent and unconformable grits, by intrusive porphyry.

Mr. Clarke also refers to the existence of fossil fish [of which he has sent "rubbings"] in the upper rocks of Sydney. They have some resemblance to the Permian fish; and, if they be true indication of the Permian character of the beds, "we are able to show," says the author, "an unbroken series from the Permian rocks to the representatives of the Old Red(?)."

* Essai sur le Gisement des Roches (1823), p. 217.

† [See also Mr. Selwyn's Note on Silurian Fossils from the Schists of Victoria; Edinb. New Phil. Journ. 1855, No. 1. p. 171.]

April 4, 1855.

E. L. J. Ridsdale, Esq., J. E. Saunders, Junr. Esq., G. H. Wathen, Esq., and E. W. Jackson, Esq., were elected Fellows.

The following Communication was read :—

On the Palæozoic *and their Associated* Rocks *of the* Thüringerwald *and the* Harz. By Sir Roderick Impey Murchison, D.C.L., F.R.S., V.P.G.S., and Professor J. Morris, F.G.S.

Contents.

PART I.

Introduction.—The advice given by a distinguished French savant many years ago to one of us, then full of zeal to discover geological phænomena unknown to his contemporaries, was,—"Examine the travelling map of the region in which you may happen to be, and wherever you see a tract void of all post roads, go thither, and you will infallibly meet with something new to science."

This suggestion has since been our guiding rule in many excursions, including several visits to the insulated mountain-tracts of the Thüringerwald and the Harz, which in bygone years were traversed by no post roads, and which in these days of rapid locomotion are avoided by all railroads.

When Sedgwick and Murchison first looked at the Thüringerwald frontier in 1839, that chain had little attracted the attention of geologists, with the exception of Von Hoff of Gotha, who had then described the physical features of its northern half, determining several altitudes, and giving a general *aperçu* of its crystalline and eruptive rocks. It was then that the English geologists compared the southern limb of the chain with the masses of older rocks in the Rhenish provinces and those with of the Harz, and also endeavoured to indicate the German districts to which the terminology used to distinguish the ancient British sedimentary formations might be applied. As that survey, the result of which was embodied in the 'Transactions of the Geological Society,' was made in one long summer only, and as at that time there were few local collectors of palæozoic fossils, it was not to be expected that the authors could offer more than a broad and suggestive outline.

In the sixteen years which have elapsed since that memoir was published, the Rhenish provinces have been sedulously examined by various able geologists and palæontologists, who have accurately defined the limits of the sub-formations of each group, and have shown that, if the distribution of animal life be the guide, there are no true Silurian rocks in the Rhenish provinces—provided the adjacent slaty masses of the Ardennes should not prove to be such. The great mass of the Rhenish fossils pertain unquestionably to the Devonian rocks, and constitute, as we have lately stated, a triple group, of which the Spirifers and stones and slates form the base, the Eifel limestones the centre, and the Cypridina and Clymenia schists and limestones the upper band *.

This group is clearly followed by the Lower Carboniferous rocks properly so called, because they contain true mountain limestone fossils, and also certain plants; the order of succession being admirably exposed on the northern edges of the hills which flank the lower country of Westphalia. Much of this lower carboniferous group is mineralogically identical with the culm series of Devonshire, whilst the uppermost band of it, the 'flœtz-leerer sandstone,' is the equivalent of the British millstone grit, as first shown in the memoir above cited †. We may here refer to the original General Section (fig. 1, pl. 23, Geol. Trans. 2 ser. vol. vi.) made by us when we first examined the Rhenish rocks in 1839—which shows how truly the physical order is what it was then represented to be.

Such is the succession in the Rhenish provinces, and of this we have elsewhere given a condensed description and synopsis ‡ as prepared from our own observation and that of competent authorities, who have corrected the details and amplified the original comparison of the rocks with British types.

When the first comparative survey of the older rocks of Germany was made, no one had developed in any part of that vast region a true Silurian series; but in the interval M. Barrande has had the high merit of showing the existence in Bohemia of a perfect basin of all those rocks which he terms Silurian, *i.e.* from an unfossiliferous base through great masses of sediment representing the Lower and Upper Silurian divisions.

Now, each of the two tracts which are brought under considera-

* 'Siluria' (1854), p. 367, &c.
† Trans. Geol. Soc. 2 ser. vol. vi. p. 228, 229.
‡ 'Siluria,' p. 382.

tion exhibits, as we shall indicate, some members of the Silurian of Bohemia and of the Devonian and Lower Carboniferous of the Rhenish provinces; the two latter groups being unknown in Bohemia. If this is what might be expected in tracts lying in an intermediate position between the gorges of the Rhine and the country of Prague, we shall have to point out distinctions in the details of succession which it is important to note, as occurring in Thuringia on the one hand and in the Harz upon the other.

Attention will also be pointedly directed to those younger palæozoic deposits which overlie the small patches of coal known in Central Germany, and which one of us has described in other works as the "Permian Group." Indicating the great break above all the series from a primordial base up to the Lower Carboniferous inclusive (the wide-spread "Grauwacke" of old geologists) as separating all such deposits from the overlying and youngest palæozoic strata, it will be shown by what agency the original direction of the lower portion whose strike is universally from N.E. to S.W. has been changed to N.W. and S.E. as respects the geographical outline. Brief and general as the sketch is, it will point out the agreements and discrepancies of these German rocks as compared with each other, and refer them to types which are well known to British geologists.

Whilst the sectional woodcuts will explain some of these varied relations, a Tabular View (see p. 448) of the general order of the Palæozoic rocks of Germany with the lower secondary rocks which immediately overlie them is appended to the memoir, and in that table we have paralleled the foreign rocks with their English analogues.

The Thüringerwald.—In the work called 'Siluria,' recently published, we have given a succinct view of the succession of the strata in the Thüringerwald, as an addition to the first general sketch of that tract which appeared many years ago in the 'Transactions of the Geological Society.' In that work we have cited the map of Richter of Saalfeld* as most illustrative of the southern portion of this mountainous tract, and have particularly adverted to the map of Credner of Gotha as developing with great accuracy the features of the northern Thüringerwald. M. Credner having now completed his map of the whole chain, we had the advantage of consulting it on our last excursion. When collated with a general view by the same author printed in the 'Transactions of the Academy of Erfurt †,' that map gives so clear a view of the range in question, that the present communication might at first sight seem superfluous. But, in truth, it is still important to make our foreign contemporaries understand the true application of our insular terms in classifying their older rocks; whilst our countrymen will, we hope, be made to apprehend more clearly the manner in which the *physical divisional lines* between the respective palæozoic formations of Germany differ from those which have been observed in England.

Viewed in a geographical sense, the Thüringerwald is a mountain-

* Zeitschr. Deutsch. Geol. Gesell. Berlin, vol. iii. p. 536. pl. 20.

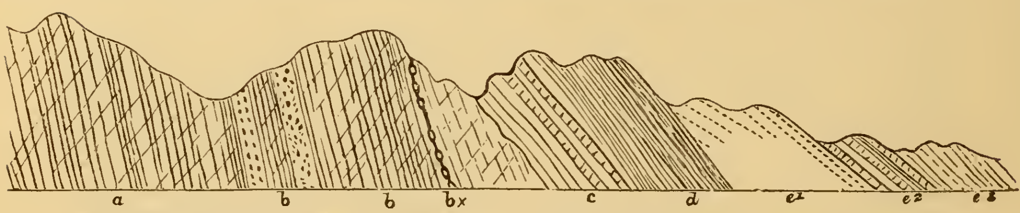
† Denkschrift der Königl. Ak. gemeinnütziger Wissensch. zu Erfurt, 1854.

ous wooded mass, the culminating points of which never exceed 3500 English feet above the sea, and whose main direction is from N.W. to S.E. Its length from the environs of Eisenach on the N.W. to those of Kronach on the S.E. is upwards of sixty miles, and swelling in width from a narrow apex on the N.W. it attains a maximum width of about twenty miles in its S.E. portion.

The south-eastern half of this tract is essentially distinct from the north-western; the first or wide part being made up of very ancient sedimentary strata, the second of crystalline rocks chiefly eruptive and here and there of metamorphic character; whilst the whole is surrounded by a girdle of Permian rocks, followed by lower mesozoic deposits which delineate the dominant direction of the mountains which they subtend.

Fig. 1.—*Diagram showing the General Succession of the Palæozoic Rocks in the Thüringerwald.* Horizontal distance about 12 miles.

N.W. S.E.



e. Permian (Rothe-todte-liegende, Zechstein, and Sandschiefer).
d. Lower Carboniferous.
c. Upper Devonian.
b. Lower Silurian (*b**, Courses of limestone).
a. Bottom rocks.

Lower Grauwacke or Cambrian, and Silurian.—The most ancient rocks, as seen in the S. Thüringerwald, consist of greenish talcose schists, traversed by white quartz veins, and of ferruginous and purple sandstone, the latter much resembling certain rocks of the Longmynd in Shropshire. When examined in detail, these rocks (marked *a* in the general diagram, fig. 1) exhibit towards the base quartz rock and dark slaty schist, the latter containing aluminiferous schist. These form the lowest courses, as seen in several undulations; the upper and chief part being the greenish slaty rocks above mentioned, and in which whetstones occur. In these rocks ("grüne grauwacke" of Richter, or "Cambrian" of the British Geological Survey), which have all been affected by a slaty cleavage, no other organic remains except Fucoids (*Phycodes circinatus*) have been found.

These fundamental rocks (*a*), exhibited in masses of great dimensions, and attaining, in the Oberland of Meiningen, elevations of upwards of 3000 feet above the sea, are covered conformably by the deposits which M. Richter termed grey grauwacke, an extensive and diversified group (*b*) of slate and sandstone with some courses of aluminiferous schist (*graue grauwacke, dach-schiefer, griffel-schiefer*, &c.), the whole of which is referable through its fossils to the Lower Silurian rocks. The section, fig. 1, merely represents the general succession. But from the observations of M. Richter, we believe that this fossiliferous Lower Silurian consists in its inferior portion of roofing-slates and coarse grits (almost conglomerates), subordinate to which are several beds with *Nereites, Orthis* resembling *O. grandis*, Sil. Syst., and *Beyrichia complicata*, whilst the schists contain many *Graptolites*. Whether there be Fucoids and Annelids in the lowest of these strata, or Trilobites, including *Ogygiæ*, of the type of *O.* (*Asaphus*) *Buchii, Orthidæ*, and *Graptolites* in the central and superior portions of the same, we have elsewhere* enumerated a sufficient number of fossils to leave no doubt of the true Silurian age of these grey-coloured slaty rocks, as recognized by M. Richter. In abundance of Graptolites and Annelids the Lower Silurians of the Thüringerwald bear, indeed, a most striking resemblance to the strata of the same age in the south of Scotland, which like them repose on rocks wherein no remains of animal life have yet been detected.

It is well worthy of note that several species of the *Graptolites* of the Thüringerwald and adjacent parts of Saxony are identical with British and particularly with Scottish types, and are also known in Bohemia, Scandinavia, North America, &c. The larger *Nereites* and the *Protovirgularia dichotoma* of this tract are also identical with Scottish types collected by Harkness and compared by Salter.

The impure limestone (b^+) lies in the upper portion of the series, and in it and the associated shale are found *Graptolites priodon* (*Ludensis*, Sil. Syst.) and other Graptolites, with *Orthoceras Bohemicum*? (*O. Ibex*), *O. styloideum*, and a Crinoid resembling *Crotalocrinus*. M. Barrande had suggested that this band might represent the base of the Upper Silurian of Bohemia or the lower part of the Wenlock; but, judging from any fossils we saw, we are unable to confirm this idea. For, whilst in Bohemia the Graptolite shales clearly overlie the mass of the Lower Silurian rocks, we know that in Britain the very same species of Graptolites descend into the inferior division of the Llandeilo formation†.

All these rocks have a strike from N.E. to S.W., which is therefore at right angles to the geographical axis or watershed of the chain, whilst the prevalent dip is to the S.E. It must here, however, be noted, that slaty cleavage planes are in general so prevalent, their dip being persistently to the N.W., that true observations on

* 'Siluria,' p. 352, 353.

† Whilst this memoir was passing through the press I received a letter from M. Richter, of Saalfeld, in which he states, that in the Lower Silurian slates there occur *Nereites, Myrianites, Lophoctenium, Orthis, Orbicula, Cladograpsus, Phytopsis, Palmophycus, Buthotrephis*. In the conglomerates which alternate with the Nereite beds are found *Beyrichia complicata*, Salt.; some undetermined Trilobites, *Orthis redux*, Barr., *O. testudinaria*, Dalm., *O. alternata*, ? 'Sil. Syst.,' *O. lata*, ib., *Leptæna sericea*, ib., *Pentamerus oblongus* and *P. globosus*, ib., *Fenestella subantiqua*, D'Orb., *Petraia subduplicata*, M'Coy, *Sarcinula organum* ?, Linn., *Nidulites favus* ?, Salt., and a Coral which was sent by me to my friend Mr. Lonsdale, who pronounced it to be a *Pleurodictyum*. M. Richter has since described it as a species distinct from the *P. problematicum* of the Devonian rocks, and has named it *P. Lonsdalei*. M. Richter confirms my view of the absence of all Devonian rocks except the Upper or Cypridina group, which he divides into two stages. As he has not observed any union between the Upper Devonian and the lowest Carboniferous strata, it is probable that there is a break, and that the Productus limestone and Kieselschiefer (which are present at Hof) being absent, the Upper Devonian of Saalfeld is at once succeeded by the equivalent of the Millstone grit—or "flœtz-leerer Sandstein" of the Germans.—R. I. MURCHISON, Sept. 15, 1855.

the real bedding are made with difficulty. Another and a still greater impediment to a clear examination of the lie of the strata consists in the dense covering of wood and the rare occurrence of rocks and open ravines. Even in places where the strata are visible, the geologist who is not versed in the lines of cleavage may easily assume that the latter are laminæ of deposit. In truth, the native geologists who have treated of these rocks were so deceived, that they were led thereby to represent in their earlier works that which would amount to a total inversion of all the mountain masses by a dip to the N.W., when in reality the strata (though subject to great undulations not represented in our general section) assume a prevalent inclination to the S.E.

Upper Devonian.—The "younger grauwacke" of this region (so styled by both Credner and Richter) consists of a union of the sub-groups which we term Upper Devonian and Lower Carboniferous. Constituting apparently one physical mass, these formations cover transgressively the Lower Silurian rocks, or abut abruptly against them (see fig. 1, *c* and *d*). In travelling across these strata, as exposed in the southernmost portion of the chain, *i. e.* between Koppelsdorf and Steinach, we found unequivocal Upper Devonian fossils in the higher strata, associated with limestones, and carboniferous plants of large size in the younger and more arenaceous deposits.

In that district, however, the disturbances have been so great (particularly along the banks of the river Steinach), and the strata are there so completely inverted, that M. Engelhardt very naturally represented as Lower Silurian those limestones which from their fossils we now know to be Devonian, and considered the rocks which are truly of that age to be Upper Silurian.

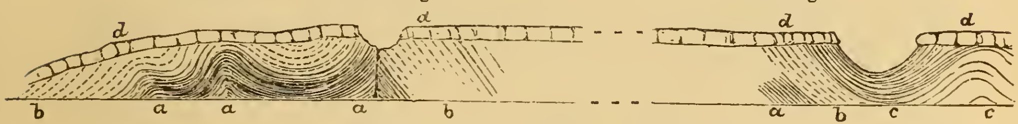
Passing, however, from that convulsed district, the real relations of the Devonian rocks of the Thüringerwald are best seen in the environs of Saalfeld, and particularly to the S.E. of that town, where they abut against the Silurian in the gorge of the river Saal. There, as in all the adjacent parts of Saxony extending by Schleitz to Plauen and Hof, there are no equivalents of the Upper Silurian or of the Lower or Middle Devonian. In the absence of the Spirifer-sandstone of the Rhine, and of the limestone of the Eifel, or their equivalents, the limestone, which we are about to describe, and which rests at once on the slaty Lower Silurian, is truly Upper Devonian.

In the undulating region to the east, which has been mapped by Naumann and his associates and described by Geinitz, the Upper Devonian is much swollen out and distinguished by interpolated sheets of igneous rock, the Schaalstein of the Rhine. On this occasion we forbear to enter into a detailed account of such rocks, and will now only speak of the Upper Devonian of Saalfeld, as seen in the cliffs at Bohlen, and the relation of the deposit to the younger strata of the Rotheberg, which we consider to be Lower Carboniferous. (See fig. 2.)

On quitting the grey Silurian, or truly "*grauwacke*" region of Saalfeld, and the tracts to the west and south of that town, and in proceeding to the east, the traveller suddenly finds himself at the foot of lofty calcareous cliffs of dark-reddish limestone and calcareous schist, with many nodules. Judging from the colour and external aspect of the rocks alone, the geologist sees, that in moving to the east he has left behind him everything to which the word 'grauwacke' can be correctly applied, and has entered among stony masses, which, whether they be red, brown, ferruginous, or dullish and greenish-white, are lithologically dissimilar to what he has traversed in the loftier hills of the forest. Overlying unconformably certain dark-coloured Silurian schists, the chief strata are calcareous beds, quarried as large flagstones, whose surfaces are distinguished by a multitude of greyish calcareous concretions, in a matrix of dark red shale.

These strata (fig. 2, *a*) are folded over in rapid undulations in the course of half a mile on the right bank of the river, and are fairly surmounted by thin-bedded, light greenish-grey, brown, and black schists, and shivery siliceous flags (*b*).

Fig. 2.—*Section showing the relations of the Upper Devonian and the Lower Carboniferous Rocks in the Gorge of the Saal, near Saalfeld.* Distance about 4 miles.



d. Zechstein, &c. (with traces of Weiss-liegende).
c. Lower Carboniferous, with Plants.
b. Flagstones and Cypridina-shale, with Plants. } Upper Devonian.
a. Undulations of Cypridina-limestone and shale. } Upper Devonian.

The inferior limestones and calcareous schists contain many fossils, which have never been referred to any type except that which the geologists of the Rhine, the brothers Sandberger and F. Roemer, class as Upper Devonian; whilst the concretionary schists and limestones in which they occur are to a great extent lithologically similar to the rocks of the western part of the Rhenish provinces, locally called Kramenzel-stein, or ant-stone*.

It may here be mentioned, that not one true carboniferous fossil (no large *Productus* for example) has been detected in this formation, which here has certainly a thickness of several hundred feet. On the other hand, all the typical forms are Devonian; viz. *Phacops*, three species; *Clymenia*, ten species; *Orthoceras*, thirteen species; *Goniatites*, eight species; and *Cypridinæ* in abundance, including the *C. serrato-striata* of the Rhine and Devonshire. The *Cypridina serrato-striata*, which so pre-eminently characterizes the Upper Devonian zone in the Rhenish provinces and the districts of Franconia,

* The Devonian fossils of Saalfeld, according to Richter, are—Cypridina, 2 sp.; Phacops, 2 sp.; Asaphus?; Bellerophon, 1 sp.; Orthoceratites, 13 sp.; Lituites, 2 sp.; Nautilus, 1 sp.; Clymenia, 10 sp.; Goniatites, 8 sp.; Euomphalus, 1 sp.; Cyathocrinus, 1 sp.; Actinocrinus, 1 sp.; and about 12 species of Cardinia, Terebratula, Avicula, &c. Many of these fossils are identical with those described by Count Münster, from the north flank of the Fichtelgebirge.

adjacent to the Thüringerwald, and, as we shall presently see, occurs in the Harz, is also here so abundant, that the name "Cypridina-schiefer" is just as applicable at Saalfeld as in the above-mentioned tracts.

A few small plants have been discovered in these schists; but it is specially as we ascend into the upper division of this formation (fig. 2, *b*) that fossil plants increase rapidly in number, particularly in certain hard, thin, siliceous courses of purplish and greenish sandstone. It is in this rock that M. Richter has found so many of the peculiar plants which, under the examination of Prof. Unger of Gratz, are stated to belong almost entirely to new genera and species. Of these, thirty-three species are enumerated as belonging to *Calamariæ, Filices, Selagines,* and two species to *Zamiæ* and *Coniferæ.* M. Unger believes that he has discovered in some of these plants a structure which indicates that they are prototypes of new genera, and possibly of new families, and others which indicate transitions between families already known*.

Following the strata in ascending order on the left bank of the Saal, and after passing over soft schists (the relations of which are obscured), we come to deep undulations, in which rocks of a mineral character quite unknown in any of the inferior deposits are exposed. These beds (*c*), which are well seen in a ravine around which the road winds opposite Teuschnitz, are highly ferruginous, brownish, micaceous sandstones, which range from the Rotheberg to the locality where we saw the plants. The surfaces of these beds are covered by many large plants, distinct from those of the inferior strata. Among them are *Calamites transitionis, Rothebergia* (*Megaphyllum*) *Holloberi,* and many others. Such lower carboniferous strata occur also in Saxony, particularly at Hainichen Ebersdorf, where coal is worked in them, and Prof. Geinitz has described the numerous plants they contain as being composed of *Calamitaceæ,* 3 species; *Filices,* 6; *Lycopodiaceæ,* 10; *Stigmaria* and *Sigillaria,* 2; and seeds of plants, 2 species. According to Geinitz, one only of these twenty-three species is found in the newer and overlying coal fields of Saxony.

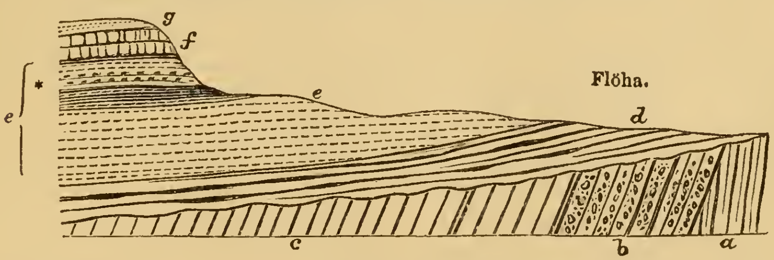
In short, all the plants last enumerated are now recognized by Geinitz as belonging to the lower coal; whilst those associated with the Cypridina-schists, or Upper Devonian, are, as Richter and Unger state, peculiar to that band. Here, then, if a transition should be traced from one set of beds to the other, we see a considerable distinction between the plants of the one and the other group. And, although the decisive test of any intermediate representative of the Mountain or Carboniferous Limestone is here wanting, it was long ago proved by Prof. Sedgwick and one of us, that in the adjacent country of Hof, in Bavaria, a Devonian limestone, which we have since ascertained to be precisely like that of Saalfeld, from its myriads of *Cypridinæ,* is at once surmounted by schists, sandstones, and a limestone with several species of *Producti* which are common in the Carboniferous Limestone of Britain.

* See 'Zur Flora des Cypridinen-schiefers,' von Prof. F. Unger, Berichte Akad. Wiss. Wien, Bd. 12. p. 595. The complete work is about to be published by Richter and Unger.

It must here be stated, though it forms no part of the Thüringerwald, that all the lower and undulating region between the eastern flank of that chain and the Erzgebirge is occupied either by Lower Silurian rocks as above defined, or by bands of Upper Devonian and Lower Carboniferous strata. The whole of these rocks, in contrast to the Thüringerwald, have preserved, to a great extent, a geographical direction from N.E. to S.W., in unison with their original strike. Associated with the Devonian and younger rocks of this large tract, the southern limits of which extend up to the Fichtelgebirge (their northern edges being buried under the Permian rocks of Gera and Pösneck), there is, as before said, a great interlamination of contemporaneous volcanic grit, or ash, which in many parts assumes precisely the form of the "Schaalstein" of the Rhine. Besides these, certain eruptive rocks, of posterior date, protrude here and there; these are quite distinct from the contemporaneous volcanic dejections above mentioned, and the deposits affected by them have been thrown into countless breaks and rapid undulations. In this way, black Lower Silurian slates, with *Graptolites* and *Orthidæ*, occur in juxtaposition to Upper Devonian. The latter, often expanded to considerable dimensions by the alternation of contemporaneous volcanic materials, and yet containing the same *Cypridinæ* and other fossils as at Saalfeld, are, in some localities, surmounted by sandstones, flinty slate, and limestone, charged with the unequivocal fossils of the Carboniferous Limestone; thus removing all doubt respecting the true order.

With this carboniferous zone terminate, in ascending order, all the formations, which the Germans have hitherto designated under the omnivorous word "Grauwacke;" *i.e.*, from the azoic base of the sedimentary rocks to the Millstone Grit inclusive. For all these rocks constitute, in a physical sense, one great mass in Germany, and, to a great extent, in France. They are entirely dismembered from all overlying formations, including the great or Upper Coal-fields of England,—a feature to which we shall again have occasion to allude in speaking of the Harz mountains, and on which we shall offer a general observation or two in our conclusions.

Fig. 3.—*Diagram exhibiting the general relations of the Palæozoic Rocks in Saxony.* (Chiefly from Naumann.)



g. Sandschiefer.
f. { Zechstein.
   { Kupfer-schiefer, &c.
e. Rothe-todte-liegende.
   * Plant-beds.
} Permian.

d. Upper Carboniferous (Flöha and Zwickau). }
c. Lower Carboniferous (Hainichen-Ebersdorf). } Geinitz.
b. Devonian.
a. Silurian.

In the meantime, attention is directed to section fig. 3, p. 417, which explains how, in the adjacent kingdom of Saxony, the three great inferior groups, viz. Silurian, Devonian, and Lower Carboniferous, are unconformably surmounted by the upper coal, and how the latter is followed by the Permian rocks. The clear physical distinction between the Lower and Upper Carboniferous, which was pointed out by Naumann, has since been confirmed by the palæontological labours of Prof. Geinitz.

Coal deposits (Kohlen-Gebirge).—In the Thüringerwald and the adjacent parts of Saxony and Bavaria, as in Bohemia, the strata from which coal is extracted overlie in transgressive positions all the other ancient rocks. (See fig. 3). In the Thüringerwald, and those places where we are acquainted with them, such coal deposits consist of lightish grey schists, or shale, and sandstones, in some of which there are numerous impressions of fossil plants. In none of these tracts has any indication yet been discovered of included animal remains, to prove that these accumulations were formed under the sea, or in marine estuaries like those of the antecedent Lower Carboniferous rocks, from which they are so sharply separated. The remains of vegetables with which they are filled have, it is true, the general *facies* of the rich carboniferous flora; but under a critical eye, the one set of plants is found to be distinct from the other in some genera, and in nearly all the species. For this fact, particularly as relates to Saxony, we are, as already mentioned, indebted to the recent researches of Prof. Geinitz *.

Whilst on this point, we can scarcely avoid reminding our countrymen, that as yet no geologist has endeavoured to ascertain whether or not there be the same marked distinctions between the floras of the Lower Carboniferous of Scotland and the overlying great coal-fields of England, as that which has been worked out in Saxony.

In the Thüringerwald, as in most parts of Central Germany, some geologists would indeed prefer to class these grey and dark coaly deposits with the red conglomerates and sandstones (Rothe-todte-liegende) which overlie them. But, guided by the analogies of Britain and North America, where the coal deposits resting upon the Lower Carboniferous rocks are symmetrically united over enormous areas, and unquestionably belong, by their remains, to the same great epoch, we adhere to the belief, that most of these small coal deposits, broken off as they are from the superior red strata of Permian age, are still to be classed with the carboniferous group. By this observation, however, it is not to be inferred that we are not quite aware of the existence of certain thin courses of coaly matter, associated with the Rothe-todte-liegende itself in parts of Germany.

Desirous of satisfying ourselves more perfectly on this point, and intending to revisit tracts where light may be thrown on the question, we must remark that, as far as our knowledge goes, the chief German coal distinctly underlies, and is never intermixed with, the Rothe-todte-liegende, or bottom rock of the Permian æra. Though

* Darstellung der Flora des Hainichen-Ebersdorfer und des Flöhaer Kohlenbassins. Fol. Leipzig (Hirzel), 1854.

Credner leaves it to be inferred (in some of the sections accompanying his map) that this coal of the Thüringerwald is conformable to the overlying red conglomerate and sandstone, there are tracts, even in this region, where the two rocks are unconformable; and Gutbier has shown that this is decisively so in the environs of Zwickau.

At Manebach, near Ilmenau, several thin seams of coal, the chief of which is about three feet thick, are extracted by horizontal galleries, on the east side of a deep valley, from beds of shale overlying gritty sandstone of dark and light colour, the last very thick-bedded, and the strata dipping N.E. about 13°. These are traversed and covered by rocks of igneous origin. In several spots the intrusive rock is a red quartziferous porphyry; at another place, about a quarter of a mile distant, the coaly strata are cut off by a granite or granitello, which, if it does not exhibit passages into porphyry, is at all events of very varied composition, even in the space of a few yards. At a third point the intrusive rock is a black porphyry (melaphyre).

These rocks have all been erupted through the coaly sediments, and have in great part overflowed them; for the red porphyry in particular forms the mass of the hill capping the coal strata.

In traversing the northern Thüringerwald on two parallels, we observed that the coal strata hardly rose up to points of any considerable elevation on the sides of the valleys; but usually outcropped from beneath those red rocks (the Rothe-todte-liegende) and the associated porphyries to which we shall presently allude.

At the southern extremity of the chain, north of Kronach, we had the clearest evidences of the coal being worked entirely from beneath accumulations of the Rothe-todte-liegende, of a thickness probably of 2000 feet, which, being inclined at high angles in a great recess in the older rocks, permits the coal strata (which are only visible in partial outcrops) to be worked by shafts of moderate depth.

In visiting two of the spots where coal is extracted, we could not satisfy ourselves as to the true character of the strata which there form the base of the coal deposit. According to M. Büttner of Kronach, one of the superintendents of these works, the lowest carbonaceous rock, abutting against the "Younger Grauwacke" (there Upper Devonian and Lower Carboniferous rocks), is a jaspidean claystone, which is followed upwards by a sort of conglomerate containing fragments of older porphyry. The immediate support, however, of the coal-bearing strata is a whitish coarse grit, not unlike one of the beds near Ilmenau. Associated with the coal, and forming its roof, there is a finely laminated indurated shale, in parts resembling the "black bat," so well known in Staffordshire and other English coal fields.

At Stockheim and Neuhaus, which we visited, and where the coal is raised in a shaft about 250 feet deep, the chief bed of coal was estimated at about 12 or 14 feet in thickness. The coal strata are much disturbed, and inclined, at angles varying from 80° to 25°, 60° to 50°, and thence to 25° near the surface, where they underlie the Rothe-todte-liegende or red rock. It is probable that part of this thickness may be in great measure due to an oblique section of the chief carbonaceous band. Again, we observed that by far the larger part of the mineral which was brought up in the shaft was not true coal, but scaly bituminous shale. The coal being carefully picked up in pieces which seldom exceeded the fist in size, and usually much smaller, was packed in neat new small barrels of wood, as carefully as herrings are stowed away at a fishing station,—so great is the value set upon the combustible, when transported from its natural position to the interior of Bavaria. At Neuhaus, where the pits are sunk in a deep depression from beneath an escarpment in the Rothe-todte-liegende, the coal is extracted in larger and cleaner fragments.

On the whole, it was manifest that the coal strata around the Thuringian chain, wherever we examined them, had been broken through and disturbed by those igneous rocks which played a still more important part in the older portion of the following or Permian æra, the strata of which are so enormously developed in and around these mountains, and especially in their northern portion.

Permian Deposits of the Thüringerwald.

Rothe-todte-liegende.—A great contrast is visible between the grey and dark coal strata of which we have taken leave and the overlying red deposits, which, under the name of Rothe-todte-liegende, occupy so large a part of this region. (See fig. 4, p. 424.). Judging from their fine lamination and their imbedded fossil plants, the former have unquestionably resulted from tranquil deposition under water, probably fluviatile or lacustrine; whilst the latter, which we now proceed to consider, have been formed in a period of turbulence, accompanied by the extrusion of much igneous matter.

The great red formation named the Rothe-todte-liegende has been described by so many German authors, that it is unnecessary to dilate upon its structure. We would, however, remark, that, much as we have examined the deposit in different parts of Germany, we know of no tract in which it is of larger vertical dimensions or is so exhibited in mountainous masses and on the sides of deep ravines as in the Thüringerwald.

The chief development of the deposit is seen in the northern half of the chain. It is singularly well displayed, for example, both in quarries and on the sides of the high road leading to Frankfort, immediately above Eisenach, and on the flanks of the hill on which the convent and castle of Wartzburg stand, once the residence of Luther.

It is indeed to be studied in so many localities, whether on the flanks of the northern ridge or in its interior, where it is associated with porphyries, that M. Credner's map and the excellent roads both longitudinal and transversal will lead every traveller to numerous exhibitions of the rock.

Though argillaceous and thick-bedded sandstones of dark red brick colour are chiefly exposed at the base of some of the natural sections where the deposit overlies the coal strata, and whilst such finely levigated red substance forms the matrix of many of the coarser beds, the dominant features of the formation, particularly of its middle and upper members, are the so-called conglomerates. These great bands, often of vast thickness, ought, strictly speaking, to be termed breccias, particularly near Eisenach. For, whatever be the included material, whether quartz rock, mica schist, old porphyry, granite, or greywacke slate, the fragments are usually angular; none of them presenting the aspect of having been rolled on a beach or rounded by the action of the waves. However these angular or subangular pieces were accumulated, the impression left on the mind of the observer is, that they were got together in a very rapid and tumultuous manner.

The movements, however, by which they were aggregated were clearly suspended and repeated many times; the intervals of quiescence allowing of those deposits of finely triturated red sand and mud which alternate with the coarse and subangular breccia. In the granitic breccia under the Wartzburg, it is curious to remark (as pointed out to us by Professor Senft of Eisenach), that the included granite fragments in one of the several courses which we observed to alternate with beds of sand and shale have been derived from a rock no longer visible in the chain of the Thüringerwald, but which was doubtless a mass once near at hand—probably just beneath the very breccia that has been made out of it. It is a granite containing pericline and black mica.

These angular breccias and conglomerates, with their associated sandstones, are of gigantic dimensions, and have been bored into in fruitless searches after coal to a depth of about 2500 English feet! Their chief mineral characteristic is their intimate association with huge masses of porphyry, some of which have manifestly been emitted coincidently with the formation of the breccias. So intimate, indeed, is the association, that here, as in many tracts of Germany, it is occasionally most difficult to disentangle that which may be termed a true eruptive rock from bands of breccia in which other fragments of altered schistose and the older sedimentary rocks are mixed up. This is peculiarly the case where the porphyritic matter has overflowed and has been extended horizontally.

An examination of this chain proves, that the northern Thüringerwald has been penetrated at almost countless points by porphyries of various characters, and of which M. Credner distinguishes about six varieties in the red or quartziferous porphyry alone. True melaphyre (or the so-called black porphyry) is also abundant.

It would appear that rocks of igneous origin have penetrated this chain from a very early period. Thus, in the Lower Silurian slates we meet with greenstone, granite, and an ancient red porphyry, the last-mentioned being in fact the rock whose fragments are found in the Coal-measures and Rothe-todte-liegende. These old eruptive masses are said by M. Credner to be limited to the Silurian and not to enter into the Devonian strata,—a point on which we have not yet satisfied ourselves.

Hypersthene rocks are seen to rise through the Upper Carboniferous layers and to have greatly altered them: but it is only on ascending to the Rothe-todte-liegende that we are surrounded on all sides with porphyry, and as this period of turbulence was followed by one of beach action and quiescent marine deposits, to which we shall presently advert, it is quite manifest, that all the breccias and coarse conglomerates, however composed of mixed materials, were formed during a period of igneous action, perhaps more intense than any to which an appeal can be made in the history of other German formations. In fact, it was in this, the earlier part of the Permian æra, that those grand eruptions took place from N.E. to S.W. which obscured the ancient physical direction of the rocky and slaty masses that trend from N.E. to S.W., and determined the axis or watershed to be at right angles to the original outline of the ridges.

As we shall have to speak of a similar phænomenon in the Harz, we reserve for awhile our inferences concerning the condition of the earth's surface during the tumultuous period of the earlier of the Permian deposits, when such vast physical changes occurred.

In the meantime we may indeed truly say, with M. Credner, that the northern portion of the Thüringerwald is essentially a porphyritic chain; since nearly all its highest central summits, from the Kahle Berg and the Inselsberg, the latter 3096 English feet, to the Schnee Kopf or highest point, about 3300 English feet above the sea, consist of red porphyries, which ranging from N.E. to S.W. constitute what is locally termed the Rennsteig or central ridge, which determines the axis or watershed to which all the rock-masses of the chain have in a geographical sense been rendered subordinate.

No organic remains have been found in the Rothe-todte-liegende of the Thüringerwald, as might indeed be expected from the mineral structure and condition of the rocks, except certain hard silicified stems of fossil plants, *Psaroniæ*, &c.

In the environs of Zwickau, Chemnitz, Dresden, &c., however, where very finely laminated claystones are intercalated in the middle of the conglomerate series, Colonel Gutbier has collected and described about sixty species of *Calamariæ*, *Filices*, *Selagines*, and *Coniferæ*; of these forty are considered by the author to be peculiar to the Permian, three of them being also found in the Permian group of Russia (*Calamites gigas*, *Sphenopteris erosa*, and *S. lobata*). On the other hand, seven of the sixty species described are considered to be forms known in the Coal-measures*.

In relation to the adjacent region of Saxony, we think it right here to allude to various outbursts of porphyry, and to wide extensions of the Rothe-todte-liegende and its subjacent coal strata, as existing near Zwickau, Chemnitz, and other parts of Saxony, where the coal, on the authority of Prof. Geinitz, lies invariably beneath every stratum to which the term "Rothe-todte-liegende" can be applied. In these tracts, as well as in the environs of Dresden, the lower division of the red rocks is composed of sandstones and shale, and the upper portion alone near Dresden (according to Geinitz) is a coarse conglomerate. In traversing the country from Freiberg to

* Versteinerungen des Permischen Systemes in Sachsen, von A. v. Gutbier. Dresden and Leipsig, 1849.

Dresden, we were much struck with a natural section which exhibits the intimate dependence of this coarse conglomerate upon contiguous eruptions of porphyry. On quitting the plateau of the so-called "gneiss" of Freiberg (a crystalline stratified rock, which we have elsewhere speculated upon as being probably nothing more than metamorphic Silurian *, and which is penetrated here and there by granite), we passed over a great breadth of red porphyry, on the western boundary of which, and in the deep gorge of Tharandt, the igneous rock is exposed in towering pinnacles, and is clearly seen to have penetrated the gneiss, which extends eastwards to near the village of Hainsberg. On approaching the latter place, powerful conglomerates of the Rothe-todte-liegende are seen resting in inclined positions on the eastern flank of the gneiss and crystalline rocks. These conglomerates, which are considered by Geinitz to lie in the upper part of the formation, are made up essentially of the gneiss and granite of the adjacent hills through which the porphyry has risen up, and have therefore directly resulted from that intrusive igneous agency. The blocks are often of several feet diameter, and on the whole the mass reminded us much of the coarse conglomerate of the Old red sandstone on the north flank of the Ord of Caithness.

In the deep ravines E. of Dresden, leading into the Plauensche-grund, into which, in company with Prof. Geinitz, we descended from plateaus of overlying horizontal sandstones of the Cretaceous group, we examined other rocks of the Rothe-todte-liegende which there overlie the coal, and saw the following descending order:—1. Conglomerate. 2. Variegated deep red shale with green spots. 3. Pink-coloured porphyry, which, though a true igneous rock, is as regularly stratified and jointed as the red strata with which it alternates. It is the "Schlam-lava" of Geinitz, and offers in truth the most perfect evidence of having been a *coulée* formed during the agglomeration of the Rothe-todte. Thus far the section is open to view on the side of the hills; the remainder is known through the sinkings for the underlying coal. According to the working plan of a very intelligent manager of the works at Häinichen, the shafts passed down through about 500 feet of other massive alternations of the Rothe-todte, alternating with porphyries, before the first traces of coal were reached. The best bed of coal has a thickness of about 3 feet, and was first worked at a depth of 158 lachter or about 1100 English feet. It was soon lost in this its first and horizontal position, and was subsequently regained in *a highly inclined position* on the slope of the hill, 48 lachter beneath the upper level. When we visited the spot another sinking was being made somewhat lower on the hill side, through 800 feet of the Rothe-todte, to win the coal in a deeper part of the valley. The works in the Plauensche-grund leave therefore no room to doubt, that whilst the coal strata were here originally quietly deposited on gneiss and other ancient rocks, they were subsequently penetrated by eruptions of porphyry accompanied by great dislocations, which broke up the carboniferous rocks and left them at the very different levels and at

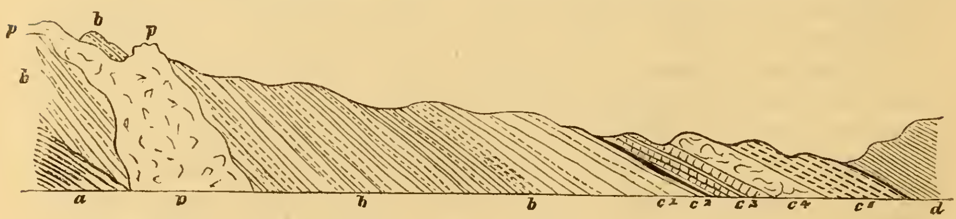
* 'Siluria,' p. 361.

the various angles of inclination which they present to the miner who explores them. This tract offers clear evidence, that the porphyritic eruptions were not only violent, but successive and numerous during the period of the Rothe-todte-liegende, and that they overflowed strata of that formation in the form of submarine *coulées*. Here also, as indeed in many other parts of Central Germany, we learn how these dejections of contemporaneous porphyry and amygdaloid have been occasionally so mixed up with pebbles and sand of the then existing sea, as to render it difficult in such cases to decide whether the stratum should be considered as one of igneous or of aqueous origin. In all such extreme examples, however, the geologist who is seeking after a truthful explanation of the works of nature will admit that such strata are not to be dogmatically defined by one mineral term only, but that, like the volcanic grit or ash of earlier periods, they are to be viewed as true indications of the internal heat of the crust, which, in bursting forth repeatedly, gave rise to those peculiar deposits which resulted from a combination of subaqueous and volcanic causes.

Weiss- or Grau-liegende—Kupfer-schiefer—Zechstein, &c.

Weiss-liegende.—The sandstones, breccias, and conglomerates of which we have just spoken are succeeded in this region, as in many other parts of Germany, by a band differing from all beneath it in its light grey or whitish colour, as derived from a quantity of pebbles of white quartz in a grey paste. This is truly a conglomerate made up of rounded small stones, which present all the appearance of having been formed by waves upon a shore. Since it forms the natural base of the Copper-slate, the miners necessarily applied to it the name of "liegende," as underlying the productive mineral stratum. This bed or band (for it varies in thickness from 3 or 4 feet to 30 or 40) may be properly considered the base of the Zechstein or Magnesian limestone division of the Permian rocks, since in it, after ascending through the siliceous strata of the Rothe-todte-liegende, we first find calcareous matter beginning to show itself, and with it a few rare fossils.

Fig. 4.—*Diagram showing the Succession of the Permian Rocks on the Flanks of the Thüringerwald.* Horizontal distance about 4 miles.



d. Lower Bunter.

c^5. Sandschiefer.
c^4. Upper Zechstein (Dolomite).
c^3. Lower Zechstein.
c^2. Kupfer-schiefer.
c^1. Weiss-liegende.
b. Rothe-todte-liegende.
} Permian Rocks.

a. Coal-strata (Upper Coal).
p. Porphyry.

The accompanying diagram (fig. 4) shows the position of this Weiss-liegende, c^1; and the open section in which we best saw it, as there represented, is to the S.W. of the village of Schmerbach, not far distant from Waltershausen near Gotha, where it rests on unequivocal Rothe-todte-liegende, in the form of red and green spotted sandstones, flagstones, &c.

Kupfer-schiefer.—At the same place, we also examined the exposure of the justly celebrated bituminous black schist called Kupfer-schiefer (fig. 4, c^2), which having been followed from its outcrop, like that which is represented in the diagram, has been worked from beneath overlying deposits throughout such extensive districts of Central Germany. Though here only exhibiting a thickness of about 5 feet, this black schist is most neatly defined in its position between the grey pebbly rock beneath and the overlying bands of limestone. The schist is little cupriferous at this spot, but we found in it many fragments of the characteristic fossil fishes.

Zechstein and Sandschiefer.—Above the Kupfer-schiefer follow thin stratified layers of marly limestone (fig. 4, c^3), on which the thick masses of Zechstein repose, that contain the *Productus horridus* and many other fossils. With its lateral extension this formation assumes varied mineral characters, some of which are more decisively impressed upon it in certain localities than in others. Thus, extending from Eisenach by Heiligenstein and Seebach to Schmerbach, Fischbach, Ilmenau, Konigsee, and Saalfeld, on the north-eastern flank of the chain,—or by Altenstein, Liebenstein, Herges, Eisfeld, and Haich near Kronach, on the south-western flank, the ordinary limestone passes up into, and is often entirely represented by, thick masses of true dolomite. This dolomite, in which organic remains are found, as well as in the adjacent marly limestone, forms highly picturesque cliffs, particularly around Liebenstein, the vertical faces of which are frequently marked by natural openings leading into extensive caverns, occasionally containing in the detritus of their floors the remains of extinct fossil mammalia.

It is also in this zone, and chiefly where the rock is a dolomite, that the great gypseous masses which so characterize the German Zechstein occur; and of these we shall have occasion to speak more at length in treating of the region of the Harz. In the region now under review, the largest natural exhibitions of these gypseous rocks which came under our notice lie immediately to the east of Saalfeld, or near the foot of the lofty escarpments of the overlying Bunter-Sandstein.

At Rheinhards-brunnen, east of Gotha, a large mass of gypsum, which has been opened out by a gallery, is here so highly crystalline and transparent, that it forms (under the name of the Glas-hohle) an object of great attraction and wonder to numerous tourists *.

It is also to be remarked, that iron ores, both the "braun-eisen" and spathose varieties, are extracted from the dolomitic or Upper

* Her Majesty the Queen visited this splendid cavern in 1845, and H.R.H. Prince Albert transmitted some magnificent specimens of the crystallized gypsum to England, one of which is to be seen in the mineralogical gallery of the British Museum.

Zechstein at Kamsdorf near Saalfeld, where they occupy two beds, described by Richter *.

The natural capping of the great masses of the Zechstein and Dolomite with its gypsum consists of the regularly bedded brown-coloured impure fetid limestone, called Rauch-kalk, in which the characteristic fossils of the formation cease.

According to the classification proposed by one of us, there are, however, yet some other overlying beds (fig. 4, c^5) which form the natural summit of the Permian rocks, but which have hitherto been classed by German geologists with the Bunter-Sandstein or base of the Trias. In numerous sections they are indeed seen to lie in the same ridge with the Zechstein and to constitute its cap. They are the lowest part only of the Bunter-Mergel of Credner (also Sand-schiefer or Sandige Mergel-Schiefer of that author), and are finely laminated and sandy marlstone, occasionally exhibiting a mineral transition through their calcareous contents into the underlying Zechstein on which they repose.

We have for some years thought that the Bunter-Sandstein of Central Germany ought fairly to be deprived of this inferior member, because it has never offered any Triassic fossil, whilst it has been found to contain a Calamite more allied to the palæozoic than to the mesozoic deposits, and also because it is physically and mineralogically connected with the Zechstein. But these reasons could not alone have led to our including this band (fig. 4, c^5) as the upper limit of the Permian, *had not our survey of Russia taught us, that over very extensive regions, the fauna and flora*—i. e. *reptiles and land plants of true Permian characters, and which are characteristic of the Zechstein zone of Germany—ascend in Perm, Orenburg, Kazan, &c., far above that zone into red sandstones, marls, and conglomerates.* In that vast country, where there are no inversions of the strata, and where the beds are nearly horizontal, there can be no mistake. Hence, until some fossil evidence shall invalidate our inference founded on such good proofs, physical and zoological, we shall continue to class the unfossiliferous bottom rocks of the hitherto so-called Bunter-Sandstein of Germany with the Permian group. In fact, our English sections of the true Permian series where it is best developed, as in Nottinghamshire and Yorkshire, sanction this classification. In his excellent memoir on the Magnesian Limestone, Prof. Sedgwick has shown, not only how the Lower Red Sandstone is surmounted by the equivalents of the Kupfer-schiefer and Zechstein, but also how the last-mentioned is capped by red and green marls, which he associated with the subjacent calcareous masses †.

The fossils of the Zechstein have been so long studied by German naturalists, that if such were our object, we should have to refer to a variety of works for a complete acquaintance with them. Recently Professor Geinitz described many new species, and subsequently M. v. Schauroth ‡ has added other forms new to science, and has con-

* Einladungs-Programm der Realschule, &c. (p. 21), 1853, Saalfeld.
† Trans. Geol. Soc. Lond. 2nd ser. vol. iii. p. 37.
‡ Zeitschrift, Deutsch. Geolog. Gesell., Band vi. p. 539.

cluded his memoir with a valuable table, in which all the species of plants from Algæ to Coniferæ, and of animals from Zoophytes through Molluscs and Crustaceans to Fishes and Reptiles, which are common to Germany, Great Britain, and Russia, are specially marked. By this comparison we learn, that out of one hundred and thirty-eight species known in Germany, sixty-nine or one half are British forms; twenty of these German species being found in those vast eastern provinces of Russia, whence the name of Permian was derived. In short, we see in the Permian that which is common in our own Isles throughout the palæozoic rocks, and on which we have previously dwelt, viz. that each natural group is characterized by a central mass of limestone, in which the fossils prevail, and from which they diminish upwards and downwards as the rocks pass into sands, shale, or other strata void of or slightly charged only with calcareous matter.

In the Permian rocks, then, of the Thüringerwald and other parts of Germany, we consider the Zechstein to be their calcareous centre; for the æra of the Rothe-todte-liegende was, on the whole, too turbulent and its sediments too much charged with iron oxides to lead us to look in them for any good examples of organic remains. In fact, a very few fragments of plants, including the well-known stems of Ferns called *Psaronites*, are all that we usually detect in the deposit, though in certain localities where the physical conditions have been favourable, as in the claystone between the conglomerates in the environs of Zwickau and in two or three spots in Saxony, an abundant flora has rewarded the researches of Colonel Gutbier *.

Now, in Russia, the physical conditions do not exist which in Germany satisfactorily account for the restriction of the fossils to one calcareous zone. In the first place, there is no great coarse conglomerate or trappoid breccia beneath the limestones, but simply some grits and sandstones with plants, &c. Again, the calcareous matter, instead of being confined to one zone, reoccurs even in the form of limestone at several levels (bands of red and variegated sandstone being interlaminated), whilst the whole of the limestone is crowned by coarse conglomerates and sandstones infinitely more resembling the Rothe-todte-liegende than any of the subjacent strata. It is in this upper band that the remains of reptiles belonging to the group of *Protorosauri* have been found, which in Germany is found beneath the limestone. It is, indeed, in these overlying sandstones and conglomerates that most of the plants of the Permian or quasi-Carboniferous type occur, the same upper zone being also that which is so extensively charged with copper ore, that mineral being in Germany invariably *beneath the limestones*.

From these evidences, therefore, which are positive, and are not discountenanced by any data in Germany, we adhere to the classification of the Permian group as originally defined by Murchison and his associates De Verneuil and Keyserling.

* Out of sixty species of these Permian plants, forty are peculiarly Permian, and of these several are identical with forms brought from *strata which lie above all the Zechstein bands in Russia*. See Verst. Perm. Systm. in Sachsen, Heft 2.

Base of the Mesozoic or Secondary Rocks, viz. the Trias.—Without having any pretension to describe the older Secondary rocks or Trias which on all sides overlie the palæozoic rocks of the chain of the Thüringerwald, and occupy all the interjacent country extending northwards to the Harz, we can scarcely avoid calling the notice of English geologists to some of their leading features.

We have already said that no animal remains have been detected in the Lower Bunter-Sandstein which forms the base of the Trias of the German geologists. Nor are we aware of any such remains having been discovered, except in the upper division of the formation and not far beneath its junction with the lower strata of the Muschelkalk.

Wherever the sandstone has been found to be fossiliferous, whether at Hilburghausen near Coburg, where the celebrated footprints of the *Cheirotherium* are found, or at any locality which has yielded the remains of large Saurians (*Trematosaurus, Capitosaurus, Metopias, Nothosaurus,* &c.), it is the superior band of sandstone in which they are found,—a rock which is separated by a vast thickness of strata from the Zechstein deposit and its natural capping. All these intermediate strata of the so-called Bunter-Sandstein, in which no remains of fossils have been detected, constitute therefore what must at least be called debateable ground by all geologists who classify formations according to their imbedded remains. Nor can the field observer who may work out his inductions by the collocation and mineral character of the rocks offer any good reason for attaching these intermediate red sandstones to the Trias above, rather than to the Permian below them. For, as has been already shown, certain Permian animals and plants rise high into those red sandstones and conglomerates which in Russia lie above the Zechstein.

As far, therefore, as evidences go, they are, I repeat, entirely in favour of our placing the upper limit of the Permian higher than it has been provisionally drawn; since if the Russian analogy is found to hold good in Germany, our associates in that country must necessarily separate all the Lower Bunter from the Trias and class it with the Permian. Even when we refer to mineral characters and the nature of the physical sequence, we can find in Germany no reason whatever for placing the lower limit of the Trias where it now stands according to native authors. If lithological distinctions be appealed to, we see good spotted sandstones, red, white, and green (particularly in Saxony), both below and above the Zechstein, thus exhibiting the Permian as a Lower or *Palæozoic Trias*.

Now, the Permian, which is thus a Lower Trias, is everywhere throughout Germany completely conformable to the original and superjacent Trias, which, having the great and widely extended Muschelkalk as a central limestone between two formations of sand and red marl, was justly so named.

Without a break, and without the trace of eruptions, which, perforating the lower strata, have spread out their *coulées*, cinders, and ashes in those contemporaneous sheets which abound in the subjacent palæozoic rocks, the highest Permian strata, *i. e.* from the

Zechstein upwards, graduate insensibly by mineral characters into the Lower or unfossiliferous Bunter, or the Uppermost Permian of our sections. The next overlying mass, which we consider to be the real Bunter, with its upper courses containing fossils, gypsum, and some calcareous matter, forms the true natural-history base of the original Trias. Then comes the Muschelkalk with its lower band of thin wavy or undulating flaggy limestone, known as "Wellenkalk," its central mass with gypsum, and its superior division a limestone;—each locally characterized by certain species of fossils. Lastly, we have the Keuper marls and sandstones, with a base called Letten-Kohle (from certain thin layers of carbonaceous matter contained in it), a middle band with gypsum, and a third or Upper Sandstone on which the Lias rests.

Whilst all this Triassic group has, through its imbedded fossils, whether animal or vegetable, a community of character, the dominant types being found in its great calcareous centre (including many Saurians and Fishes and a rich invertebrate fauna), there are not in the whole group any forms identical with what existed at the close of the Palæozoic æra. An entirely new creation succeeded in this first stage of Mesozoic succession; and yet this wonderful change in life was unaccompanied by any visible interference with the regular increment of submarine and estuary matter, and without any dislocations or disturbances of the successive sea-bottoms in which the fossil animals are imbedded.

We have dwelt pointedly on this great feature of geology in other works*, but we revert to it specially on this occasion, since, as far as we know, there are no tracts in Europe in which the conformable succession of the uppermost palæozoic and the lowest mesozoic, as characterized by distinct relics, is so well exhibited as on the flanks of the Thüringerwald, and in the region lying between that chain and the Harz,—a vast trough, in which the grand undulations of the Trias are so clearly exposed.

PART II.

The Harz.—Long as the Harz Mountains have been explored by naturalists, and well as their mineral composition and fractures are known, through the labours of Von Buch, Hausmann, and others, their true geological history is yet far from complete. Referring little to the numerous mineralogists who formerly wrote on this small but highly diversified excrescence on the surface of Northern Germany before its palæozoic classification was attempted, we can now do little more than offer some additions to a memoir written in the year 1839, and published in the Geological Transactions by Sedgwick and Murchison. In that Memoir it was shown, for the first time, that a large portion of its so-called "grauwacke and quartz rocks" was of no higher antiquity than our British Lower Carboniferous deposits, and was the true equivalent of the "Culm" series of schists, limestones, and grits of Devonshire;—that a great mass beneath the above,

* See particularly 'Russia in Europe,' vol. i. p. 582; 'Siluria,' p. 464.

consisting of limestone and schists, was of the same age as those strata to which we had then just assigned the name Devonian; and the belief was expressed that, whilst certain shelly sandstones (Rammelsberg near Goslar) probably stood in the place of the uppermost Silurian, the rocks occupying the south-eastern portion of these mountains, and in which at that time a very few imperfect Trilobites only had been found, would prove to be among the oldest in the chain.

Though it formed no part of that earlier sketch to describe the secondary deposits which range along the northern flank of the ridge, still, as on two different occasions the authors had cast a rapid general glance over them, they indicated some of their chief dislocations and remarkable inversions of order. They also treated of the probable periods at which the granite of the Brocken and other igneous rocks around that mountain had been erupted.

At that time, however, the "Zechstein" was classed with the Secondary rocks, and not grouped, as it has since been, with the "Rothe-todte-liegende," so as to constitute that which one of us has since termed "Permian."

A notice like the present, which is brought before the Geological Society after an interval of fifteen years, must necessarily indicate other features and new bases of classification, the result of recent researches and comparisons. At the same time, it is due to Prof. Sedgwick and his coadjutor to state, that their views regarding the "Culm" strata and the underlying Devonian limestones and schists, as well as their opinion that the south-eastern portions of the Harz were older than the western limits, have all proved to be correct. In short, the general order of superposition of the strata, since called "palæozoic," which was then indicated, is accurate. The only changes made are palæontological, not stratigraphical, and consist in the application to the Harz of that portion of the classification by organic remains, established in the Rhenish provinces by Ferdinand Roemer and the brothers Sandberger, whereby the sandstone charged with large "Spirifers" has been abstracted from the Upper Silurian of the original sketch alluded to and classed as "Lower Devonian," a change, which has, indeed, been long ago adopted by ourselves and all geologists.

In the present communication we shall therefore in the first instance simply attempt to give a general sketch and fill up some lacunæ of detail in the distribution of the palæozoic rocks of the Harz; leaving it to native geologists to complete what is still wanting, a full illustration of this convulsed, mineralized and metamorphosed region,—a task which, however difficult of accomplishment, has been commenced by M. Adolf Roemer, by the publication of a geological map.

General view of the order in which the Palæozoic Rocks succeed each other in the Harz.—In a tract so perforated by igneous rocks of various characters, and where, as we approach the chief axis, or that of the Brocken, even the carboniferous or culm rocks are often in a crystalline condition and in inverted positions, it is hopeless to look for clear evidences of the general succession of the strata. Nor can we expect to find satisfactory proofs of order in the highly mineralized masses which range from Clausthal by Andreasberg towards Hasselfeld, where deposits of very different age lie frequently in juxtaposition, and are often highly altered, and enclose veins of argentiferous galena, copper, &c.

At the south-eastern extremity of the region, and where the mountainous outline subsides into featureless low hills and plateaux, the river Wippra, flowing in a deep valley, exposes peculiar crystalline rocks. These consist of masses of glossy, thinly foliated, grey and greenish "shillat" or chlorite slate, with innumerable subordinate laminæ of white quartz. On the north bank of the gorge these strata are well exposed on the sides of the steep precipitous road which descends to the village of Wippra, where they are vertical or very highly inclined, with a strike from N.E. to S.W. Though we followed the Wippra valley, by the picturesque Schloss * of Rammelsberg and its eruptive rocks, amidst a reddish-coloured grauwacke, to Biesengerode, Vaterrode, and Lembach to Mansfeld, we could see no natural sections exhibiting any consecutive order until we met with the conglomerates of the Rothe-todte-liegende, lying unconformably on older strata, "grauwacke," the white quartz bands of which had evidently afforded the pebbles of the red conglomerate.

We incline to the belief, that the glossy chloritic and quartzose slates of the Wippra are probably the oldest in the chain, and for the following reasons :—First, that we are unacquainted with any rocks like them in the general series of deposits of the Harz (which we are about to notice), whilst they bear a strong mineralogical resemblance to the oldest sediments of the Thüringerwald. 2ndly. That the Wippra schists most resemble (if indeed they are not a southerly extension and probably an inferior portion of) those adjacent strata near Harzgerode, which, judging from the fossils, are supposed to be of Upper Silurian age. As, however, no country can well be more featureless and obscure than the tract between the Wippra and Harzgerode, we offer this surmise with caution ; the more so, as the only rocks visible in the intervening tract are a few bosses of greenstone or other igneous rocks with contorted flinty slates (Kieselschiefer).

Silurian rocks†.—In the tract extending from the environs of Harzgerode on the east towards Guntersberg, Hasselfeld, and Andreasberg on the west, a series of low undulations expose here and there bosses of limestone, in which fossils have been detected at a few localities only. In one of these masses of limestone, as exposed to the west of Harzgerode, and formerly noticed by Sedgwick and Murchison, and also in another a mile or two further to the west, at

* We are not aware that any other British geologists, except ourselves, have examined the banks of the Wippra.

† Since this memoir was read, I have been informed that M. Ad. Roemer has discovered *Graptolites* in some of the schists of Lauthenthal, and the existence of true Silurian rocks in the western as well as in the eastern Harz is thus indicated.—R. I. Murchison, Sept. 11, 1855.

the lime-works of the Silber-Hütte, a few imperfect fossils were long ago observed. At the latter, a limestone subordinate to greenish and greyish schists is followed upwards by a much coarser grauwacke, which becomes almost a conglomerate. Here the strike is nearly N. and S. and the dip E.; but, as the dips of these schists, grits, and calcareous interpolations frequently change, we now only notice the direction and inclination of the beds at the Silber-Hütte, because the strata there have a strike transverse to the usual direction of the older rocks.

Passing into the Selke-Thal, the continual undulation of the strata is well seen in the gorge between Alexis Baden and Mägdesprung. Unable to decide, in a rapid survey of this confused tract, whether the rocks at Alexis Baden lie over or under those of Mägdesprung, we met at that place with strata well exposed in quarries on the left bank of the Selke, which have been much opened out in the years which have elapsed since they were examined by Sedgwick and his coadjutor. There the succession is decidedly exposed, and thanks to the labours of M. Bischof, Inspector of Mines, a rich collection of fossils has been made, which, as we think, determines one mass of these rocks (*i. e.* the calcareous member of them) to be Silurian. (See fig. 5.)

Fig. 5.—*Section of the Upper Silurian Rocks at Mägdesprung.* Distance $1\frac{1}{2}$ mile.

c. Schists and sandstone.
b. Limestone with Upper Silurian fossils.
a. Flagstones with Plants.
*a**. Altered schists.
g. Greenstone and other eruptive rocks.

The inferior strata visible, as exposed in the so-called "Treppen Stufen" or great flagstone quarries opposite the hamlet of Mägdesprung, have the normal strike of N.E.–S.W., and dip to the S.E. at 65°. They are very fine-grained, have glossy surfaces, and are of bluish-grey, purple, or greenish tints, so that they are distinguishable in mineral aspect from both the ordinary Devonian and the Culm rocks of the chain. Either they have no cleavage, or the divisional planes are coarse and coincide with the bedding. The flagstones, the varied green and grey tints of which indicate the successive strata, are cut across by devious and irregularly meandering clefts called "Stossen" by the workmen. These are frequently accompanied by quartzose veins, and when they approach to horizontality are made use of by the workmen as stages or tops and bottoms for quarrying out the flagstones. The slabs are often of very large dimensions, whilst their surface, exhibiting undulation and ripple-marks, leave no doubt of the true nature of their bedding. This is, indeed, still more unequivocally proved by their exhibiting (though very rarely) traces of plants and apparently the trails of animals. Some of the plants have the aspect of forked sea-weeds; but one large and true land plant has also been found, and has been called by M. Adolf Roemer a *Sigillaria*. On the whole, these flagstones, which when extracted are occasionally 10 feet by 7 feet, reminded us in their aspect of the Scottish Arbroath paving stones, and the so-called Valentia slates of Ireland, both of Devonian age *.

Plunging distinctly at 65° to the S.E., these strata are followed by others slightly differing in mineral characters, but which, being little cut into, are not so well known as those at the works of Mägdesprung; but the apparent ascending order is unambiguous in exposing a seemingly conformable succession upwards, with a dip to the S.E. for about half a mile, until a band of limestone (*b*) is reached, in which the numerous fossils have been found which constitute the Silurian collection of M. Bischof. This limestone, from 30 to 40 feet thick, is hard and crystalline, of dark grey colour with white veins, rough to the touch, and is separated into a lower and upper portion by a thin course of schist. In another layer of schist which immediately overlies the limestone, we detected innumerable small *Tentaculites* †. In the mass of the limestone M. Bischof collected numerous organic remains, of which we will only now allude to those that best prove the rock to be of Upper Silurian age: some of them we now exhibit. Thus, among several genera of *Trilobites* we recognized *Calymene, Acidaspis, Lichas*, and *Cheirurus*, common in Upper Silurian and unknown in Devonian rocks. These, however, are associated with *Phacops* and *Bronteus*, which chiefly prevail in the Devonian. Among the mollusca are *Leptæna transversalis*, and *L. borealis* and *L. robustus* (Barr.), *Nerita haliotis, Orbicula Forbesii, Acroculia depressa* (*haliotis*, Sil. var.), *Orthis alata*, together with the corals *Favosites Gothlandica* and *Cystiphyllum turbinatum*. Again, whilst the above are unquestionably Silurian, *Terebratula princeps*, and some other forms, indicate a close approach to the Devonian.

These fossiliferous flagstones, schists, and limestone are surmounted by a coarser grauwacke approaching to gritty sandstone,

* In a memoir recently published in the 'Palæontographica' of Dunker and Von Meyer (Cassel, 1855), M. Adolf Roemer, in further describing the structure of the Harz, has given a map of the tract around Elbingerode, which represents a considerable band of Silurian grauwacke with an included limestone along the north flank of the chain, S. of Wernigerode, followed by various subdivisions of the Devonian series from the Spirifer-sandstone through the Wissenbach schists, Stringocephalus-limestone, grauwacke, schist, and schaalstein to the Iberger or Upper Devonian limestone.

In the short notices prefixed to the descriptions of the fossils, the author has misunderstood the opinions I formed as to the age of the limestones of the Schneckenberg near Harzgerode, and of the flagstones with plants near Mägdesprung. With regard to the former, I did not see sufficient fossil evidence to enable me to come to a decisive opinion, though it is probable, judging from some of the forms described by Roemer, that the rock may be Upper Silurian.

The age of the flagstones of Mägdesprung with plants has been regarded by me in the text as Devonian,—and not Silurian, as stated by Roemer. The recent discoveries of large land-plants low down in the rocks of Devonian age in Caithness would seem to sustain this suggestion.—R. I. M., Oct. 12, 1855.

† Resembling *T. lævis* of the Devonian rocks, but probably another species.

and that again by finer schists (fig. 5, *c*). As, however, we could hear of no limestone nor fossils in those masses, and had little time at our disposal, we did not explore them to the edge of the chain, where they are overlapped unconformably by some Upper Carboniferous strata, the latter being covered by conglomerates of the Rothe-todte-liegende. (See Trans. Geol. Soc. 2 ser. vol. vi. p. 295.)

But whilst we thus recognized the existence of an Upper Silurian rock in the limestone near Mägdesprung, we were unable to follow it upwards to a junction with strata unequivocally Devonian, or downwards to any other Silurian rocks.

In fact, no sooner do we issue from that portion of the Selke valley, in which for a very short space there is a connected and ascending series, and proceed towards Gernrode and Blankenburg on the north and west, and Alexis Baden on the west, than we meet with much eruptive rock (fig. 5, *g*), principally "gabbro," greenstone, hypersthene, and granite, all of which rising to considerable heights cut off the sequence and exhibit on their flanks many examples of altered strata. (See Section fig. 5, *a**.)

Penetrated as the tract is by such eruptive rocks, and obscured in great parts by wild woodlands, it is manifestly impracticable with our present knowledge to affirm that the strata near Mägdesprung, as exhibited in the Section fig. 5, are not overturned. The large plants found in the flagstones are unlike anything ever detected in Silurian rocks, and resemble Devonian, if not Lower Carboniferous forms. Again, whilst the animal relics of the limestone are said to approach most in character to Barrande's *uppermost* Silurian of Bohemia, they make (according to Mr. Salter, who has examined the specimens we have collected) a very near approach to Devonian, and contain some species which are certainly of that age.

Seeing the amount of protruded igneous rock to the west of these strata of Mägdesprung, we must leave it to be ascertained by future researches in this most dislocated tract, whether the flagstones of Mägdesprung are not of younger age than the limestone, and that the whole series has been inverted. Such inversion would indeed surprise no geologist who knows the Harz; for on the northern flank of the chain the Permian and Secondary rocks are occasionally seen in overturned positions; the younger strata underlying the older.

If M. Adolf Roemer's first map be appealed to, we see in it a confirmation of this idea; for, according to his view, the culm or Carboniferous masses are usually interpolated between the chief eruptive rocks and the Devonian and Silurian groups!

Other rocks containing Upper Silurian fossils have been discovered in a very small patch or two only on the northern flank of the granitic axis of the Ross-Trappe near Ilsenburg, and particularly by M. Jasche of the latter place. We visited one of the localities, called Klosterholz, accompanied by that gentleman, and found there a small portion of dark limestone, which had been formerly quarried for mining purposes, on the side of a rivulet in the woodlands which there slope rapidly from the chain. But no physical features of other rocks are there visible. It is simply a boss of hard limestone on the grassy flank of the Patter Berg, and which, having no visible relation to the altered grauwacke or eruptive rocks of the mountain on the south, is at once succeeded on the north by mural and more or less vertical Zechstein with gypsum, followed by Muschelkalk and other secondary formations up to the Chalk inclusive. Debarred therefore from pronouncing any opinion respecting the relations of the protruding bosses of the older limestone, we have merely to report upon their chief fossils, as extracted by the assiduous labours of M. Jasche, for in our brief inspection we could observe no organic remains in the rocks *in situ*.

Among the fossils collected by M. Jasche *, we saw several which would unquestionably induce us to view them as Silurian; such as a *Pentamerus*, not distant from *P. Knightii*, and very much resembling *P. Vogulicus* of the Ural Mountains; *Orthis antiquata*, and two or three others of that genus, one of which is near to *O. expansa*, another to *O. elegantula*; *Chonetes* (*Leptæna*) *lata* (the small form), *L. depressa*; *Orbicula rugata*, *O. Forbesii*? (Davidson); *Lingula minima*; *Cornulites*, &c. There are also forms of *Terebratula*, such as *T. princeps*, Barr., and *T. melonia*, Barr., which mark the uppermost Silurian of Bohemia, and are also undoubted Devonian types. There are here other forms which unquestionably have more of a Devonian than a Silurian character. Such were the *Phacops* and the *Amplexus*; and to these must be added the *Terebratula princeps*, to which M. de Verneuil (who has seen the collection since we inspected it) attaches great weight as a good Devonian type. Another spot whence M. Jasche has procured many fossils is called Tannenberg, and these have a more Silurian character than those of Klosterholz, including *Cardiola interrupta*, with many Lamellibranchiate shells (*Grammysiæ*, *Cypricardiæ*, &c.), and *Orthoceratites* both large and small.

It is highly probable, therefore, that if all the older palæozoic strata which were originally deposited in this neighbourhood could be detected amidst the dislocated chaotic piles resulting from the eruptions of the granitic and other igneous rocks of the chain, we should meet with links which connect the uppermost Silurian with the true and well-known fossiliferous base of the Devonian, or the "broad-winged Spirifer strata" of the Rhine. Already, indeed, the rock of Klosterholz exhibits an approach to that deposit in the several species of *Spirifer* which occur in it, though none of these are known Devonian forms; still less has the *Pleurodictyum problematicum*, or any of the types common in the lowest Devonian rocks of the adjacent Rammelsberg near Goslar, been found near Ilsenburg. Until better evidences be produced, we would therefore also class these rocks as Upper Silurian, and consider them as a link higher in the series than the limestone of Mägdesprung.

In a memoir recently published†, M. Carl Prediger has, indeed,

* In the 'Palæontographica,' vol. v. part 1, 1855, are detailed descriptions and figures of the fossils from these localities by Adolf Roemer, forming a portion of the 3rd part of his "Geology of the North-western Harz."

† Zeitschrift für die gesammten Naturwissenschaften, Halle, June 1854, p. 34.

thrown some additional light on the western extremity of the region which Roemer has coloured in his map as Silurian; though it must be observed that some of the most unequivocal of our Silurian localities are therein laid down as "Culm." After describing four classes of sedimentary rocks under the terms of Grauwacke, Grauwacke-schiefer, Thon-schiefer, and Quarzfels, besides other rocks of metamorphic or igneous origin, he indicates that which we shall presently speak of as a series of true Carboniferous strata, as originally stated in the 'Transactions of the Geological Society,' 2 ser. vol. vi.

The same author also mentions, towards the close of his paper, a considerable mass of limestone to the north of Wieda which is fossiliferous. Not having seen the organic remains of that rock, we cannot affirm that this limestone is truly Silurian, as believed by M. Adolf Roemer, though, if its organic remains be correctly identified, we have little doubt that M. Barrande would class the rock with the Upper Silurian of the Continent. The fossils are said to be, *Terebratula princeps* (Barr.), *T. bidentata* (His.), *Spirifer cultrijugatus* (Sow.), *Cardium striatum* (Sow.).

Knowing as we now do, that, besides this mass to the north of Wieda, there are numerous other protrusions of limestone which have scarcely been examined, between that place and Harzgerode on the east, and believing that these quasi-Silurian rocks on the south are not separated from the unequivocal Devonian rocks of Elbingerode on the north by any continuous band of eruptive rocks, we trust that, notwithstanding the monotonous and covered outline of the country, closer researches will obtain the requisite proofs of order in an ascending series.

Devonian Rocks.—These rocks occupy altogether a considerable space to the east and south of the northern granitic axis, though seldom in masses of any great, continuous extent. Like all the other sedimentary formations, they occur, for the most part, in disjointed masses, separated either by igneous or highly altered and metamorphosed rocks, so that the true sequence, even from one member of the group to another, is seldom to be detected. The oldest unequivocal Devonian stratum of the Harz, as on the Rhine, is the Spirifer-sandstone with its associated slates and schists. The largest and clearest exhibition of this rock is to be seen in the well-known hill of the Rammelsberg, which overlooks the ancient town of Goslar from the south, and which, owing to the aid of M. Zincken, who furnished us with good fossils, was paralleled by Sedgwick and Murchison with the shelly sandy "grauwacke" of Coblentz. Clearly defined by the presence of characteristic large Spirifers, the *Pleurodictyum problematicum*, a *Homalonotus*, and other fossils, there could be no doubt respecting the age of this subformation, which here, as in the Rhenish provinces, is associated with slaty schists, both underlying and overlying. Thus, near Goslar, the slates of Nordberg, and others to the south of the town, which are truly Devonian, seem, as formerly indicated*, to pass by a great inversion under the Spirifer-sandstone,

* Trans. Geol. Soc. Lond. 2 ser. vol. vi. p. 291.

whilst other schists overlie the latter. To term either of these slaty masses the Wissenbach slates, without the strongest and most copious fossil evidences, would be presumptuous; for even in the Rhenish provinces, the succession on the two banks of the Rhine presents no means of making such close comparisons. In putting forth this caution, and particularly in so convulsed and fragmentary a tract as the Harz, we are bound to state, that M. Adolf Roemer believes, that a course of Lower Devonian or Spirifer-sandstone near Schalefeld and Zellerfeld (which we did not see) is overlaid by Calceola-schiefer, and that the latter, which on the left bank of the Rhine is the well-known base of the Eifel limestone, is surmounted by slates which he considers to be of the same age as those of Wissenbach, because they contain the *Bactrites*, a Cephalopod first supposed to be an Orthoceratite, and peculiar certainly, as far as we know, to the deposit in question. But though peculiar in the Rhine country to the Wissenbach slates, we cannot suppose that this fossil may not be found throughout a considerable thickness of the schistose grauwacke of Lower Devonian age. Not having seen the only locality where this sequence is said by M. Adolf Roemer to be indicated, we must apologize for doubting whether the true order in the Harz differs after all from that established on the banks of the Rhine. Not questioning the sincerity with which M. Roemer has come to his conclusion, we beg to say that in such a complicated and obscure case as that of the Harz, our inference must also mainly depend upon the precision with which the terms "Wissenbach slate" and "Calceola-schiefer" are applied. In speaking of the rocks in the Harz, the geologist who has explored the Rhenish provinces well knows that the Calceola-schiefer of the Eifel or left bank of the Rhine has no exact representative on the right bank, and that the Wissenbach slate of the latter is not recognizable in the former.

Again, supposing that in the localities above mentioned, the strata are truly so named, not merely from the actual presence of one fossil or from lithological resemblance, it must also be shown clearly, in a country where inversions of strata are so very frequent, that the beds are in their normal position.

Passing, however, from this subject of detail, on which we hope to satisfy ourselves on a future occasion, we would next remark, that even the lithological distinctions of the subformations of the Devonian rocks of the Harz are so irregular and fugitive, that the features which are dominant in one part of the tract disappear altogether at the distance of a few miles.

Thus, putting aside what may be considered the equivalent of the Wissenbach slates and Calceola-schiefer of the Rhenish provinces, we see towards the east and in the environs of Elbingerode, and between that place and Hüttenrode, enormous masses of limestone, the lowest of which is unquestionably of the same age as the great Devonian or Eifel limestone of the Rhine; since it contains *Stringocephalus Burtini*, *Bronteus*, and other characteristic fossils.

It is specially this limestone which has afforded such large quantities of iron ore in the Harz. It is often so saturated with iron, that the calcareous portions are just sufficient to serve as a flux for the smelting of the ore. This is well seen at the Blaue Binge Mines in the Bücherberg, north of Elbingerode, of which we annex a diagram to exhibit the contortions of the strata (fig. 6).

There the iron rock, plunging under much schist and interlaminated volcanic ash or "schaalstein," is distinctly overlaid towards Elbingerode by coarse gritty greywacke, and the latter by dark schists; the whole of which are seen to be surmounted by a dark limestone of totally different characters from that beneath. Though much contorted, fractured, and perforated by dykes of black porphyry and bosses of a light porphyry with pinite, this upper limestone, which is highly crystalline, passes at one place into black and in another into variegated coralline marble, and occupies the cliffs of the gorge of the river Bode near Rubiland, and its well-known caverns.

Though fossils are rare in it, *Terebratula cuboides* and other forms elsewhere characteristic of the Upper Devonian have been detected by M. Adolf Roemer;—fossils quite distinct from those of the inferior or Stringocephalus limestone. In passing from the valley of the Bode over the plateau by Hüttenrode towards Blankenburg, the upper limestone is seen to be separated from the ironstone by bands of schists, grauwacke, and schaalstein.

The section (fig. 6) explanatory of this succession is merely offered as a very rude approximation; for whilst we believe that it is correct in presenting a general view of the relation of the two limestones and their separation, we are aware that numberless features of the strata which are not visible at the surface and many points of eruptive rock have been omitted.

Our chief objects, however, in calling attention to these two limestones of Elbingerode and the Bode-Thal are to show—

Fig. 6.—Section showing the general relations of the Lower and Upper Devonian Limestones near Elbingerode. Distance about 9 miles.

c. Upper dark limestone with *Terebratula cuboides*; usually in the state of marble; with many caverns.
b. Dividing dark shale.
*a*². Coarse gritty rock (local).
*a*¹. Shale and Schaalstein (local).
a. Red Stringocephalus-limestone, with much iron ore.
p. Porphyry.
m. Melaphyre.

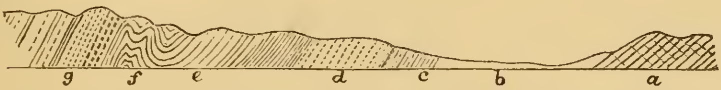
1st. That even the lowest of them is entirely distinct from the limestones of the adjacent tract on the east, watered by the Selke, and which we have shown to be Upper Silurian.

2ndly. That in following these calcareous rocks westward along the southern slopes of the Brocken to the tracts between Goslar and

Clausthal, and still more when we pursue them into the Lauthenthal, the lower limestone thins out, and the only calcareous rocks visible between enormous masses of inferior slaty grauwacke with *Bactrites*, called "Wissenbach slate" by Roemer, and the overlying Carboniferous rocks, is that which is clearly the upper limestone, as distinguished by the *Terebratula cuboides* and other fossils.

This is seen at and to the north of the bridge near the mining works of Lauthenthal, in a natural section pointed out to us by M. Ad. Roemer himself (see fig. 7).

Fig. 7.—*Section of the Lower Carboniferous and the Devonian Rocks in the Lauthenthal.* Distance about 2 miles.



Lower Carboniferous. { *g.* Herborn schists, with *Posidonomya Becheri.* *f.* Kieselschiefer. *e.* Sandy schists.

Devonian. { *d.* Cypridina-shale (Upper Devonian). *c.* Schists and Cypridina-limestone. *b.* Place of Stringocephalus-limestone (denuded). *a.* Slaty black schists.

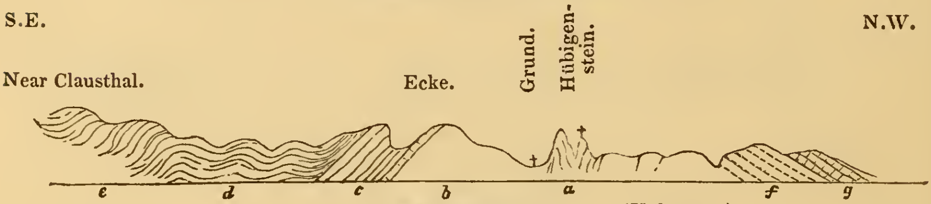
Now whether M. Roemer be correct or not, in assigning to the inferior slates of this section the place of the Wissenbach slates, because he has found the *Bactrites* in them, it is manifest that there is here no representative of the Stringocephalus-limestone, for hundreds, nay, thousands of feet of slaty rocks are well exposed between Lauthenthal and Goslar without a course of subordinate or underlying limestone to represent the rocks of the Eifel, which are so clearly exhibited in other parts of the Harz. At Goslar, on the contrary, the only inferior rock met with is, as before said, the Spirifer-sandstone. On the other hand, the ascending section at Lauthenthal is clear. The overlying calcareous strata contain schists charged with *Cypridinæ*, which pass into calcareo-concretionary beds with *Terebratula pugnus*; the whole representing the Uppermost Devonian.

In fact, these masses not only resemble the Kramenzel or "antstone" of the Rhine, which is of that age, but are overlaid by schistose grauwacke, which is immediately covered by the Lowest Carboniferous beds (here in the state of Kiesel-schiefer), and these by other schists which are identically the same schistose representative of the Carboniferous Limestone which at Herborn and so many places in the Rhenish provinces and elsewhere, as well as in the British Isles, is charged with the *Posidonomya Becheri*, as well as with *Goniatites*, Crinoids, and many land plants.

As, therefore, there is no true representative of the Eifel limestone in the Lauthenthal, where the consecutive series is so well exhibited and where so little eruptive rock appears, the reader may judge of the impossibility of reasoning on the general succession from the lithological evidence of any one local section.

This rapid change in mineral conditions is again seen in the western end of the old rocks of the Harz. We have merely to pass from the Lauthenthal a few miles to the N.N.W., when, instead of the nodular calcareo-schists we have just spoken of as Upper Devonian, we find ourselves at the feet of enormous masses of amorphous crystalline limestone, void of all alternating schists, which stand out from the dense woodlands to the north of the village of Grund. The chief of these is the pyramidal boss called the Hübigenstein. In these altered amorphous masses it is almost impossible to trace stratigraphical relations among the fragments. (See fig. 8.)

Fig. 8.—*Section from near Clausthal to beyond Hübigenstein.* Distance about 7 miles.



Permian. { *g.* Zechstein and Gypsum. *f.* Rothe-todte-liegende.

Lower Carboniferous. { *e.* Culm sandstone and schists. *d.* Sandstones (Millstone-grit ?). *c.* Carboniferous limestone and schists. Kieselschiefer, &c.

Devonian. { *b.* Place of the Upper Devonian. *a.* Stringocephalus-limestone, with iron ore; much altered and forming mural masses of marble (Hübigenstein).

Analogically, however, and by comparing them with the rocks of Elbingerode, something may be inferred. In the first place, we see that on its western side, the chief boss of limestone is flanked by highly ferruginous red schists, succeeded by vertical bands of ironstone, which, if not absolutely in, are clearly associated with Devonian limestone containing corals and exposing traces of beds plunging rapidly at 45° to the S.E. Passing over these you come to the great fissured abnormal masses of limestone (Hübigenstein), on one of which a cross is placed, and in which all traces of stratification disappear. When, however, we know that the *Stringocephalus Burtini, Spirifer multirugata, Terebratula reticularis, Pentamerus galeatus*?, with Trilobites of the genera *Bronteus* and *Cheirurus*, have been found in or near these rocks, there can be little hesitation in saying that we have in them representatives of the Eifel limestone.

Whether the eastern peak of the Hübigenstein belongs to the lower or upper Devonian limestone, it would be difficult to determine from its altered and crystalline aspect; but numerous fossils characteristic of the latter are found in the debris of the adjacent woodlands on the east, which belong unequivocally to the higher rock, such as *Terebratula cuboides* and its associates.

Transition from Devonian to Carboniferous.—We have a still better palæontological proof of an ascending succession in the same locality from west to east in the fact, that a limestone of another mineral character, which succeeds to the last, contains many highly characteristic fossils of the Carboniferous Limestone. These occur chiefly in detached fragmentary portions of the rock, resulting from partial excavations made by miners in search of ore in the highly mineralized tract north of Grund, where, besides lead, stray veins of barytes are apparent even at the surface.

In the spots to which we were conducted by M. Adolf Roemer, we could indeed detect no physical signs of any order of succession, except the very obscure evidence above noticed in proceeding from those strata on the west, which our contemporary considers to be "Culm," whilst we view them as unequivocal Devonian iron schists, probably lower. We were, however, informed by a miner named Diedrich, who has been the collector of fossils around Grund, that at a spot called the "Ecke," a high point in the wood, which M. Ad. Roemer had not then examined, and about two miles east of Grund, a *dark grey* limestone, as distinguished from the white-veined Devonian rock, occurs in regular beds, exposed in a thickness of about 10 feet (Section fig. 8, *c*).

Whether this collector obtained any of his dark-coloured fossils from this solid rock, or from fragments at other spots, it is manifest that such fossils are nearly all well-known Carboniferous types; amounting, according to Ad. Roemer, to about forty species, whilst the same authority enumerates upwards of two hundred from the adjacent Devonian limestone.

In saying thus much as derived from fossil evidence only, we have introduced a general section across the Hübigenstein (see fig. 8), to show how difficult it is in a hasty visit to assign the true physical order to this distorted, mineralized, and amorphous mass. Obscure as this hilly tract is from its dense woodlands, still a close comparison of the works of the miners—particularly a register of all the strata passed through in a great adjacent adit, which is about a mile in length; to say nothing of the natural features which may be detected in the gorges and the summits,—would no doubt yield up to close researches like those of our Government Survey, much more accurate results than any which have been yet obtained.

In the mean time, the fossils which are found in and about Grund entitle us to say, that they exhibit a transition from true Devonian into the Carboniferous group. They, in fact, quite confirm the description of this tract given in the year 1839, which states, "We have no doubt that the calcareous mass of Grund is a true Devonian limestone, and that the overlying beds are the equivalents of those parts of the Westphalian sections which extend from the great [Carboniferous] limestone to the base of the Coal-measures*."

Carboniferous Rocks.—From what has already been said, it will have been observed, that the lowest members of the Carboniferous rocks, where they are in contact with or pass into the Upper De-

* Trans. Geol. Soc. Lond. 2 ser. vol. vi. p. 289.

vonian, are in one spot (as at Lauthenthal) in the form of flinty slates (Kiesel-schiefer) and Posidonomya schists (fig. 7, *e*, *f*, *g*), while in another locality distant only four or five English miles, they are limestones charged with numerous *Producti* and fossils of the Mountain Limestone (fig. 8, *c*, *d*, *e*).

In its partial appearance and disappearance within very short distances, and in its passage into flinty schist and Posidonomya shale, the Carboniferous Limestone of the Western Harz entirely resembles the rock of the same age in Westphalia, as described by one of us and his companion, and those of the Thüringerwald and Saxony. In no other part of this region, except near Grund, is there any band of Carboniferous limestone like that in question. But its associates and equivalents occur in very many spots, and specially near Clausthal, where some of the richest veins of true argentiferous galena traverse the strata containing the *Posidonomya Becheri*, with occasional hard flinty slate.

These Posidonomya strata, often of very considerable dimensions, and inclined in every direction from verticality to a slight deviation from horizontality, are succeeded upwards by other sandstones and schists, which we considered to be of the same age as the Millstone-grit and Culm deposits of England. Occasionally there are to be seen great masses of thick-bedded sandstone of lightish colours, which were described as having subordinate layers of micaceous flagstone and dark carbonaceous shale, as well as beds of a very coarse grit, with granules of greasy quartz as large as peas, like some varieties of the millstone grit of Britain.

The greater and uppermost mass of all this series was said to consist of dark shale and schist, with very thin-bedded hard sandstone, containing reed-like and grassy small plants; and this was first compared by Sedgwick and Murchison with the Culm fields of Devonshire.

It would appear that subsequent researches (even to the year 1854 inclusive) have confirmed these early comparisons. Besides the labours of M. Adolf Roemer near Clausthal, where the dislocations are so great as to render it almost hopeless to trace any order, except through the discovery of fossils, we again call attention to the memoir of M. Carl Prediger, who seems to have met with some physical proofs of succession to the south of Andreasberg. The "ältere *Kulm*-grauwacke" of this author is the band which was formerly shown by English geologists to be the equivalent of the Carboniferous Limestone and Posidonomya shale; this "*Kulm*-sandstein" (which in the long ridge of the Bruch Berg becomes, as in the Taunus, a sort of quartz rock) is that which they paralleled with the Millstone-grit; and his "obere *Kulm*-grauwacke" is the Culm-field proper of North Devon, as long ago indicated *.

* We are the more particular in referring the reader to the original comparison by Sedgwick and Murchison whereby these rocks were first paralleled with the *Culm* series of the S.W. of England, because modern German writers, like M. Prediger, seem to ignore the fact. M. Prediger refers to M. Adolf Roemer as the author of a comparison which is, we believe, exclusively that of the English explorers of 1839. See Trans. Geol. Soc. Lond. 2 ser. vol. vi. (Section from Osterode to Clausthal) p. 288.

Upper Palæozoic Rocks surrounding the Chain of the Harz.—The physical feature of the geographical outline of the Harz being at right angles to the ancient strike of the older rocks of the chain, which was formerly noticed by Humboldt, and dwelt upon by Sedgwick and Murchison, is analogous to the phænomenon already pointed out in the Thüringerwald. In the Harz, as in Thuringia, the Permian deposits (with some slight underlying courses of coal, see fig. 10, p. 445) are abruptly and entirely separated from all the more ancient rocks, including the Lower Carboniferous, and form a girdle around an elongated ellipsoid, the major axis of which trends from W.N.W. to E.S.E., or nearly at right angles to the original direction of the older and elevated deposits.

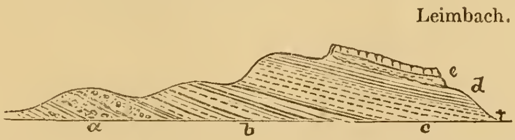
When the original communication above cited was offered to the Geological Society, the formations known as the Rothe-todte-liegende were classed with the Secondary rocks; but since then they have been grouped as Upper Palæozoic, under the name of Permian. In respect to the few shreds of coal which have been detected around the Harz, they all lie, we believe, beneath the red rocks as in Thuringia; and we are now of opinion that in the example of Meisdorf, near Ballenstedt, the coal is not subordinate to the red conglomerate, as was once supposed, but crops out from below it*.

That great red conglomerate and sandstone (the Rothe-todte-liegende), which is the equivalent of the Lower Red Sandstone of Britain, appears as a wrapper of very unequal dimensions around the western, southern, and eastern parts of the chain. Thinly developed to the south of Lauthenthal, between the older slaty rocks and the Zechstein, it is not again visible in proceeding eastwards until we reach the environs of Sachsa and Ilfeld, where it was formerly shown† to be associated in its lower parts with a vast accumulation of newer and quasi-stratified red porphyry,—the "quarz-freier porphyr" of the Germans. In the hill of Kyfhausen, to the south of that tract, many silicified stems of ferns (*Psaronites*) are found, similar to those which occur in rocks of the same age in Saxony and Thuringia.

The clearest and most instructive natural section of this deposit, in a small space, with which we are acquainted, where it flanks the Harz, is at Leimbach, near Mansfeld.

Accompanied by M. Hoffman, attached to the mines of that place, we examined in some detail the hill to the north of it (see fig. 9).

Fig. 9.—*Section of the Permian Rocks at Leimbach.*
Distance about 1 mile.



e. Zechstein. (Bottom beds concretionary.)
d. Red earthy sandstone.
c. Conglomerate with white quartz-pebbles.
b. Deep-red shaly sandstone.
a. Porphyritic and amygdaloidal conglomerate.

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* Trans. Geol. Soc. Lond. 2 ser. vol. vi. p. 295. This coal is not now worked.
† See Trans. Geol. Soc. Lond. 2 ser. vol. vi. p. 286, and section fig. 15.

1. Among the lower beds visible towards the west is an amygdaloid (fig. 9, *a*) composed of two varieties of quartzless porphyry, one of which contains small nests of zeolite in a base of felspar-wacke. The other is a sort of "bladder-stein" with green earth, and both are interlaminated with the red sandstone, and are manifestly contemporaneous with the other strata.

2. A thick mass of deep red, earthy, thin-layered sandstone (*b*), containing many grains of whitish felspar. Though not exhibited in the hill of Leimbach, this part of the formation (south of Mansfeld) affords extensive quarries of finely laminated, but thick-bedded building-stone; the beds being separated at intervals by earthy greenish layers.

3. A whitish-coloured conglomerate (*c*), studded with many pebbles of white quartz, doubtless derived, as before stated, from the old quartz rocks of the Wippra Thal (see p. 431). This band forms a striking feature on the hill side.

4. Dark red argillaceous sandstone (*d*), with thin concretionary courses of brown and grey calcareous grit.

5. The underlying strata just described are at once conformably overlaid by about 30 feet of Zechstein (*e*), the base of which, however, is ill-exhibited. It appears that the German miners, who have so accurate an acquaintance with their Kupfer-schiefer, have not been able to detect it here, in its usual place between the lower rock and the Zechstein. The course sets in, however, in that position a little to the east of Mansfeld. This layer, originally deposited in the state of cupriferous mud, must here have thinned out on an ancient pebbly shore, the bed of which now forms the escarpment described. In other and adjacent tracts of Central Germany, its extraordinary persistence over wide areas has already been explained.

The magnificent ruins of the once powerful castle of Mansfeld stand on the upper and pebbly beds of the Rothe-todte-liegende; but great dislocations have affected the flanks of this mass, and no good section like that of Leimbach is there to be seen.

Before we quit the consideration of the Rothe-todte-liegende of the region around the Harz, we beg to state, that, although, as before said, there are very rare occurrences of poor and thin coal in that rock, all the best local authorities, including M. Plumecke of Eisleben, are agreed, that the old coal* properly so called (the Stein-kohlen-gebirge of the Germans) lies entirely beneath the Red rock. Having also interrogated M. Breslau, a practical "bergmeister" who has observed the progress of a great trial for coal now going on near Rotheburg, we ascertained that slightly inclined red sandstone and conglomerate, in which one thin course of limestone without fossils has been noted, have there been pierced to a depth of 1000 feet without a trace of coal. Though the speculators hope to find it beneath the great Red cover, we have already adverted to much deeper sinkings in the same rock, near Eisenach, which have entirely failed.

Zechstein, with Kupfer-schiefer and other associated strata.—In numerous places around the older rocks of the Harz, the Zechstein

* At Wettin, Ilmenau, &c.

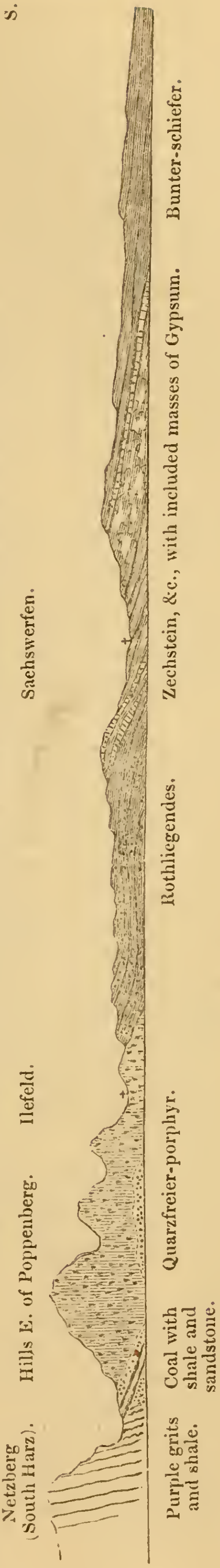
and associated strata are extensive deposits which sometimes rest upon the Rothe-todte-liegende as just mentioned, but are often placed at once on the edges of the older slaty rocks. At Osterode and to the W.S.W., the Zechstein is characterized by vast interlaminated bands of anhydrite, which, on weathering, become gypsum.

The fine laminæ of sulphate of lime are quite apparent, and as the beds both repose upon and are surmounted by limestone, it might be inferred by some geologists, that the intermediate beds of anhydrite were formerly carbonate of lime, which have been altered by the transfusion of sulphuric acid.

To the south of Sachswerfen, where the Zechstein reposes on the Rothe-todte-liegende, it is seen to be conformably surmounted by beds of earthy red sandstone; and, although these have been hitherto classed with the Bunter-Sandstein, or base of the Trias, we have already assigned reasons why this lower portion of that rock should be considered as the natural roof of the Zechstein, and therefore classed with the Permian*. The accompanying section (fig. 10), showing a succession from the younger coal-beds, resting against highly-inclined Lower Carboniferous strata, and followed by Permian rocks to the south of the Harz, is taken from the Geol. Trans. 2 ser. vol. vi. p. 286. See also the Diagram of the Permian succession on the flanks of the Thüringerwald, p. 424.

In extensive portions of their range, the chief limestones are dolomites. Near Mansfeld, where the lower part only is seen, the rock is a subconcretionary, flat-bedded, impure, sandy limestone, of dark brown colour, weathering into insulated turrets, like some of the Sunderland beds.

Fig. 10.—Section of the Upper Coal and Permian Rocks South of the Harz.



* We much regret not to have had time to visit the remarkable insulated mass of Permian rocks which lies a few miles to the S.E. of Nordhausen. There the conglomerates of the Rothe-todte-liegende contain *Psaronites* (Kyfhausen near Kelbra). These rocks, associated with melaphyre and surmounted by Zechstein, rise up through the wide extent of Trias that lies between the Thüringerwald and the Harz. We hope to explore hereafter this insular Permian mass.

In the environs of Eisleben, however, where numberless sinkings have been made to extract ore from the underlying copper-slate, the miners observe with minute precision the mineral character of every layer of the deposit. The underlying rock is the "Weiss-Liegende," which, as before said, forms the natural base of the Zechstein. This light greyish pebbly bed, of about 3 or 4 feet in thickness, is at once conformably covered, as on the flanks of the Thüringerwald, by the Kupfer-schiefer with its fossil fishes and peculiar flora, all of which are here contained in a thickness of 2 feet. This is surmounted by a little shale and impure limestone, and then by about 28 feet of anhydrite and gypsum, and the overlying succession is made of the alternations of rocks locally called "Asche," "Stinkstein," and "Rauch-kalk."

The lower portion of the Bunter-Sandstein, which immediately rests on the Zechstein, clearly exhibits a passage into it, and forms its natural cover. The lowest of these beds near Eisleben consist of greenish calcareous shale, with concretions of impure limestone, similar to some of the immediately underlying beds of Rauchstein and Stinkstein. Again, in some of the red and green beds, thin courses of coaly matter have been found (Gerdstedt).

Looking, then, at the similarity of these features to those of strata having the same position in the Thüringerwald, we necessarily adhere to the Permian classification already proposed.

Secondary or Mesozoic Rocks.—Though it does not enter into our present plan to describe the succession of secondary rocks, whether triassic, jurassic, and cretaceous, or of the older tertiary rocks, which, flanking the granite of the Brocken and the Ross-Trappe, and their associated slaty rocks, constitute the mural, broken, and occasionally inverted bands to which attention was formerly* directed, we think it right, in taking leave of the Harz, to say a few words respecting these younger rocks, if only to show what great movements have affected all the strata from the Bunter-Sandstein to the Upper Chalk inclusive, if not also certain older Tertiary strata.

The Bunter-Sandstein of the Trias, N. of the Harz, contains a very remarkable band of ferruginous pisolite, the "Rogenstein" of the Germans, which to the east of Ilsenburg is exposed in vertical bands†.

Above this rock, and between it and the Muschelkalk, is a lighter-coloured and often yellowish sandstone, in which Saurians occur, including the *Trematosaurus*, the finest specimens of which have been detected at Bernberg, in the north-eastern extension of this formation.

Of the Muschelkalk we will only say that its upturned edges are admirably displayed towards the north-eastern end of the flank of the Harz, between Ballenstadt and Quedlinburg, flanked by the Keuper sandstone.

Above the Trias, the Lias of Quedlinburg is copiously rich in fos-

* Trans. Geol. Soc. 2 ser. vol. vi. p. 291.

† One, if not others, of the magnificent old churches of Brunswick is built of this "Rogenstein."

sils, and is followed by representatives of both the lower and upper Jurassic deposits, often in rapid undulations.

In Hanover and Brunswick the Cretaceous group is singularly well developed: for beneath it there is a genuine representative of the Wealden; whilst the true base of the group is the distinct northern German equivalent of the Neocomian limestone of southern Europe, called here the "Hils-conglomerat." The remainder or really great mass of the Lower Greensand of England has no adequate representative; and the siliceous sandstones, on the north flank of the Harz, which from mineral character were formerly considered as such belong to a much higher member of the Cretaceous series.

The formation, however, which the German geologists term Gault, may be said to represent both the upper portion of our Lower Greensand and the Gault proper. In the interesting collection of M. v. Strombeck, we observed indeed as Gault fossils certain species which are found in our Lower Greensand.

The Lower "Quader Sandstein," in which much iron occurs, and the upper part of which is charged with many green grains, contains the fossils of our Upper Greensand, and is supposed to be of older date than the "Pläner Sandstein" of Saxony.

The Upper "Quader Sandstein," which forms those remarkable walls of rock to the N.E. of Blankenburg, and which were formerly taken for Lower Greensand, is in fact the equivalent of the White Chalk of Western Europe! It contains, in short, many of the most characteristic fossils of that subdivision. The plants collected by the zealous botanist, M. Hempé of Blankenburg, afford an instructive illustration of the fossil flora of these upper cretaceous rocks.

There is still an "Oberste Quader Sandstein," representing the very highest beds of our Chalk.

These siliceous strata, standing in the place of the Upper Chalk, are followed near Goslar by a great mass of whitish chalky-looking rock, which is in truth an old Tertiary rock. This also seems to be thrown abruptly off the chain, in common with the secondary strata.

In thus briefly adverting to the vertical, disrupted, shattered, or convoluted strata of secondary age on the north flank of the Harz, or along its chief granitic frontier, we should do injustice to the subject if we did not call attention to the praiseworthy and precise labours of M. von Strombeck of Brunswick. We visited that city purposely to inspect the collections which that gentleman has made there during a series of years, and were delighted with the clear order in which he had arranged the fossils of his neighbourhood,—from the base of the Trias to the younger Tertiary strata. It is truly a remarkable collection; and, in respect to the magnificent specimens of the *Encrinus liliiformis* of the Muschelkalk, is quite unrivalled. As, however, it would require a separate treatise and a detailed survey of the country to enable us to describe the result of the labours of M. von Strombeck, we confine ourselves to pointing out, in few words, a striking physical phænomenon which he has brought into a clear light, and to illustrate which he has prepared excellent sections, which are not yet published.

The English reader may well be surprised when he learns, that in the comparatively flat region around Brunswick, where the hills are of small elevation only, the secondary strata, though not in such abrupt and broken walls as they occupy alongside of the granite of the Harz, have still partaken of the influence of the same great movements as the formations contiguous to it, though distant about twenty-five miles from that line of eruption, whilst their major axis is precisely parallel to the vertical masses on the north flank of the Harz.

Thus, the strata in question, every member of which has been accurately identified through its fossils, are in some instances seen to have been thrown into sharp and broad undulations, by anticlinal and synclinal flexures, the axes of some of which are actually overturned or inverted, like many well-known examples of the Palæozoic rocks.

In this region such movements have affected all the deposits, from the Palæozoic to the older Tertiary, both inclusive.

Recapitulation.—In the preceding pages we have shown, that of the two chains described, the Thüringerwald only exhibits any of the oldest sedimentary rocks; the strata containing the lowest Silurian fossils being there underlaid, as in Great Britain and Bohemia, by vast masses of slate and sandstone, in which no forms of a more composite structure than Fucoids have yet been detected. These bottom rocks, and the superposed Lower Silurian of that tract, were, it appears, elevated into dry land, and placed during a long period out of the reach of sedimentary influence; since none of those strata of the unequivocal Upper Silurian of Bohemia or the Lower and Middle Devonian, which are so much developed in the Harz, are to be seen in the Thüringerwald.

Towards the close, however, of the Devonian æra, both tracts were again covered by a sea in which animals lived differing from all those which preceded them, whilst the recesses of that ocean, whether in this region or in the Rhenish Provinces, were spread over by volcanic dejections, which were interlaminated with ordinary submarine beds.

These volcanic dejections ceasing, there followed other accumulations of mud and sand, into which stems, branches, and leaves of land-plants were transported, and out of which thin courses of coal were formed.

After these Lower Carboniferous beds had been accumulated, a great upheaval took place over all those parts of Germany and France where such strata occur, and raised up such lower carboniferous beds in conjunction with those which preceded them; the whole constituting the Grauwacke series of the Germans. The next sediments formed on the edges of all that went before them are the feeble equivalents of our Upper coal fields. These again, after partial oscillations, were succeeded by the Rothe-todte-liegende, or Lower red sandstone. Much as each range has been, at various antecedent periods, subjected to eruption of igneous rocks, it was then that one of the most marked of the physical revolutions of this portion of the crust of the earth was accomplished, in the change of the geogra-

THE PALÆOZOIC ROCKS IN GERMANY. (Underlying the Trias.)

Natural Groups.		Divisions.	Subdivisions.	Some Localities.	Characteristic Fossils in Germany.	British Equivalents.
Base of Mesozoic.	Trias.	Keuper.	Upper Keuper and Sandstone, Gypsum, Lettenkohl.	Stuttgart, Coburg, Gotha, Erfurt, Gottingen, Nurnberg, Waltershausen, &c.	Mastodontosaurus, Metopias, &c. (Labyrinthodonts); Nothosaurus, Simosaurus (Enaliosaurians).	"Keuper" Marls and Sands of Worcester, Leicester, Droitwich, Nantwich, &c.
		Muschelkalk.	Upper Muschelkalk. Lower, or Wellenkalk.	Weimar, Wurzburg, Jena, S. & N. of Harz, and around the Thüringerwald, Eisenach, Arnstedt, &c.	Avicula socialis, Terebratula vulgaris, Encrinites liliiformis.	(Wanting.)
		Bunter-Sandstein.	Upper. Lower.	Region around Thüringerwald and Harz, &c.	Trematosaurus, Odontosaurus, } Labyrinthodonts.	New Red or "Bunter" Sandstone of Chester, Liverpool, &c.
Palæozoic Rocks.	Permian.	Bunter-Schiefer.	Red sandstone, &c. Schist. with impure limestone.	Around the Thüringerwald, S. of the Harz, &c.	Calamites arenarius.	Red and green gypseous marls (Sedgwick). Yorkshire, Lancashire, and Nottinghamshire.
		Zechstein and Kupfer-Schiefer.	Rauchwacke, Gypsum, &c. Dolomite, Zechstein.	Around the Harz and Thüringerwald, and numerous tracts of Germany.	Productus horridus, Spirifer alatus, Strophalosia Morrisiana, Avicula speluncaria, &c.	Brecciated & compact limestones; Humbleton, Sunderland; cliffs from Hartlepool to Sunderland.
		Rothe-Todte-Liegende.	Bituminous and Copper Slate.	Mansfeld, Reichelsdorf, around the Harz and Thüringerwald.	*Fishes.*—Palæoniscus, Pygopterus, Platysomus, &c. *Reptiles.*—Protorosaurus (2 sp.).	Marl-slate; Sunderland and Hartlepool (Durham), Knaresborough to Mansfield.
			Grau- and Weiss-Liegende. Conglomerate, Red Sandstone, &c.	Around the Thüringerwald, Mansfeld, &c. Eisenach, Kyfhausen, Rotheburg, S. Harz, Halle near Dresden.	Walchia and many other Permian plants, near Zwickau. (Psaronites) Kyfhausen, S. of the Harz.	Pontefract Rock (Smith). Lower Red Sandstone, &c., of Cumberland, Lancashire, Nottinghamshire, Worcestershire, Staffordshire, &c.
	Carboniferous.	Stein-Kohlen.	Shale, Sandstone, and Coal.	Southern Harz, N. & S. Thuringia, Wettin, Ilmenau, Westphalian & Bohemian Coal tracts.	Characteristic fossil plants. Archegosaurus (2 sp.).	Coal-fields of Durham, S. Wales, Lancashire, &c.
		Floetzleerer Sandstein and "Kulm."	Youngest Grauwacke of the Germans.	Zone around the Rhenish Provinces, south-west part of the Harz, Taunus, and Nauheim. Tracts between Saalfeld and Schleitz.	Fossil plants occasionally.	Millstone Grit of Yorkshire, Derbyshire, Lancashire, and South Wales. Culm Series of Devonshire. Coal-measures of a part of Scotland.
		Berg-kalk.	Posidonomya-schist. Platten-formige Kalk. Kiesel-Schiefer.	Herborn, Rhine, near Grund, Harz, Ratingen, Arnsberg, E. of Hof, Rhenish Provinces.	Posidonomya Becheri, Productus semireticulatus, and others. Amplexus coralloides, &c.	Mountain Limestone Series (Phillips), Culm Limestone of Devonshire, and Lower Limestones and Coal of Scotland.
	Devonian.	Upper Devonian.	Cypridinen-Schiefer, with peculiar land plants. (Kramenzel-Stein.) Flint-Schiefer.	Right bank of Rhine, Mecklinghausen, Laasphe, Selters, Weilburg, Saalfeld, and Saxony. Westphalia (Mestode, &c.).	Cypridina serrato-striata, Clymeniæ. Plants of many new forms. Goniatites retrorsus.	Petherwin and Barnstaple Limestone, Baggy Point Sandstone, Upper Old Red of Scotland. Hard Slate and Schist of Morte Bay, N. Devon.
		Middle Devonian.	Eifel Limestone and Calceola-Schiefer.	Both banks of the Rhine, Eifel, Paffrath, Refrath, &c. Elbingerode, Harz, &c.	Stringocephalus Burtini, Megalodon cucullatus. Coccosteus and other fishes.	Combe Martin, Ilfracombe, North Devon. Plymouth and Babbicombe, Devonshire slates (Austen). Middle Old Red Sandstone and Cornstone. Caithness Flags, with fishes and plants.
		Lower Devonian.	Wissenbach Slates. Spirifer Sandstone and Slate. (Syst. Rhénan, Dumont.)	Wissenbach and Caub. Coblentz and bank of the Rhine, N.-Western Harz, &c.	Bactrites, Orthocerata, Goniatites. Spirifer macropterus, Pleurodictyum problematicum, Chonetes semiradiatus, Phacops laciniatus, &c.	N. Foreland and Porlock, North Devon, Torquay in S. Devon. Lower Old Red Sandstone, and Conglomerate of Scotland*.
	Silurian.	Upper Silurian.	Limestones and Shales of Prague.	Prague; Eastern Harz.	Trilobites; 75 species of the genera Acidaspis, Calymene, Cheirurus, Cyphaspis, Harpes, and Phacops; Graptolites and many Cephalopoda in the lower beds.	Ludlow and Wenlock Rocks.
		Lower Silurian.	Schistose Slates, Grits, Quartzites.	Prague and Bohemia, South Thüringerwald, S. and W. of Saalfeld, Steinach, Schwartzburg, Schleitz, &c.	Graptolites of many species, mostly Diplograpsus; also Graptolithus Ludensis; Trilobites of the genera Trinucleus, Æglina, Asaphus, Illænus, Remopleurides, Agnostus, &c. Orthis, Leptæna, and other Brachiopods; Cystideæ, Nereites, &c.	Caradoc Sandstone and Llandeilo Rocks.
			"Primordial zone" of Barrande's Silurian Basin.	S. of Prague; South Thüringerwald?	Paradoxides, Conocephalus, Sao, Agnostus, Olenus; Orthis and Cystideæ. Fucoids.	Lingula Flags of N. Wales (Stiper Stones, Shropshire; W. flank of Snowdon).
		Base of the Silurians of Bohemia (Barrande).	Slaty and Quartzose Rocks (often green and purple).	S. of Prague and Southern Thüringerwald.	Fucoids the only fossils yet found in Germany.	Longmynd Rocks (Cambrian of the British Geological Surveyors).

* The *exact* relations which the Devonian divisions of the Continent of Europe and England bear to those of the *Old Red Series of Scotland* still require definition. It is, however, suggested, that the Upper Old Red of Scotland, as characterized by certain species of *Holoptychius* and *Glyptopomus*, is the Sandstone equivalent of the Upper Devonian,—*i. e.* of the "Cypridinen-schiefer" of Germany and the Petherwin or Clymenia Limestone of Devonshire. The bituminous and calcareous flagstones of Caithness, with their numerous ichthyolites and peculiar plants, both marine and terrestrial, represent, it is believed, the Eifelian or Middle Devonian passing down into the lower division; whilst the coarse breccias and conglomerates in the Sandstones which form the base of the vast Old Red Series of the north of Scotland probably occupy the horizon of the Lower Devonian or "Système Rhénan" of Dumont. Whether or not these suggested parallelisms be maintained, it is manifest to every one who has studied the great mineral masses of Scotland which are included in the term "Old Red Sandstone," that they constitute full equivalents *in time* of all the deposits to which in any region the name of "Devonian" has been applied.—R. I. M., Sept. 29, 1855.

phical direction of the masses of rock, from their normal alinement of N.E. & S.W. to one trending from N.W. to S.E.; the turbulence of the period being decisively characterized by great outbursts of porphyry and the extravasation of vast sheets of porphyritic lava.

It is, indeed, manifest from the convoluted and dislocated condition of the secondary strata, particularly those of the Muschelkalk, which lie between the Thüringerwald and the Harz, as well as from similar appearances extending even to the older tertiary rocks lying north of the Harz, or between that ridge and the line of ancient rocks near Magdeburg, that each of the elder or flanking masses was an habitual area of upheaval and oscillation, the upward and downward movements of which compressed the interjacent formations into the plicated forms which they still exhibit.

In reflecting upon the broad external features only which were successively impressed on the one tract and on the other, we infer, that, however the two regions were thrown into nearly parallel directions, there are in the Thüringerwald proofs of ancient movements of which we find no trace in the Harz. In this way we obtain evidence of the truly *local* character of all such disruptions, in addition to the examples previously cited by one of us, and to other cases mentioned by M. Barrande*.

In truth, whilst each of the tracts here spoken of present some marked analogies to the Silurian basin of Bohemia, each of them differs more from that tract than they do from one another. In their great fundamental rocks of greenish and talcose grauwacke, the South Thüringerwald and the district of Prague are alike, as well as in the chief mass of the Lower Silurian rocks, though the fossils of the primordial zone of Bohemia have not been found in the Thüringerwald, and all the Lower Silurian is wanting in the Harz.

Again, the rich Upper Silurian limestones of Bohemia have no true representatives in Thuringia,—the uppermost member only of that division having been detected in the Harz.

Still more striking is the distinction between the two tracts under consideration and the basin of Bohemia; for whilst the Harz contains all the members of the Devonian rocks, with a copious development of the Lower Carboniferous, and whilst the Thüringerwald differs from it in not possessing either the central or the lower Devonian bands, there are no evidences of the existence of these formations in Bohemia, where the Silurian rocks are at once and abruptly followed by the Upper Coal-fields.

We collate these data to show, that whilst there are breaks in the Silurian series of Britain,—*ex. gr.* in one part of S. Wales beneath the Wenlock Shale, and above the Upper Caradoc or May Hill sandstone, and in another below the latter rock,—that in the north of England the Devonian rocks consist of a mere conglomerate, and that even one part of the south-west coal field is known to be transgressive to another,—our country offers no example of that great fracture between the lower and upper divisions of the Carboniferous group which is so very dominant a physical feature throughout Germany and France.

* See Bull. Soc. Géol. France, vol. xi. p. 311, &c.

But, notwithstanding all these differences—whether consisting of such local dismemberments or varied lithological conditions, the four natural palæozoic groups of Russia, Scandinavia, Germany, and France have been perfectly assimilated, through their organic remains, to their congeners in Britain; so that, despite of great breaks in each natural division of these regions, the classification by Silurian, Devonian, Carboniferous, and Permian remains is everywhere maintained.

Lastly, let us recollect, that the very first step which the geologist takes in ascending from the palæozoic to the mesozoic formations must convince him, that great and general mutations of life upon the surface of the globe were not dependent on such disruptions as those to which we have alluded; for in Germany no physical dismemberment has been observed which separates the strata accumulated at the close of the Permian rocks from those formed in the earliest period of the Trias,—the summit of the one being everywhere conformable to the base of the other; and yet the change of life which took place at that period of quiet physical transition was absolute and complete.

April 18, 1855.

J. G. Blackburn, Esq., and the Rev. W. C. Kendall were elected Fellows.

The following Communications were read:—

1. *Notice of* Fossils *from the* Keuper Sandstone *of* Pendock, Worcestershire. By the Rev. W. S. Symonds, F.G.S.

The Keuper sandstone quarry from which the fossils here referred to were obtained is situated in the village of Pendock, about three miles from the base of the south end of the Malverns, and exactly opposite the Holly Bush Pass. These sandstones are quarried to the depth of 14 or 15 feet. They dip under the Upper Red Marls and Lower Lias of the Berrow Hill, at an angle of from 5° to 6°. Their position as regards the Bone Bed, at the base of the Lias, cannot be less than from 250 to 300 feet below that deposit.

The section in the quarry exhibits the following series:—

	ft	in.	
Surface soil..........	2	6	
Marl	2	6	Posidonomya.
Sandstone	0	7	
Marl	0	5	Posidonomya.
Sandstone	0	6	
Marl	0	1	
Sandstone	0	5	
Osseous conglomerate..	0	1½	Fish teeth and bones.
Marl and thin Sandstone	1	6	Posidonomya.
Thick Sandstone and Marls	Unknown.		Plants.

Fossils are very abundant, but difficult to work out, the sandstone being extremely brittle. The suite of fossils now exhibited to the Society comprise:—1. Two specimens of *Posidonomya minuta* (retaining portions of the shell) from calcareous nodules in the marls above the conglomerate:—2. Specimens of the osseous conglomerate, which forms a thin bed, not 2 inches thick, about the middle of the sandstone series; and detached portions of the *Ichthyodorulites* and other osseous remains, which are abundant in this "bone-bed":—3. A series of detached fish-teeth, from the sandstones and the conglomerate, some of which have been submitted to Sir P. Egerton, who believes them to belong to a new species of *Acrodus*:—4. Seven specimens of Plant-remains; these are found in the bottom beds at the quarry, where apparently the sandstone becomes finer and less gritty and conglomeratic: the sandstone in which these plants are imbedded contains numerous dispersed particles and patches of carbonaceous and coaly matter*. Many plants are also scattered through the different beds, but are all much more imperfect than those from the lower bed.

Note on the Plant Remains.—The fossil plants have been kindly examined by Dr. Hooker and Mr. Bunbury. Dr. Hooker considers the larger specimen as probably referable to *Equisetites columnaris*, a plant of the Keuper near Wurtemburg, and which was discovered by Sir Roderick Murchison at Brora; it has also been found abundantly in the Oolites of Yorkshire, but had not been hitherto met with in the Keuper Sandstone of England. The smaller specimens Dr. Hooker refers doubtfully to *Calamites arenaceus*, a plant of the Keuper in Germany, and which is scarcely distinguishable from various fossils of the same and other formations; its botanical characters being vague and unsatisfactory. Considering how imperfect our knowledge is of either of the above genera, and that several fossils referred to *Calamites* have been supposed, with much probability, to be merely the casts of hollow stems, or piths of plants, Dr. Hooker suggests that no reliance should be placed in these approximate identifications, and adds that it is quite possible to conceive that *Calamites* and *Equisetites* are parts of one and the same plant.

Mr. Bunbury refers all the specimens to *Calamites arenaceus*; and rightly observes that the larger specimen presents none of the characteristics of *Equisetites columnaris*: this, however, Dr. Hooker is rather inclined to attribute to the imperfection of the specimen.

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2. *On the* St. Cassian Beds *between the* Keuper *and the* Lias *in the* Vorarlberg Alps. By Prof. Merian.

[Extract of Letter to Sir R. I. Murchison, V.P.G.S.]

I have lately visited, with my friend Escher von der Linth, the Alps of the Vorarlberg, and the neighbourhood of the Lake of Lugano and the Lake of Como. In the Vorarlberg we found immediately under

* [The specimens of this coaly matter which have been examined under the microscope do not offer any traces of organic structure.—Ed.]

the Lias, which is well developed, the beds of the Dachstein Limestone, characterized by numerous Corals and a large bivalve (*Megalodon scutatus* of Schafhäutl, "Dachstein bivalve" of the Austrians). Below the Dachstein limestone are the Gervillia-beds (lately called Kössen-beds by Von Hauer). The *Cardita crenata*, Goldf., the *Aviculæ* of the family of the *Gryphæatæ*, and small turrited univalves, contained in these beds, induced me to refer them to some of the St. Cassian beds. Lower still are thickly developed masses of dolomite, under which sandstones with impressions of Keuper plants occur.

The exact relation of the Salzburg beds containing *Ammonites globosus* with the Gervillia-beds has not yet been made out. We have not hitherto been able to find in the Alps of the Vorarlberg this characteristic family of Ammonites.

In the vicinity of the Lake of Como, the dolomitic masses change their appearance; but beneath the lias the Gervillia-beds form a good geological horizon, which can be found in numerous places when once one has become accustomed to its position. This bed is also found under the Lias of the chain of the Stockhorn, Canton Berne; and Escher has found it in the neighbourhood of Geneva.

We have called the whole of the beds situated between the Lias and the Keuper, "*St. Casciano formation.*" It is a marine formation, which appears to be wanting in the North of Europe, and which is only developed in the South, commencing with the chain of the Alps, and in Eastern Europe. In a palæontological point of view, it is distinguished from the overlying Lias by the absence of Belemnites, and from the Trias, on which it lies, by the existence of Ammonites with foliated septa.

You know that the Austrian geologists formerly considered the "Dachstein Limestone" as Lower Muschelkalk. Von Buch and his successors thought that the Gervillia-beds should be placed on a parallel with the Brown Jura. It is easy to perceive how such suppositions must have obscured the geology of the Western Alps; but this has become much clearer since the true position of the different beds has been better established.

The Austrian geologists are now of the same opinion as ourselves respecting the true position of the Dachstein Limestone and of the Gervillia-beds (their Kössen-beds). They connect them nevertheless with the Lower Lias, and they consider the beds with *Ammonites globosus* at Salzburg, and those of St. Cassian, as a separate formation, which they call Upper Muschelkalk. This is a questionable point, which will be decided, I hope, as soon as we get more positive data respecting the position of the *Ammonites globosus* of Salzburg, a time which is not far distant.

It appears that the true Muschelkalk is wanting along the whole northern slope of the Western Alps; it reappears to the south. Besides the localities already known, Escher has discovered several others. I have lately received from Messrs. Lavizzaci and Stabile at Lugano a considerable number of fossils found in the well-known dolomite of the chain of Monte Salvadore, near Lugano, which most clearly prove it to be Muschelkalk. It appears that the Keuperin the neighbourhood of the Lakes of Lugano and Como is also in the state of dolomite, which renders it difficult to separate it from the dolomites which underlie the Muschelkalk; the Lower Lias is well developed at Arzo, Saltzio, and at Monte Generoso near Mendrisio, and on the shores of the Lake of Como. Then follow, forming an extensive horizon, the beds of the *Calcareo ammonitifero rosso*, of Erba, &c., which evidently belong to the *Etage Toarcien* of D'Orbigny, and which can be traced over a considerable portion of Italy.

Basle, April 9, 1854.

[*Note.*—Compare Escher von der Linth "on the Vorarlberg," Mém. Soc. Helv. vol. xiii.; and Quart. Journ. Geol. Soc. No. 42. Miscell. pp. 16, &c.; Suess "on the Vorarlberg," and "on the Kössen Brachiopods," *ibid.* No. 43. Miscell. p. 25, &c.; and Von Hauer "on the Trias, Lias, and Jura of the Eastern Alps," Jarhb. K. K. Geol. Reichsanst. 1853, pp. 715, &c.; and the Anniversary Address, 1855, Quart. Journ. Geol. Soc. No. 42. pp. lxiii, &c.—Ed.]

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3. *Notice of some* Cretaceous Rocks *near* Natal, South Africa.

By R. J. Garden, Esq., late Capt. H.M. 45th Reg.

[Communicated by R. Godwin-Austen, Esq., F.G.S.]

[Abstract.]

The discovery of these fossiliferous rocks, near the Umtafuna* (on some maps spelt "Umtavooma") River, on the coast of South Africa, was made by Mr. H. F. Fynn, in 1824. About three miles to the southward of the river commence certain excavations in the cliffs, formed by the action of the sea, and called by the natives "Izinhlu-zabalungu†." These caves extend for about 800 yards. In 1851 Capt. Garden visited the spot with Mr. Fynn, and, with the aid of his servant (the late Private Thomas Souton), and the natives, collected a suite of fossils‡ from the walls of the caves and from the adjoining cliffs. The cliffs vary considerably in height, and their tops are covered with vegetation; the *Strelitzia alba* grows abundantly in the hollows. The lowest rock visible is a hard shelly rock with pebbles; above it is a brownish-red sandstone, traversed in every direction with white veins, which are the broken edges of colossal bivalve shells (*Inoceramus*). These shells are thin, and too easily broken to be extracted from the rock; the corrugated surface of a portion of one was exposed to the extent of 2 feet in length by 1 foot in breadth, and the author estimated others to be nearly 3 feet in length. This shell is common to all the strata in the cliff. Alternate layers of the above-mentioned two rocks occur to the height of about 18 feet; above which are hard bluish-black, brown,

* Pronounced Oom-tā-fū-nā.

† Pronounced Izīnthlū zābālūngū: "the houses of the white men;" so called probably from the caverns having once been occupied by shipwrecked sailors.

‡ These fossils are described by Mr. Baily in the next following communication.

and greenish argillaceous and sandy beds. Shells were found in all these clay-beds, and Ammonites at different heights and in certain of the strata. Many fossils are exposed on the cliffs, and washed out on to the shore by the action of the sea.

Fossil trees are seen at low water on a reef of flat rocks near these caverns; and about three miles to the southward Capt. Garden found at the extreme point of the left bank of the Umpahlanyani* stream a piece of fossil wood, imbedded in a rock similar to that at the caves.

About half a mile beyond the caves runs the Umzambani† River, across which the cretaceous rocks are continued, appearing on its right bank; after which they are lost sight of, except at a few places: the author, however, believes this formation to extend as far as the Umtata River, having been informed by the late Mr. W. H. D. Fynn that fossil Turtle remains were to be procured from the rocks at the mouth of that river.

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4. *Description of some* Cretaceous Fossils *from* South Africa; *collected by* Capt. Garden, *of the 45th Regiment.* By William H. Baily, Esq., of the Geological Survey of Great Britain.

[Communicated by R. Godwin-Austen, Esq., F.G.S.]

[Plates XI. XII. XIII.]

The late Professor Edward Forbes having entrusted to my examination the interesting series of fossils collected on the coast of South Africa, near Natal, and brought to England by Capt. Garden‡, to whose exertions and liberality we are indebted for this valuable addition to the Colonial Department of the Museum of Practical Geology, the following communication has been drawn up on the plan of Prof. Forbes's able "Report on the Fossil Invertebrata from Southern India§," to which collection of fossils the series here described bears a close affinity, as also to the fossils from the greensand of Blackdown in our own country, and the *Craie Chloritée* of France.

Cephalopoda.

Genus Ammonites, Auctorum.

There are four species of *Ammonites* in this collection; the specimens generally are in fine preservation, and of remarkable size and beauty, some of them having portions of the shell still adhering. All are allied to Cretaceous forms, and belong to the following groups:—

* Pronounced Oom-pā-thlān-yā-nĭ.
† Pronounced Oom-zăm-bā-nĭ.
‡ See above, p. 453. This collection was briefly noticed in the Rep. Brit. Assoc. 1854, Transact. Sect. p. 83.
§ Transactions Geol. Soc., 2nd Series, vol. vii.

1. *Cristati*, D'Orbigny; a group of which all the species are cretaceous. To this section *Ammonites Soutonii* and *A. Stangeri* may be referred.
2. *Clypeiformes*, D'Orbigny; lower cretaceous and oolitic. *Ammonites Umbulazi* appears to belong to this group.
3. *Lævigati*, a section established by Prof. Forbes for a Pondicherry cretaceous form, and in which *Ammonites Gardeni* may now be included.

Number of specimens of each species in this collection:—

Ammonites Soutonii	2	Ammonites Gardeni	3
,, Stangeri	4	,, Umbulazi	2

Cristati.

1. Ammonites Soutonii, nov. sp. Pl. XI. fig. 1.

A. testâ discoideâ carinatâ; anfractibus 5; costis numerosis flexuosis, internis acutè tuberculatis; dorso utrinque tuberculato, medio carinato; umbilico mediocri; aperturâ ovato-ellipticâ.

Diameter, 1 foot $5\frac{1}{2}$ inches.
Diameter of disk formed by the inner whorls, 7 inches.
Length of aperture, 6 inches.
Breadth of aperture, $4\frac{1}{2}$ inches.

Shell discoidal; whorls 5, with numerous flexuous ribs, each of which bears a small tubercle on the edge of the umbilicus, and two broader ones at its termination on the back; umbilicus small; inner whorls partly concealed, flattened, with prominent tubercles upon the centre of the numerous ribs; back somewhat round, with a distinct keel, and a row of lengthened tubercles on each side. Aperture ovate and elliptical.

This very large and magnificent Ammonite, which is in fine preservation, with portions of the shell a quarter of an inch in thickness still attached, is somewhat distantly related to *Ammonites rostratus* and *A. varians* from the Lower Chalk.

It is dedicated to the memory of the late private Thomas Souton, of the Grenadier Company, 45th Regiment, who, whilst acting as Capt. Garden's servant, zealously extracted it, after much perseverance and labour, from a very hard stratum high up the cliff.

Locality.—Cliffs of the coast of S. Africa, near the Umtafuna and Umzambani Rivers.

2. Ammonites Stangeri, nov. sp. Pl. XI. fig. 2.

A. testâ discoideâ, carinatâ; anfractibus 6, angustatis; costis numerosis tuberculatis, internis bifurcatis; dorso utrinque tuberculato, medio carinato; aperturâ ovato-ellipticâ.

Diameter, 1 foot.
Diameter of disk formed by inner whorls, 8 inches.
Length of aperture, $3\frac{1}{2}$ inches.
Breadth of aperture, $2\frac{7}{10}$ inches.

Shell discoidal; whorls 6, narrow and rounded; ribs numerous, and divided into regularly arranged rather indistinct tubercles; some of the interior ribs are bifurcated; back narrow and keeled, with a row of lengthened tubercles on each side; aperture ovate.

The characters of this fine large Ammonite somewhat approach that of the last species, although the form is very distinct, being more wheel-shaped and compressed.

Named in memory of the late Dr. Stanger, of the Niger Expedition, and Surveyor-General of Natal, whose recent death in South Africa, and consequent loss to science of so able an investigator, we have to deplore.

Locality.—Cliffs of the South African coast, near the Umtafuna and Umzambani Rivers.

Clypeiformes.

3. Ammonites Umbulazi, nov. sp. Pl. XI. fig. 4.

A. testâ compressâ, carinatâ; anfractibus compressis, radiis latis flexuosis; angustissimè umbilicatâ; dorso acuto, angulato; aperturâ sagittatâ.

Diameter, 1 inch $\frac{4}{10}$ths.
Diameter of inner whorls, $\frac{7}{10}$ths of an inch.
Length of aperture, $\frac{8}{10}$ths of an inch.
Breadth of aperture, $\frac{4}{10}$ths of an inch.

Shell compressed, keeled; whorls compressed, with obtuse flexuous radiations; inner whorls partly concealed; umbilicus very small; back sharp, keeled, and angular, or bevelled off on each side; aperture lanceolate.

This small compressed Ammonite has part of the shell still adhering, and appears to be nearly related to *Ammonites Requienianus*, D'Orb., from the *Craie Chloritée.*

The specific appellation of this Ammonite is the native name of Mr. H. F. Fynn, who is mentioned in Capt. Garden's paper as the discoverer of these Cretaceous deposits, and as his companion on his visit to these cliffs.

Locality.—Cliffs of the South African coast, near the Umtafuna and Umzambani Rivers.

Lævigati.

4. Ammonites Gardeni, nov. sp. Pl. XI. fig. 3.

A. testâ compressâ, discoideâ, lævigatâ; anfractibus 6, complanatis, ad umbilicum abruptis; latè umbilicatâ; dorso carinato; carinâ simplice filiformi; lateribus sulcatis; aperturâ oblongâ, compressâ.

Diameter, 5 inches.
Diameter of inner whorls, $2\frac{1}{2}$ inches.
Breadth of outer whorl, $1\frac{1}{2}$ inch; thickness, $\frac{9}{10}$ths of an inch.
Breadth of outer whorl of larger fragment, 2 inches; thickness, 1 inch $\frac{2}{10}$ths.

Shell compressed, nearly circular, smooth, with 6 whorls, flattened, rounded towards the keel, abruptly and perpendicularly depressed at its umbilical margin; umbilicus wide; back keeled; the sides obliquely and faintly striated; aperture oblong, compressed.

This characteristic Ammonite (named after the discoverer) belongs to the section *Lævigati*, established by Prof. E. Forbes, and is nearly related to *Ammonites Rembda* from Pondicherry. The prismatic colours of the nacre are still preserved.

Locality.—"White-men's Houses," coast of S. Africa, near the Umzambani River, in compact siliceous grit containing numerous fossils, and in soft greenish sandstone.

Genus Baculites, Lamarck.

Of this characteristic cretaceous genus there are three specimens, of, I believe, one species only, associated with a furrowed *Poromya* in a soft greenish sandstone.

Baculites sulcatus, nov. sp. Pl. XI. fig. 5.

B. testâ ovatâ, subcompressâ, lævi vel transversim undulatâ; dorso leviter compresso; ventre crassiore, obtuso; aperturâ obliquâ, sinuatâ; septis lobatis.

Length of the most entire specimen, 2 inches.

Greatest breadth, $\frac{4\frac{1}{2}}{10}$ths of an inch.

Thickness, $\frac{3\frac{1}{2}}{10}$ths of an inch.

Shell elongate, ovate in section, rather flattened, broadest at the aperture, and slightly tapering; with smooth transverse undulations, strongly marked near the aperture, and gradually becoming lost towards the lower extremity; back slightly compressed, ventral side rounded; aperture very oblique; septa lobed.

This species appears to be distinct from, although closely allied to, the *Baculites anceps*, figured by D'Orbigny from the *Craie Chloritée*, and differs from it in the greater rotundity of the dorsal side, and greater angularity of the transverse undulations, the section exhibiting a form more nearly approaching that of *Baculites Faujasii* from the Chalk of Ireland.

The shell is partly preserved, showing its prismatic colours.

Locality.—Cliffs of the coast of S. Africa, near the Umtafuna and Umzambani Rivers.

Gasteropoda.

Genus Solarium, Lamarck.

Solarium pulchellum, nov. sp. Pl. XII. fig. 3.

S. testâ discoideâ, spirâ parvâ, anfractibus 5, rotundatis, longitudinaliter transversimque striatis; umbilico parvo, externè crenulato; aperturâ rotundatâ.

Diameter, $\frac{3}{10}$ths of an inch.

Shell discoidal; spire small; whorls 5, rounded, transversely striated, and partially reticulated by encircling lines. The tranverse striations are strongest at the upper part of the whorls next the suture, and form crenulations at the umbilicus, which is small; mouth round.

This beautiful little *Solarium* appears to be not uncommon in this deposit, three very perfect specimens having been extracted from one small piece of the soft greenish sandstone in which they are imbedded.

Locality.—Cliffs of the coast of S. Africa, near the Umtafuna and Umzambani Rivers.

Genus Turritella, Lamarck.

Turritella Bonei, nov. sp. Pl. XII. fig. 7.

T. testâ conicâ; anfractibus 12, convexis, transversè 3-costatis; costis simplicibus; suturis profundis; aperturâ subquadratâ; basi convexo.

Length, 2 inches.
Breadth of last whorl, $\frac{6}{10}$ths of an inch.

Shell moderately elongated, tapering, with about 12 rather ventricose whorls, divided by a deep suture. The whorls have three large ridges, not granulated, and are numerously striated spirally; the base is convex, and the aperture round.

It is allied to *Turritella difficilis* of D'Orbigny, from the *Craie Chloritée* of France, but differs in having fewer ribs, and in being striated in the interspaces; it also bears a considerable resemblance to *Turritella monilifera* from Pondicherry.

Named after Mr. C. Bone of the Geological Survey.

Locality.—Cliffs of the coast of South Africa, near the Umtafuna and Umzambani Rivers.

Turritella Meadii, nov. sp. Pl. XII. fig. 6.

T. testâ conicâ; anfractibus 12, transversim inæqualiter striatis, longitudinaliter plicatis; plicis flexuosis; suturis profundis; aperturâ ovali.

Length, $\frac{7}{10}$ths of an inch.
Breadth of last whorl, $\frac{2}{10}$ths of an inch.

Shell conical; whorls 12, unequally and faintly striated by transverse and longitudinal flexuous plications; aperture oval.

Found associated with *Ammonites Umbulazi* in compact siliceous grit.

Named after Mr. Mead of the Geological Survey.

Locality.—"White-men's Houses," near the Umzambani River, S. Africa.

Turritella Renauxiana, D'Orbigny, *Ter. Crét.* pl. 152. figs. 1–4.

A much-worn specimen from Umpahlanayani River, included in this collection, appears to be identical with the peculiarly formed shell described by D'Orbigny under the above name from the *Craie Chloritée* of France.

Genus Scalaria, Lamarck.

Scalaria ornata, nov. sp. Pl. XII. fig. 2.

S. testâ turritâ, imperforatâ; anfractibus 9, longitudinaliter costatis (costis in ultimo anfractu 16); interstitiis striatis; ultimo anfractu anticè carinato; aperturâ suborbiculari.

Length, 2 inches.
Breadth of last whorl, $\frac{8}{10}$ths of an inch.

Shell conical, not umbilicated; whorls about 9, which are crossed by 16 equal elevated continuous ribs; the whorls are closely striated transversely, and decussated with very fine lines of growth, forming a terminal edge upon each rib; aperture suborbicular.

This beautiful species is closely allied to *Scalaria Dupiniana*, D'Orbigny, but has a greater number of ribs, and is more finely striated transversely.

Locality.—Cliffs of the coast near the Umtafuna and Umzambani Rivers, S. Africa.

Genus Chemnitzia, D'Orbigny.

Chemnitzia Sutherlandii, nov. sp. Pl. XII. fig. 5.

C. testâ turritâ; anfractibus 10, convexis, longitudinaliter plicatis; plicis flexuosis; aperturâ elongatâ, ovatâ.

Length, 3 inches $\frac{8}{10}$ths.
Breadth of last whorl, 1 inch $\frac{1}{10}$th.

Shell turreted, elongated; whorls 10, convex, with longitudinal incurved plications; aperture elongated and ovate.

Named after Dr. P. C. Sutherland, late Surgeon to the Arctic Expedition, and now in Natal, to whose valuable researches science is greatly indebted.

Locality.—Cliffs of the S. African coast near the Umtafuna and Umzambani Rivers.

Genus Voluta, Linnæus.

Voluta rigida, nov. sp. Pl. XII. fig. 4.

V. testâ oblongâ; spirâ conicâ; anfractibus supernè angulatis, longitudinaliter costatis; costis in angulis turgidis, et prope suturam subobsoletis, spiraliter sulcatis; aperturâ angulatâ, elongatâ.

Length of broken specimen, 1 inch $\frac{5}{10}$ths; probable entire length, 1 inch $\frac{8}{10}$ths.
Breadth $\frac{17}{20}$ths of an inch.

Shell somewhat cone-shaped, with about 18 longitudinal ribs; coarsely striated spirally. The summit of the whorls is formed at the suture into a rim with slight continuations of the longitudinal costæ and striæ of growth. The plications of the columella are not exposed.

This species is nearly related to *Voluta cincta*, Sowerby, from Pondicherry.

Locality.—Cliffs of the coast near the Umtafuna and Umzambani Rivers, S. Africa.

Genus Natica, Lamarck.

Natica multistriata, nov. sp. Pl. XII. fig. 8.

N. testâ subconicâ; spirâ elatâ; anfractibus 5, convexis, transversim striatis; aperturâ obliquè ovatâ.

Length, $\frac{8}{10}$ths of an inch.
Breadth, $\frac{7}{10}$ths of an inch.

Shell subconical; spire elevated; whorls 5, rounded, with numerous transverse striations; mouth obliquely ovate.

This form is nearly related to *Natica pagoda*, from Pondicherry.

Locality.—Cliffs of the coast of S. Africa, near the Umtafuna and Umzambani Rivers.

Several small Gasteropoda, which have been obtained in clearing out the larger fossils, appear to belong to the genera *Trochus*, *Phasianella*, and *Natica*. They are mostly too obscure, however, for specific determination.

Lamellibranchiata.

Genus Cardium, Linnæus.

Cardium denticulatum, nov. sp. Pl. XIII. fig. 4.

C. testâ suborbiculatâ, convexâ, anticè rotundatâ, posticè truncatâ; transversim costatis, costis 34, elevatis, imbricatis, et denticulatis; interstitiis concentricè striatis.

Length, $\frac{6}{10}$ths of an inch.
Breadth, $\frac{5}{10}$ths of an inch.

Shell suborbicular, convex, anterior side rounded, posterior truncated; ribs about 34, angular, and elevated, with scale-like markings and concentric striæ between; posterior margin deeply indented by the sharp ribs.

This small *Cardium*, which is beautifully preserved, is very unlike any other known fossil species, the deeply serrated posterior margin distinguishing it from all others, and giving it a greater resemblance to living forms.

Locality.—Cliffs on S. African coast, near the Umtafuna and Umzambani Rivers.

Genus Arca, Linnæus.

Arca Umzambaniensis, nov. sp. Pl. XIII. fig. 1.

A. testâ inflatâ, gibbâ, obliquè trigonâ, abruptè truncatâ, fortiter carinatâ, carinâ elevatâ, longitudinaliter concentricèque striatâ; umbonibus approximatis; areâ ligamenti angustatâ.

Length, 2 inches $\frac{3}{10}$ths.
Breadth, 2 inches $\frac{2}{10}$ths.

Shell gibbous, obliquely triangular, very abruptly truncate and carinate. The keel is elevated, and is the highest part of the shell; umbos approximating; hinge-area narrow.

The two valves of this fine large *Arca*, which are still united, have a reticulated appearance, caused by the radiating lines being crossed by transverse furrows of growth.

It is allied to *Arca fibrosa*, from the Greensand of Blackdown; also to *A. Trinchinopolitensis*, Forbes.

Locality.—Cliffs on S. African coast, near the Umtafuna and Umzambani Rivers.

Arca Natalensis, nov. sp. Pl. XIII. fig. 2.

A. testâ subinflatâ, carinatâ, transversè ovatâ, anticè obliquè truncatâ, angulatâ, posticè rotundatâ; lateribus striatis, in medio sulcato-striatis; areâ cardinali latâ, 4-striatâ; umbonibus distantibus.

Length, 1 inch $\frac{4}{10}$ths.
Breadth, 1 inch $\frac{1}{10}$th.

Shell somewhat inflated, carinated, transversely ovate; anterior side obliquely truncated, and angular; longitudinally sulcated; cardinal area large, with four striations; umbos distant.

This description is founded on a single valve, in beautiful preservation, and showing the interior and hinge-area. The strongly ridged exterior and difference of form sufficiently distinguish it from the last species. It closely resembles *A. Japetica*, from Pondicherry.

There is also another species of *Arca*, too imperfect to determine.

Locality.—Cliffs of S. African coast, near the Umtafuna and Umzambani Rivers.

Genus Trigonia, Bruguière.

Trigonia elegans, nov. sp. Pl. XIII. fig. 3.

T. testâ ovato-trigonâ, anticè rotundatâ, posticè productâ et rostratâ; costis arcuatis, obliquè crenulato-rugosis, umbonibus obtusis subrecurvis; areâ longitudinaliter sulcatâ, transversim costatâ; carinis marginali et internâ depressis.

Length $\frac{8}{10}$ths of an inch.
Breadth $\frac{6\frac{1}{2}}{10}$ths of an inch.

Shell ovately trigonal, moderately convex; anterior extremity rounded; posterior extremity produced and rostrated; ribs somewhat arched and crenulated obliquely; umbos obtuse, slightly recurved; area longitudinally sulcated and transversely striated; striations of inner carina less numerous and more distinct; carina depressed.

This small *Trigonia,* in very perfect condition, both valves being united and the ligament preserved, is distantly related to *Trigonia crenularis,* Lamarck, figured by D'Orbigny, from the *Craie Chloritée.*

Locality.—Cliffs on coast of S. Africa, near the Umtafuna and Umzambani Rivers.

Fragments of another species of *Trigonia* accompany this with large tubercles like *Trigonia rudis.*

Genus Inoceramus, Parkinson.

Inoceramus expansus, nov. sp. Pl. XIII. fig. 5.

I. testâ ovato-obliquâ, subdepressâ, subæquivalvi, concentricè plicatâ; margine cardinali elongato.

Length of fragment $5\frac{1}{2}$ inches.

Shell ovate, oblique, rather depressed, subæquivalve, with concentrically prominent plications; hinge-margin elongated.

Several fragments were procured, showing the lengthened hinge and great dilatation of this species *. One specimen has the valves united. They are from soft greenish sandstone and hard siliceous conglomerate, containing numerous fragments of broken shells. It approaches slightly the *Inoceramus latus* of the Lower Chalk and Upper Greensand.

Locality.—Cliffs on coast of S. Africa, near the Umtafuna and Umzambani Rivers.

Genus Pecten, Bruguière.

Pecten quinquecostatus, Sowerby.—A small but perfect specimen, associated with the *Inoceramus,* is identical with the Upper Greensand species from Warminster.

Locality.—Cliffs of S. African coast, near the Umzambani River.

Pecten, sp.; allied to *P. virgatus,* Nilsson. A fragment too imperfect for description; found associated with the *Voluta.*

Locality.—Cliffs of S. African coast, near the Umzambani River.

Genus Ostræa, Linn. There are two small species of *Ostræa,* one of them attached to *Inoceramus,* too imperfect to determine.

Locality.—Cliffs of S. African coast, near the Umzambani River.

Genus Teredina, Lamarck. A large mass of the tubes formed by this shell in fossil wood, much weathered, with indistinct traces of the valves, undistinguishable from the London clay species.

Locality.—"White Men's Houses," near the Umzambani River.

A group of smaller tubes from the same locality exactly resembles *Teredo antenautæ* of the London clay; probably they are formed by younger specimens of the first-mentioned species.

* See also above, p. 453.

Small bivalve shells of what appear to be the following genera, but too indistinct to determine specifically, were also included in this collection :—

Corbula ; like *C. carinata,* D'Orb.
Poromya ? ; furrowed form.
Lucina ; like *L. caperata,* from Blackdown.
Pectunculus.
Cardium.
Lucina, Nucula, Astarte, and Solecurtus ?

ECHINODERMATA.

Genus Hemiaster, Desor.

Hemiaster Forbesii, nov. sp. Pl. XII. fig. 1.

This, the only Echinoderm in the collection, is deprived of nearly all trace of its test ; some fragments, however, accompany it with the tubercles and pores well preserved.

The contour is broadly cordate, with the greatest elevation posteriorly, and slightly declining anteriorly. The dorsal ambulacra are widely petaloid, very unequal, and all lodged in deep excavations. The antero-lateral ones are $1\frac{1}{2}$ time as long as the postero-laterals. The latter are broadly ovate and have about 20 pairs of pores in each row. The antero-laterals are oblong ovate, and have about 30 pairs of pores in each series, lodged in rather broad transverse grooves. The hollowed-out portion of the odd ambulacrum is very broad and extends round to the mouth. The elevated spaces between the petals are narrow, and as if pinched up. The sides are very prominent ; the caudal extremity is obtuse ; the vent is obscured. The mouth is transversely oval. A fragment of the shell of another specimen of this species, from between the anterior and posterior ambulacra, is covered with slightly scattered small equal tubercles, the interspaces being granulated. The specimen is not sufficiently perfect to distinguish its fasciole.

Length 1 inch $\frac{1}{10}$th. Breadth 1 inch $\frac{2}{10}$ths.

Dedicated to the late Professor Edward Forbes, who has added so much to our knowledge of this class of animals, both recent and fossil, and by whose much-lamented death science has lost one of her most able advocates.

Locality.—Cliffs of S. African coast, near the Umtafuna and Umzambani Rivers.

PISCES.

Placoid Order. Squaloid Family.

Corax. Represented by a tooth, nearly allied to *C. incisus,* Egerton *, from Pondicherry.

Locality.—Cliffs of S. African coast, near the Umtafuna and Umzambani Rivers.

* Trans. Geol. Soc. 2 ser. vol. vii. p. 92.

REPTILIA.

The fragments of Reptilian bones comprised in Capt. Garden's collection, eight in number, were submitted to Professor Owen, who kindly determined such as were sufficiently perfect. He considers them to be all *Chelonian*, and described them as follows:—

1 and 2. Portions of a rib, with carinated costal plate, of a flat-formed Chelonian.

3. Apparently the coracoid of a Chelonian: and two others; portions of Chelonian bones.

Locality.—Cliffs of S. African coast, near the Umtafuna and Umzambani Rivers.

Inferences drawn from a Study of the Species.

The total number of species of *Mollusca* in this Collection are 35, viz.:—

Cephalopoda	5	35 species.
Gasteropoda	11	
Lamellibranchiata....	19	

Of these, 30 are hitherto undescribed forms, and related or having a close affinity with Cretaceous species; the only apparent exceptions being that of the *Voluta*, a genus characteristic of the Tertiaries of our own country (but as Professor Forbes states in his Report on the Indian fossils, to which this collection bears a considerable resemblance, "having representatives, and those not peculiar forms, as low down as the Upper Greensand in Europe, and occurring also in Cretaceous strata in North America"); and the *Teredo*, which is undistinguishable from the London Clay species.

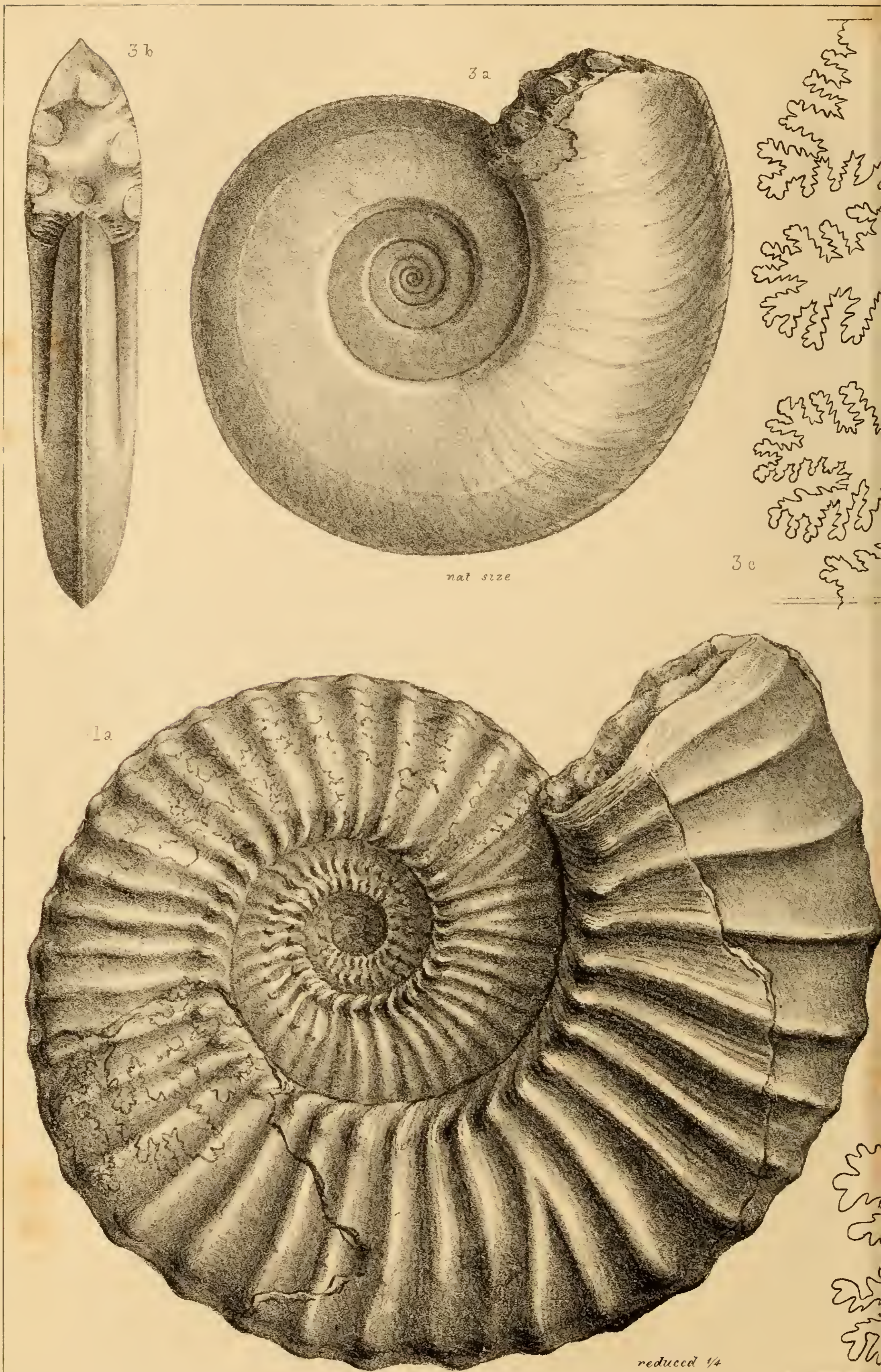
There is but one species, however, which can be positively identified with English fossils, and that is *Pecten quinquecostatus*, one of the most characteristic of cretaceous species.

Of the *Gasteropoda*, the *Scalaria* is closely related to a cretaceous species found in the Gault of Folkestone and Greensand of Blackdown; one of the species of *Turritella* is also allied to a cretaceous form from France; another, but very imperfect specimen, appears to be identical with *Turritella Renauxiana*, described by D'Orbigny from the *Craie Chloritée*.

The genera of Bivalves in this collection are all known in cretaceous or older strata; the peculiar forms of *Arca, Trigonia, Corbula, Poromya, Lucina, Astarte, Nucula, Inoceramus*, and *Pecten* being also characteristically cretaceous.

There is but one species of Echinoderm; and this is a characteristic cretaceous form of the genus *Hemiaster*.

There appears, therefore, from the evidence adduced, no difficulty in believing that the beds from which these fossils were obtained, are "cretaceous," and probably palæontologically equivalent to the Upper Greensand of this country and *Craie Chloritée* of France.



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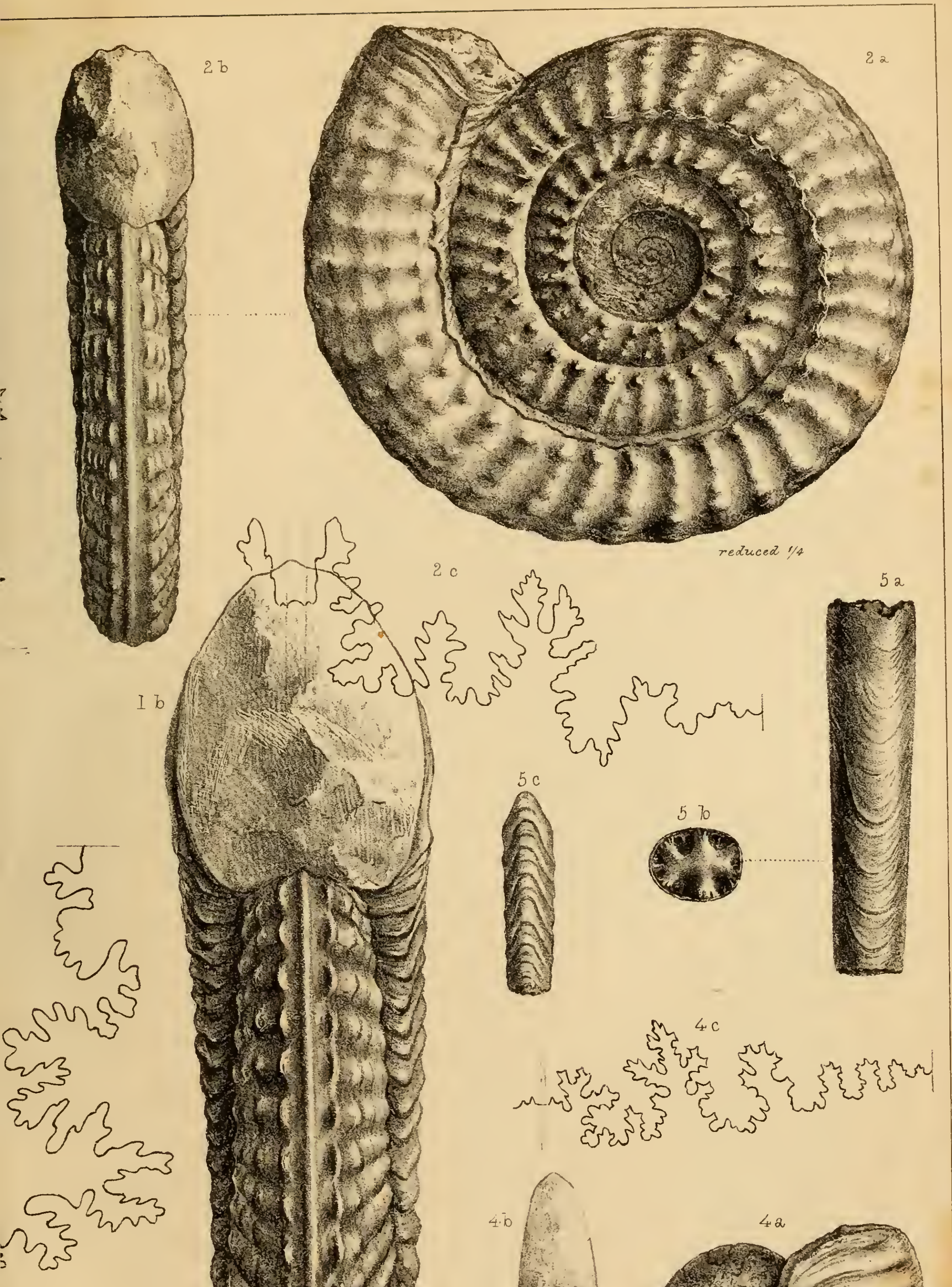
CRETACEOUS FOSS



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S OF SOUTH AFRICA.

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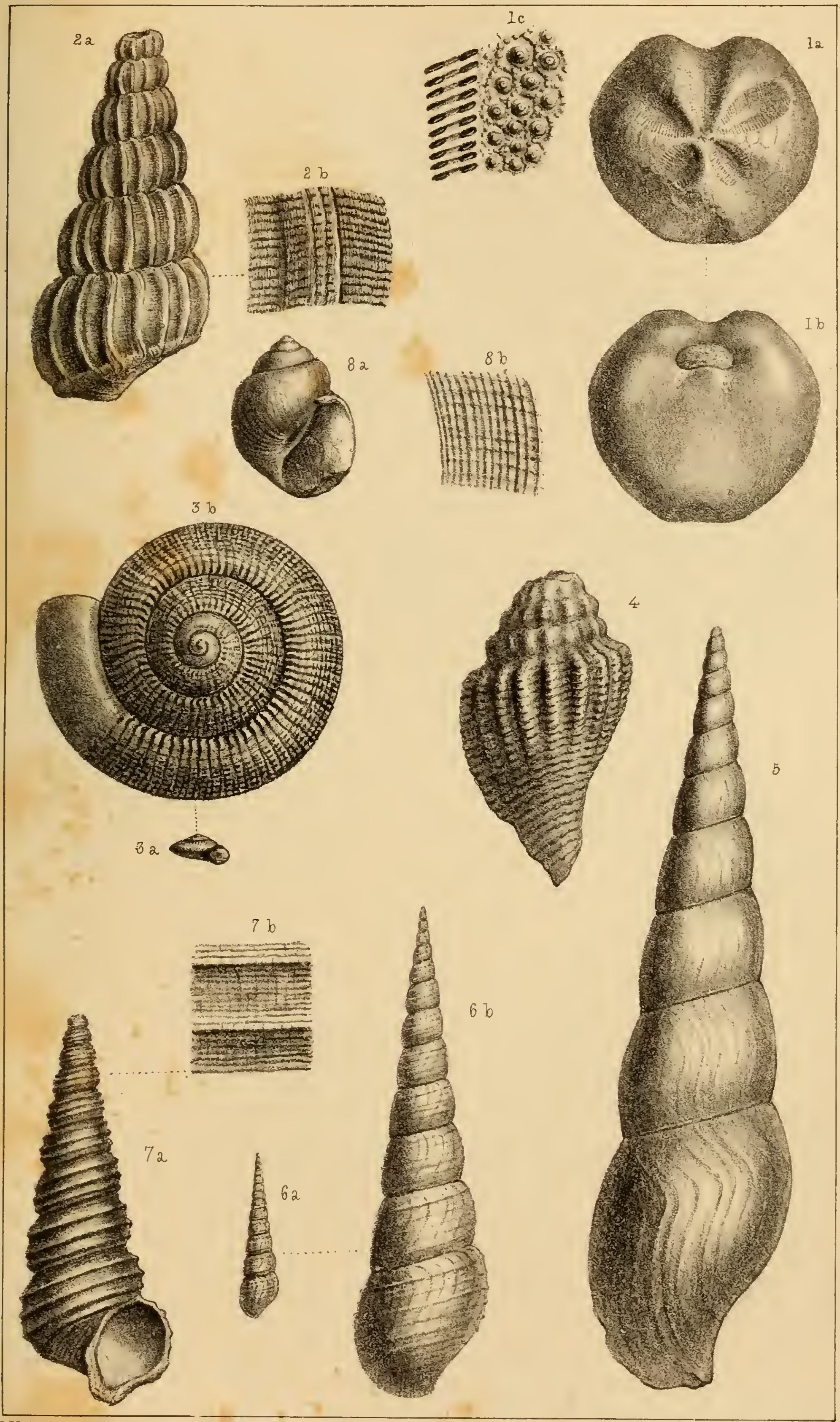
CRETACEOUS FOSSILS OF SOUTH AFRICA.



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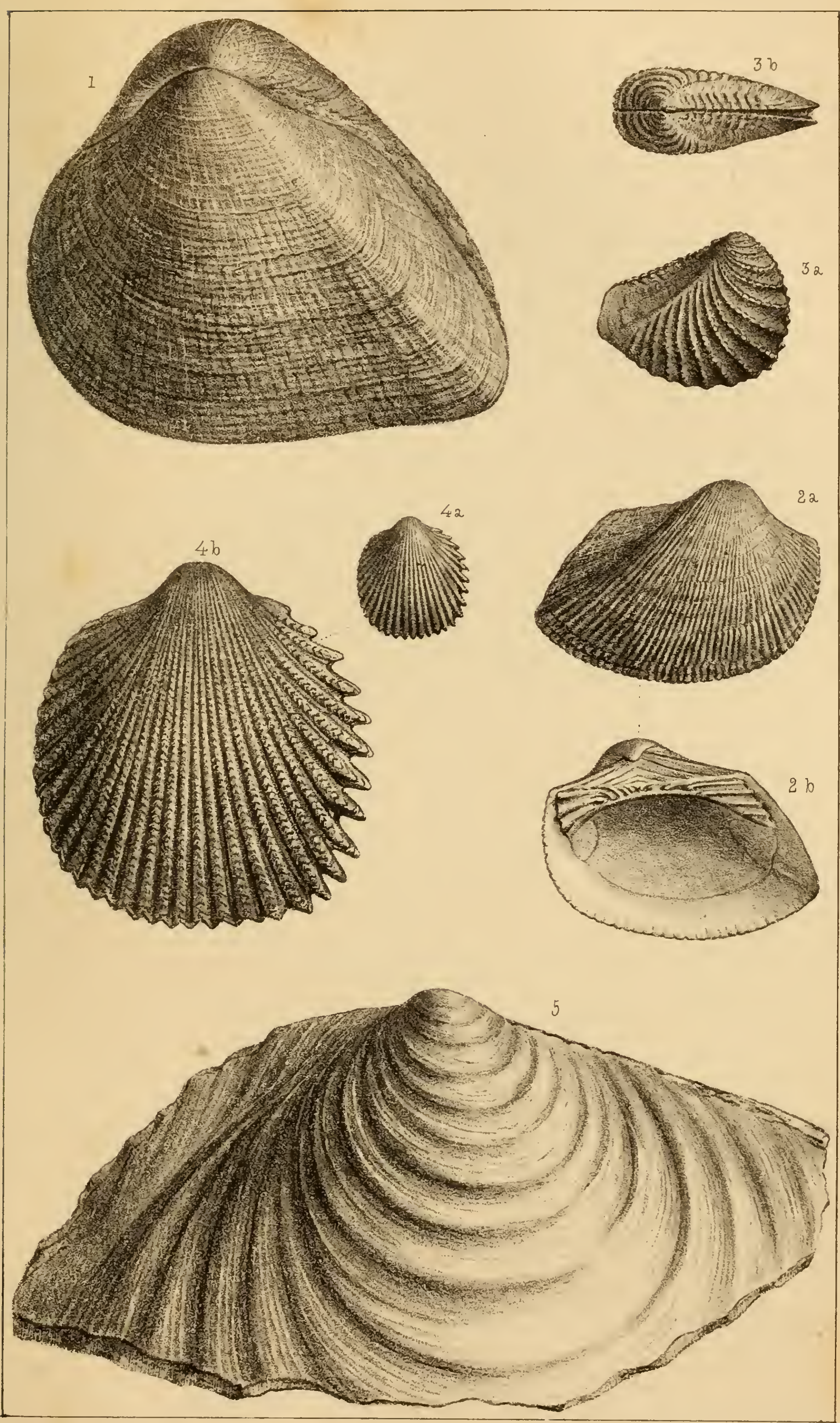

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CRETACEOUS FOSSILS OF SOUTH AFRICA.

EXPLANATION OF PLATES XI., XII., XIII.

Plate XI.

Fig. 1. Ammonites Soutonii: *a*, front view of whorls; *b*, back view reduced to one-fourth of natural size; *c*, septal suture, half-natural size.
Fig. 2. Ammonites Stangeri: *a*, front view of whorls; *b*, back view, reduced to one-fourth of natural size; *c*, septal suture, natural size.
Fig. 3. Ammonites Gardeni: *a*, front view of inner whorls; *b*, back view, natural size; *c*, septal suture, enlarged 2 diameters.
Fig. 4. Ammonites Umbulazi: *a*, front view of whorls; *b*, back view, natural size; *c*, septal suture, enlarged 3 diameters.
Fig. 5. Baculites sulcatus: *a*, front view; *b*, section of one of the chambers; *c*, back view of another specimen with deeper sulcations.

Plate XII.

Fig. 1. Hemiaster Forbesii: *a*, upper surface; *b*, under surface; *c*, portion of upper surface with ambulacra, perforated tubercles, and encircling granules, magnified.
Fig. 2. Scalaria ornata: *a*, natural size; *b*, portion of surface, magnified.
Fig. 3. Solarium pulchellum: *a*, side view, natural size; *b*, upper view of whorls enlarged 5 diameters.
Fig. 4. Voluta rigida; natural size.
Fig. 5. Chemnitzia Sutherlandii; natural size.
Fig. 6. Turritella Meadii: *a*, natural size; *b*, enlarged 3 diameters.
Fig. 7. Turritella Bonei: *a*, natural size; *b*, portion of surface magnified.
Fig. 8. Natica multistriata: *a*, natural size; *b*, portion of the surface magnified.

Plate XIII.

Fig. 1. Arca Umzambaniensis; natural size.
Fig. 2. Arca Natalensis: *a*, outer view of single valve; *b*, inner view of the same; natural size.
Fig. 3. Trigonia elegans: *a*, front view; *b*, hinge view; natural size.
Fig. 4. Cardium denticulatum: *a*, natural size; *b*, enlarged 3 diameters.
Fig. 5. Inoceramus expansus: hinge portion of shell, reduced one-third.

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5. *Notes on the* Geology *of* Natal, South Africa. By Dr. P. C. Sutherland.

[In Letters* to Sir R. I. Murchison, V.P.G.S.]

The sea-coast of Natal, to a distance of twenty to thirty miles inland, appears to be composed of beds of sandstone and shale alternating with trap-rock, the former containing thin layers of woody coal and very faint vegetable impressions. These beds of trap and sedimentary matter are not individually of great extent. Six of each sometimes occur in a linear space of a quarter of a mile.

The best specimens of the coal yet found are only slightly bituminous; and much is of very inferior character. The thickness of the seams varies from a mere film up to about $2\frac{1}{2}$ to 3 feet. Where the best coal exists, three seams crop out in a space of 20 feet; the aggregate thickness of which is upwards of 4 feet. From the manner in which they run into each other, thin out, again thicken,

* Dated D'Urban, March 13, 1854; and Natal, Nov. 3, 1854.

and are separated by lenticular deposits of arenaceous shale and grit, I have hopes, by following them, we may find them passing permanently into one or more thick beds. The distance, however, of this locality from a sea-port (200 miles) is such, that the value of the coal will not repay the expense of working and carriage. It is of importance, however, for use in the Colony [Natal], and since it began to be wrought the imports of coal into Natal have ceased.

Judging from the cursory examination I have been able to make of the impressions of leaves and stems contained in the shale, they resemble the Oolitic flora more than that of the true Coal-formation. Bones, apparently of a Saurian *, are imbedded in a highly calcareous rock which crops out above the coal-strata, and are associated with the vegetable impressions which characterize the latter.

The arenaceous shale is frequently found beautifully ripple-marked, and that too within half a foot, in the descending series, beneath the coal.

The crystalline rocks, cropping out in a line nearly parallel with the direction of the sea-coast, are infringed upon by beds of coarse sandstone, which occasionally show symptoms of disturbance from extensive beds of a species of trachyte containing fragments of the crystalline rocks on which the less disturbed sandstone strata rest. At first I had considerable doubt about the true character of the trachytic rock, but they were removed by finding the sandstone beds scored and grooved where the superincumbent erupted matter had passed over them in a state of semi-fusion. This condition of semi-fusion must have conduced to the mechanical suspension of the granitic fragments. Where the grooves and scratches were observed, the inclination of the strata is 1° 17′. Removal of the erupted matter by the denuding agency of the weather reveals the grooved surface of the stratified rock, which has been rendered the more enduring by contact with the former. On the coast and inland sides of these beds, extensive strata of shales and sandstone alternate with irregular beds of greenstone, which frequently crop out as basaltic cliffs. Dykes of the same material traverse the strata in all directions.

The metamorphic strata of the district frequently show extensive contorted laminæ of quartz, which undergo disintegration under atmospheric influences, but gold does not appear to have been yet found in connexion with them.

Undulating table-lands of considerable extent are not uncommon at a height of 5000 feet in this district, and many such are composed of a bed of greenstone at the top, resting on beds of shale and sandstone, the latter being traversed by dykes of the volcanic rock. These table-hills occur about twenty or thirty miles from the coast, and are several miles in extent. Some of these rise precipitously above level plains of equal extent.

A huge dyke of granite runs from N.E. to S.W. in a somewhat

* [The author thinks this to be *Ichthyosaurus*, but perhaps it is *Dicynodon*, as these strata appear to be continuous with those described by Mr. Bain.—Ed.]

tortuous course, and is flanked on both sides by the table-hills, which, curious as it may appear, are at a higher elevation above the sea. The Table-hills are composed of a rudely stratified sandstone, without fossils, and containing rounded pebbles of gneiss, quartz, clay-slate, and other metamorphic rocks. The granite is very rough-grained, almost porphyritic, and in some instances large masses are seen protruding through, and resting in, beds of the same material, which has undergone some peculiar decomposing process. As we advance inland, the beds of sandstone and shale are of much greater thickness than on the coast. In one or two instances beds of basalt have been cut through to a depth of nearly 300 feet by the river. Such deep beds give rise to a somewhat terrace-like character in the contour of the country, from the protrusion of the granite to the Draakensberg Range.

The sea-coast is in some places fringed with reefs of the dark basaltic rocks. In other parts large dunes of sand, containing sea-shells in a fragmentary state, are thrown up by the wind, and, from the large proportion of lime they contain (70 per cent. of the carbonate), they soon become consolidated into stone fit for building-purposes *. These dunes are, for the most part, covered with a rank verdure or a low thick and impenetrable bush, in which land-shells are abundant, the impressions of which are not unfrequently met with in the newly constructed sandstone. The rivers, with a descent of about 40 feet in the mile, flow very rapidly, and bring down great quantities of detrital matter in a highly subdivided state. This becomes deposited at their mouths to form rock, which not unfrequently is found to include the enduring shells of Oysters and other littoral molluscs †. The water sometimes bears down fine debris of dark greenstone, which, alternating with the lighter-coloured detritus, forms a deposit in which several strata can be counted in the space of a single inch.

The recent deposits in the upper parts of the district yield fine agates, derived from dykes of amygdaloidal rock.

The Quathlamba Range appears to be composed of alternating strata of greenstone and the shaly rocks of the Colony. It attains a height little less than 9000 feet.

The copper of the Natal District, and of the district of the Free Republic beyond the Vaal River (one of the chief branches of the Orange River), occurs in the form of malachite in highly contorted gneiss, the mica of which is not unfrequently replaced by hornblende, thus forming a laminated syenitic rock. From the diffusion of the ore in the rock, and the readiness with which the outcrops are

* [See also Capt. Nelson's Observations on these rocks of Æolian formation on the South African Coast and elsewhere, Quart. Journ. Geol. Soc. vol. ix. p. 206.]

† The author incidentally alludes to the richness of the existing molluscan fauna, both of land and sea, on the Natal Coast, and the characteristic difference existing between it and that on the coast of the Cape Colony,—a difference arising from the heating influence of a current flowing southward along the shore from the Equator, through the Mozambique Channel.

exhausted, I am not very sanguine that the sources hitherto discovered will prove productive. I believe, however, that beyond the Vaal River the ore is in considerable abundance, but up to this time I am not aware that any attempts have been made to develope a trade in that valuable metal from the inland quarter in question.

May 2, 1855.

W. Foster White, Esq., C. S. Mann, Esq., L. Barrett, Esq., and J. D'Urban, Esq., were elected Fellows.

The following Communications were read:—

1. *On the* Anthracitic Schists *and the* Fucoidal Remains *occurring in the* Lower Silurian Rocks *of the* South *of* Scotland. By Professor R. Harkness, F.G.S.

The Lower Silurians of the South of Scotland, as shown by other authors*, constitute the whole of the mountainous region which, lying south of the Firths of Forth and Clyde, forms the Southern Highlands of Scotland, except a small patch at the eastern extremity of Kirkcudbright Bay, which appertains to the Upper Silurians†. These Lower Silurians have a prevailing inclination towards the N.N.W., and along their northern margin we have the highest strata developed. At the north-western extremity of the range, near Girvan in Ayrshire, these higher beds consist of limestone and sandstones, abounding in fossils characteristic of the Llandeilo portion of the Lower Silurians. Towards the south deeper-seated strata occur; and as we find no traces of limestone beds in these, fossil remains become rare, the deposits consisting principally of sandstone, with some shales. Among these, however, under certain circumstances, organic remains are met with, more particularly as we approach the lowest portion of the formation.

A locality where these deep-seated strata are well seen is in Glenkiln‡, in the parish of Kirkmichael, about nine miles north of Dumfries. Commencing at the entrance of the glen, we find exposed, in the course of the Glenkiln Burn (see fig.) underneath the manse of Kirkmichael, a small patch of bunter-sandstone (?) conglomerate (*a*) abutting against a purple sandstone (1), which forms the lowest portion of the Silurian strata here seen. Similar sandstones or grits (1) make their appearance higher up the stream, and, although partially covered with gravel, form the bed of the brook until we reach a spot known as Lamb-foot.

Besides purple grits, some of which contain quartz fragments, bluish-grey grits occur, and with these are associated purple and greyish indurated shales.

* See Nicol, Quart. Journ. Geol. Soc. vol. iv. p. 204, &c.; J. C. Moore, *ibid.* vol. v. p. 7, &c.; Murchison, *ibid.* vol. vii. p. 139, &c., and 'Siluria,' p. 149.

† See Quart. Journ. Geol. Soc. vol. vii. p. 46, &c.; and vol. viii. p. 393.

‡ *Ibid.* vol. vii. p. 49, and vol. viii. p. 393.

These purple and grey grits and shales have a prevailing dip towards the N.N.W. at an angle of about 40°, much less than the ordinary dip of the Silurians, which is in the same direction, usually at an angle of about 70°; and these strata, having the smaller dip, attain a perpendicular thickness of about 1500 feet, throughout which no fossils are seen.

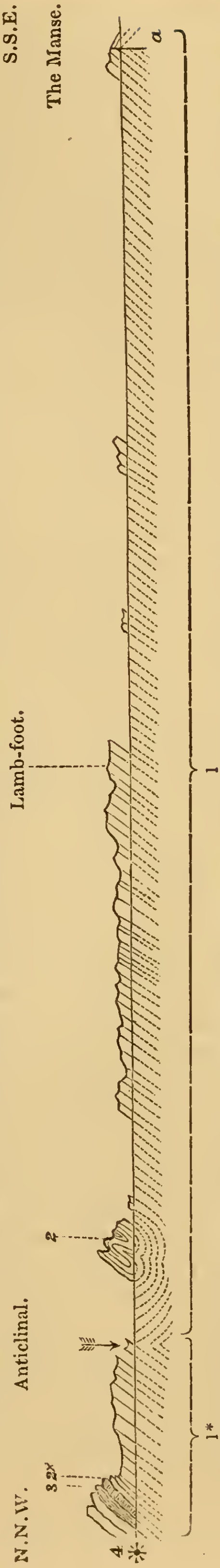
Above this series of grits and shales, we find in the course of the brook beds of anthracitic shale (2), which are crumpled up by flexures. As the brook immediately above and below the anthracite-shales flows over pebbles, the deposits upon which these shales rest are not here seen. The lower beds of the anthracite-shale occur in the form of indurated black shales, having anthracitic laminæ running through them.

In the more anthracitic shales we have abundance of fossils, which consist of *Graptolites sagittarius*, *Diplograpsus pristis*, *D. ramosus*, *D. mucronatus*, and *D. bicornis*; but these, as we shall afterwards see, are not the lowest fossils which present themselves.

After leaving the flexured anthracite-shale, the strata are hidden for a distance of about 80 yards across the strike, when they again appear to a small extent, dipping at a high angle towards the S., and are immediately succeeded by others (1*) with the same dip as occurs in the deposits below the anthracite-shale, viz. about 40° N.N.W. They resemble those which are seen lower down the stream, and seem to be a repetition of the same strata, resulting from a small anticlinal. Grits and shales, about 240 feet in perpendicular thickness, here present themselves; and are succeeded by a thin black shale, immediately underlying the anthracite-shales here repeated (2*); and in this black shale we have fossils which occupy the lowest position in this locality.

This black shale is about 6 inches in thickness; its lower portion is filled

Section of the Lower Silurian schists in Glenkiln, Dumfriesshire.—Length of Section about two miles.



a. Bunter-sandstone (?) conglomerate.
1, 1*. Purple and grey grits.
2. Anthracite and graptolite shales.
2*. Anthracite shale, overlying thin shale, 6 inches thick, containing *Siphonotreta* and *Graptolites*.
3. Graptolite shale.
4. Drab-coloured shales.
* Level of the brook.

with a small rounded variety of the *Diplograpsus folium*, generally in an imperfect state. In the same shale *Didymograpsus sextans*, Hall, is found along with the Graptolites already referred to as occurring in the anthracite-shale, and also a new form of *Rastrites*, characterized by the length of its cells, which attain almost an inch in size (see p. 475). Besides these, an orbicular Brachiopod, which Mr. Salter informs me is the *Siphonotreta micula*, M'Coy, occurs; this is the only bivalve shell as yet obtained in these low deposits. Separating this black shale from the underlying purple and grey grits is a thin drab-coloured shale, in which no fossils are found.

In the anthracite-shales (2*) which succeed the black shale, we meet with the same fossils which make their appearance in the flexured beds below (2); and above these there is seen another dark-coloured shale (3), also abounding in Graptolites, some of which do not occur in the anthracitic schists, viz. *Graptolites Sedgwickii*, *Diplograpsus folium*, and *Rastrites peregrinus*. Above this another bed of black shale appears, in which only *Diplograpsus teretiusculus* occurs.

Light drab-coloured shales (4) succeed; these are devoid of fossils, but resemble lithologically the deposit which underlies the thin black fossiliferous shale. Beyond the drab-coloured shales (4) the bed of the stream in the glen above consists of gravel.

Deposits similar to those above-described are common to many localities in the Silurians of the South of Scotland. They are well seen in the course of the Duffkinnell Burn, in the neighbourhood of Rae Hills, in the parish of Johnstone, Dumfriesshire; and here they afford many of the fossils just alluded to, as well as a form of *Rastrites* new to Great Britain, the *R. Linnæi*, Barr. In this locality, besides the remains of these zoophytes, we have evidence of a more highly organized race of animals. These consist of portions of Crustacea. One of them is figured in the Quart. Journ. Geol. Soc. vol. viii. pl. 21. fig. 10, and is named by Mr. Salter *Dithyrocaris? aptychoides*. Another, which at first sight was a puzzle to palæontologists, Mr. Salter informs me is a portion of the carapace of a crustacean probably of the same genus,—a genus which has hitherto been found only in the carboniferous formation, principally in coal-shales; a circumstance supporting the conclusion that the anthracitic schists owe their origin to conditions somewhat akin to those under which the shales of the coal-measures were formed.

Among these strata of the South of Scotland, we have as yet seen no organic remains from which we can form any idea as to the origin of the anthracite present in some of the schists; the fossils already referred to being of animal nature, and occurring in the form of pyritous stains. In one instance, however, in black shales overlying the anthracite-schists, the remains of a Fucoid were found; and this is probably the lowest position in which *distinct* traces of such remains have been met with in Scotland. On referring this fossil to Mr. Salter, he writes me thus:—"It is, I believe, a Fucoid; but that of itself is most interesting, as we have no clear traces of fucoids so low."

Although the anthracitic schists themselves have not yet afforded this form of fossil, still there are some reasons for inferring that this deposit has derived its carbonaceous matter from the existence of sea-weeds during the earlier portion of the Lower Silurian epoch.

In order to obtain more intimate knowledge with regard to the origin of the anthracite, I submitted portions of it to a minute microscopical examination, both in the form of powder and likewise in the state of ash. In no case, however, could I obtain anything which indicated vegetable structure, the ash presenting itself in the form of minute grains of quartz, having upon them the transverse striation prevailing in this mineral. Through the kindness of my friend and colleague Dr. Blyth, I am enabled also to give the analysis of the anthracitic schists, which is as follows:—

Water	1·05
Carbon	5·05
Ashes	93·90
	100·00

The ashes consist of,—

Silica	96·83
Iron	2·27
Alumina	0·90
Lime	a trace
	100·00

From this analysis of the ashes of the anthracite-schists, they appear in their mineral composition to approach exceedingly near to the nature of pure quartz ; and it would seem that these schists were originally beds of fine sand, or, in other words, sand-banks, impregnated with organic substances. The question as to the source from whence the carbon has been derived, is in no way answered by the microscopical examination, or by the analysis, except that this latter points to an affinity to some of the coal-measure shales rich in carbon, and renders the circumstance probable, that, like these coal-shales, the anthracite was obtained from altered vegetable matter. The occurrence of such animal remains as are seen in these schists in the form of *iron pyrites* rather than as carbonaceous markings, would also justify the inference that the carbon of these shales had a different origin from that which had entered into the composition of the Graptolites when these were living animals, and would, to some extent, lead to the conclusion that vegetable remains furnished this substance,—an inference which is further supported by the appearance of a genus of Crustaceans, the *Dithyrocaris*, which had its habitat among the vegetable mud of the succeeding carboniferous formation.

When we consider the large portion of earthy matter in the anthracitic shales, we must regard them as having an origin in some respect allied to that of coals which contain a large amount of earthy substances, although the latter derive their organic matter from a different class of vegetables. And if we bear in mind the low organization of Fucoids, which consist of a simple mass of parenchymatous tissue of a very succulent character, we can easily conceive how readily all traces of the external form of such vegetables would become obliterated, and also how all distinct evidence from the state of internal tissue should have disappeared.

In Sweden, where the anthracitic or bituminous shale occurs among the Silurians, it has been shown by Murchison* to rest upon a sandstone containing Fucoidal remains, indicating the source from whence the shales probably derived their carbonaceous matter. In Russia, however, where they underlie limestones of the Llandeilo age, they have less of an anthracitic, and more of a coaly nature; since, from the observations of Colonel Helmersen, these deposits contain about 25 per cent. of bitumen, with a considerable amount of inflammable gas.

In the Silurians of the South of Scotland, vegetable remains are apparently not confined to the anthracite-shales and their accompanying beds. There exists another zone in these Silurians affording Fucoidal remains in at least one locality. This zone forms the beds from whence Graptolites were first obtained by Prof. Nicol at Greiston in Peeblesshire; and, following these deposits from this locality in the direction of their strike, W.S.W., we meet with them again at Barlae, in the parish of Dalry, about seven miles north of the town of New Galloway, in the Stewartry of Kirkcudbright. Here the Fucoid remains occur under entirely different circumstances from those at Glenkiln. They are in no way associated with anthracite-shales, neither do they make their appearance in soft beds along with Graptolites.

The deposits in this locality consist of sandstones and flaggy beds: the latter were formerly used for slating-purposes; but, in consequence of exfoliating by exposure to the weather, and requiring heavy timber to support them, the working of these so-called slates is now abandoned in the South of Scotland, the Welsh and Cumberland slates having supplied their place. On the faces both of these sandstones and of the flaggy beds, various fossils are seen. Sometimes they occur in the form of the tracks of Annelids of the genus *Crossopodia*, M'Coy; and sometimes *Nereites* present themselves, as well as the rare zoophyte *Protovirgularia*, M'Coy; also filiform bodies, the nature of which is somewhat uncertain, but having, in the opinion of the late Prof. E. Forbes, some relation to the genus *Oldhamia* of the Irish Cambrians; and along with these, fucoids of the genera *Palæochorda* and *Chondrites*, M'Coy, occur, the former in considerable abundance. Of the branching fucoid, *Chondrites*, several species may be seen, and amongst these are *C. informis*, M'Coy, and *C. acutangulus*, M'Coy, fossils which are found in the black slate of Skiddaw.

These fucoids present no traces of anthracite, but are converted into the substance in which they lie; and the physical evidence associated with their occurrence leads to the inference that the strata were formed in comparatively shallow water, since we have ripple-marks on the faces of the beds; these ripples, in some instances, being partially filled with sand.

* See Russia in Europe, vol. i. p. 15*, and Siluria, p. 318.

The evidence afforded by the deposits which accompany the anthracitic shales, however, is such as to show that different circumstances prevailed from those which have produced the fucoid-sandstones of Barlae. The character of the shales both subjacent and superior to the anthracite-schists leads to the inference that tranquil water deposited them; and they have every aspect of being the result of a deeper sea; the conditions being such as to support the conclusion that other forms of fucoids than those which occur in the higher-lying sandstones of Barlae produced the anthracite-schists; an inference, which is supported by the occurrence in the graptolite-shales of a fucoid which in its external characters bears no relation to either the *Palæochorda* or *Chondrites*. When we consider the large area which the anthracitic shales occupy, extending all across the South of Scotland, it is probable that these owe their carbonaceous matter to some form of ancient sea-weed, which, like the present *Macrocystis pyrifera*, occurred in immense masses over extensive tracts of sea; the recent form referred to having a distribution through no less than 140 degrees of longitude.

Notes on the Fossil Fucoids, Zoophytes, *and* Annelids *of the* Flags *and* Sandstones *at* Barlae. By Professor R. Harkness, F.G.S.

Fucoids.

1. Chondrites regularis, nov. spec. This species of branching fucoid is characterized by the regular mode in which it is divided; the branches in the specimen under examination appearing to issue from a central stem, at nearly equal distances from each other on one side, where the portion of the central stem and branches are seen in a state of considerable relief. On the opposite side no branches are apparent, and the stem is obscure, owing probably to the stony matter enclosing this part of the fucoid. The branches are slightly curved, and become more flattened and expanded near their extremity. The lowest and largest of these in the specimen is about an inch in length, the other two being smaller, and the branches seeming to lessen in size as they approach the upper part of the fucoid. The central stem in this specimen is about 3 inches long and $\frac{1}{10}$th of an inch in thickness, and has a rounded form.

Locality.—Found along with other species at Barlae Quarry, Kirkcudbrightshire, in indurated shale.

2. Chondrites informis, M'Coy*. This species, which occurs in the black slate of Skiddaw (Whitless), is met with in considerable abundance in the grey shales and sandstones of Barlae; but in general it presents itself in a more indistinct state than as seen on the slates of Cumberland.

3. Palæochorda major, M'Coy†. This fucoid is seen in

* Palæoz. Foss. Cambr. pl. 1A. fig. 4. † *Ibid.* pl. 1A. fig. 3.

greater abundance than any other which occurs among the sandstones at Barlae. It is usually found in the form of long, rounded, straight, or slightly-curved bodies, of which the latter portion of the generic term well expresses the appearance. Sometimes individuals are found which have the aspect of having been subjected to sudden force, presenting themselves sharply bent at a right, or even an acute angle, showing that their succulent tissues had been injured by breaking. This form has a great resemblance to *Scolithus linearis*, Hall, from the Potsdam sandstone, where it occurs in a straight state. The American fucoid* is, however, found traversing the rock in a perpendicular direction, while the Scotch *Palæochorda major* is met with scattered horizontally over the faces of the strata. M'Coy's specimens are from Kirkfell, near Scawgill.

4. PALÆOCHORDA ? TERES, nov. sp. This species (if it belongs to the genus *Palæochorda*), may be recognized by the gradual tapering of the stems, which are much broader at what appears to be the base than at the opposite end. The length is also much less than in *P. major*. But the thinning of this form is its most distinguishing characteristic. In one of the specimens the apparent base is $\frac{3}{10}$ths of an inch across, while the opposite extremity is only $\frac{1}{10}$th; the whole length of the specimen, as it now appears, being only about 3 inches.

This species, which appears to have been well rounded, seems to have been much shorter than the other forms of the *Palæochorda* which make their appearance in the Lower Silurians of Great Britain.

Locality.—Associated with *P. major* and other fossils in the hard shales and sandstone beds of Barlae.

5. TRICHOIDES† AMBIGUUS, nov. gen. et spec. These specimens, the nature of which is uncertain, consist of hair-like bodies, generally straight, but sometimes having a slight curve. They occur scattered over the faces of some of the beds in an irregular manner. They sometimes, however, seem to be collected in groups, the hair-like forms having an arrangement approaching to imperfect radiation. Some of the scattered portions have the aspect of bifurcation; but this, perhaps, may be owing to two individuals coming in contact with each other. When magnified, the surface seems to have a serrated aspect, somewhat resembling the serratures which mark Graptolites of the genus *Diplograpsus*, but much more minute. The length of the hair-like bodies is irregular; sometimes they exceed an inch, and at other times they are much less, having a broken aspect. Whether these bodies be Fucoids, or Zoophytes allied to Graptolites, is at present difficult to say. Their apparent branching, and the serratures which occur on their side, would lead to the conclusion that they belong to the latter; and the late Prof. E. Forbes,

* Regarded by Mr. W. E. Logan as the cylindrical casts of vertical Worm-holes. See Quart. Journ. Geol. Soc. vol. viii. p. 200.

† From Gr. τριχοειδής, hair-like.

from a slight examination of them, was disposed to regard them as having some affinity to *Oldhamia*. Whatever may have been their nature, they must have existed in great quantities in this locality during the deposition of the muds and fine sands which now form the shales and sandstones of this portion of the Lower Silurians, since they are found in considerable abundance on the surfaces of the strata in Barlae Quarry.

Zoophytes.

1. Rastrites Barrandi, nov. sp. Axis apparently spirally curved; narrower than the cells. Cells arranged on the convex margin, at the distance of about $\frac{1}{12}$th of an inch from each other; slightly curved; and, when perfect, more than $\frac{3}{4}$ of an inch long; narrowest at the base. The cells show traces of tubular structure, the result of a collapsing of their walls.

This form is very distinct from the other species of *Rastrites*, being well marked by the great length of the cells.

Locality.—Occurs in the black shale immediately underlying the anthracite in Glenkiln Burn, Dumfriesshire. Also found, though rare, in the black slates of Cairn Ryan, Wigtonshire.

2. Protovirgularia dichotoma, M'Coy?* Among the fossils which occur at Barlae is a zoophyte which appears to be nearly allied to the *Protovirgularia dichotoma* of M'Coy. In some respects, however, it differs from the species alluded to. The portions which have been found at Barlae do not present the dichotomous branching of M'Coy's species, nor indeed any branching at all, although the length exceeds the specimens of his *P. dichotoma*, which show several branchings. Probably this form from Barlae may be a new species, devoid of branching altogether, or having its branches remote from each other. The portions supporting the cells have the arrangement which prevails in this genus.

Locality.—Found very sparingly on the surfaces of the shales at Barlae.

Annelides.

1. Crossopodia Scotica, M'Coy †. The tracks of this Annelid occur in great abundance on many of the faces of the strata at Barlae. These tracks commonly appear in the form of a sinuous line, about $\frac{3}{10}$ths of an inch broad. The original state of the strata has frequently prevented the cirrated lines, which mark this species, from being recognized, as these strata were, when deposited, very fine mud in an exceedingly soft state. Where the mud has been of a harder nature, the cirrated markings are distinctly visible, and they present all the characters of the form referred to. M'Coy's specimens were from near Inverleithen.

* Palæoz. Foss. Cambr. p. 10. pl. 1B. fig. 11, 12.
† *Ibid.* p. 130. pl. 1D. fig. 15.

2. Nereites multiforis, nov. spec. The tracks which have received this name are seen on some of the flaggy beds at Barlae. The most common appearance which they present is a double row of small pits, generally oval in form, and arranged alternately. When they occur in their most perfect state, the pits are larger, and have a furrow between them. The greatest width of the pits does not exceed $\frac{1}{5}$th of an inch. These impressions have some affinity to those figured by Prof. Hall (Palæont. of New York, vol. ii. p. 14, 2 *h* & *i*), as tracks from the "Clinton group." In the American specimens, however, the pits are opposite, instead of alternate, and the impressions are of smaller size.

Locality.—Occurring on the faces of the indurated shales, Barlae Quarry, Kirkcudbrightshire.

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2. *Notice of the Occurrence of* Coal *near the* Gulf *of* Nicomedia. By D. Sandison, Esq., H.M. Consul at Brussa. *With a Note;* by W. J. Hamilton, Esq., Pres. G.S., F.R.S.

[Communicated from the Foreign Office by order of the Earl of Clarendon.]

[Abstract.]

Hearing of the existence of fossil coal in this District, I lately sent to a person of some experience in such matters to make research, and trials, by digging up a certain quantity where seams might be found; for which purpose he was furnished with the necessary orders from our Kaïmakam.

The result was, that he met with one or more coal-seams in the Sub-district of Bazarkuy, about three hours distant from Ghio, and three to four hours from Yallova in the Gulf of Nicomedia, and sent some horse-loads to Ghio, whence the first report I received was, that the coal was superior to that of Heraclea*, and gave promise of being serviceable for steam-navigation.

With respect to the coal last received at Ghio, and taken, I believe, also from the surface, the information which has just reached me is not so favourable. There has been no time, however (particularly with the agitation prevailing here since the earthquake shocks commenced), for me to get the coal-bed in question, which has been reported as extending over many miles of country, and containing various sorts of coal, visited by a competent person worthy of confidence.

Some previous attempts have been made, seven to five years ago, to extract coals from seams belonging to the same bed, but were not followed up, either from the coals proving worthless, or on account of the expense of land-carriage to the sea-side, and subsequent transport to the capital, coming too high to answer at the low rate then paid for coals from England.

Brussa, March 7, 1855.

[* For notices of the Coal of Heraclea see Capt. Spratt's Note, New Edinburgh Phil. Journ. 1855, No. 1. p. 172; and Annales des Mines, 5 Ser. vol. vi.]

Note by W. J. Hamilton, Esq., President of the Society.

Notwithstanding the small amount of information contained in this communication, it becomes of great importance, when taken in connexion with the well-known coal-field of Heraclea. If we draw a line, N.E. and S.W., from Heraclea to the head of the Gulf of Nicomedia, all the hitherto known Devonian and Palæozoic formations of this part of Asia Minor will be found on the N.W. side of this line, whereas the greatly-developed systems of Cretaceous and other rocks extend on the E. and S.E. of this line. A considerable development of the Carboniferous formation may therefore be looked for in the direction between Heraclea and the Gulf of Nicomedia, with great probability of finding other valuable coal-fields in the intervening district.

[W. J. H.]

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3. *On the* Physical Geography *and* Pleistocene Phænomena *of the* Cotteswold Hills. By Edward Hull, Esq., A.B., F.G.S.

Contents.

Introduction.—Physical features.—The area embraced under the following observations is nearly included within the limits of Sheet 44 of the Ordnance Survey, from its eastern termination to the banks of the Severn.

The most marked physical feature of the district is the escarpment of the Inferior Oolite. Commencing at the south-west, in the neighbourhood of Painswick, it ranges towards the north-east in a line often broken into by valleys or headlands, until it terminates in a bold promontory at Ebrington Hill; whence, ranging south, and passing by Stow-on-the-Wold, it reaches the village of Shipton, its most southerly limit. (See Map, fig. 1.) This feature has now lost the character of an escarpment, and is merely a long sloping ridge, the higher portion of which consists of Great Oolite, the inferior strata having become extremely degraded in their extension eastward. From this point, the ridge commences to curve round towards the north-east; thence continuing its course into Northamptonshire.

Included within the bounds of these escarpments is an elevated table-land, intersected by numerous long and narrow valleys, generally highly picturesque. The course of the greater number of these valleys is towards the south and south-east, being at right angles to the watershed; but this is often modified by causes to which I shall hereafter refer. The highest elevation is at Cleve Cloud, above Cheltenham, where the Inferior Oolite attains a height of 1081 feet above the sea *.

The flanks of the escarpment are composed of Upper Lias and Marlstone,—the latter often forming tabular promontories; and from their base, the slightly undulating plains of the Lower Lias stretch away to the banks of the Severn, and overspread the Vale of Moreton-on-the-Marsh. See fig. 2, p. 480.

Scattered at intervals over the Gloucester plain are several outliers of the higher formations, forming isolated hills, which when viewed from a commanding position call forcibly to the imagination a state of physical conditions formerly in existence,—when an arm of the sea overspread the plains, bathing on the east the flanks of the Cotteswolds, and on the west those of the Malvern and May Hills, and from the level of which the present outstanding hills arose in the form of islands.

On viewing these *outliers*, the question which naturally suggests itself is this—Why have these isolated portions been preserved, while the contemporaneous strata all around have been swept away? I shall now attempt its solution.

Causes which have contributed to the preservation of the Outliers.—Breedon Hill is the most remarkable outlier in our district, both on account of its extent, and the distance by which it is separated from the main mass of its contemporaneous formations. The form of the hill is oval; the major diameter being nearly east and west. Along the north side numerous tabulated promontories of Marlstone run out into the Lias plain. These are surmounted by the Upper Lias, and finally by the Inferior Oolite. Along the south side an east and west fault extends, the discovery of which is due to Mr. H. Howell of the Geological Survey. By this fault the Oolite, with its subjacent beds, is thrown down on the north side against the Lower Lias of the plain. (See fig. 3, p. 480.) This fault satisfactorily accounts for the preservation of this extensive outlier. By its means, the level of the country on the north side has been considerably lowered, and consequently rendered less exposed to the denuding agency of the ancient sea.

South of Breedon Hill, and intervening between it and the Cotteswold escarpment, are five additional outliers. Two of them, Oxenton

* Proceedings of the Cotteswold Naturalists' Club, 1850. In this paper, by W. H. Hyett, Esq., F.R.S., the altitudes of many places and objects in the district are given.

Fig. 1.—MAP OF THE COTTESWOLDS,

illustrating the Drift Deposits of Gloucestershire.

SCALE OF MILES.

0 1 2 3 4 5 10

The figures represent the heights in feet.

The ground without any tint is devoid of Drift.

Northern Drift.

Estuarine mammaliferous deposits.

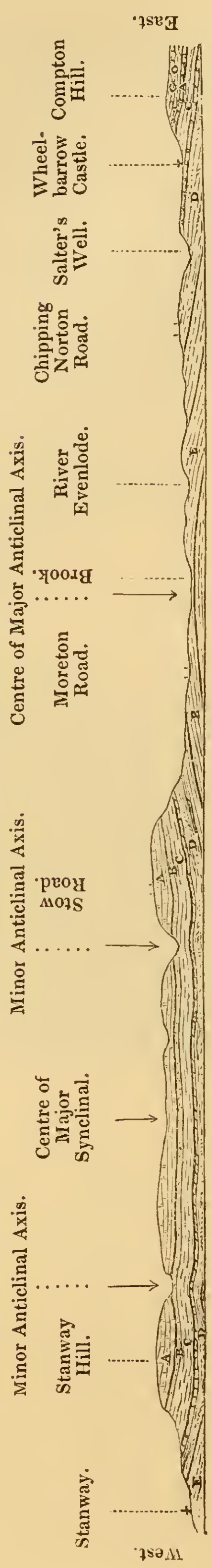
* * Quartz-pebbles at a height of about 600 feet.

× × × Scattered quartzose pebbles.

(The Fluviatile Deposits are omitted.)

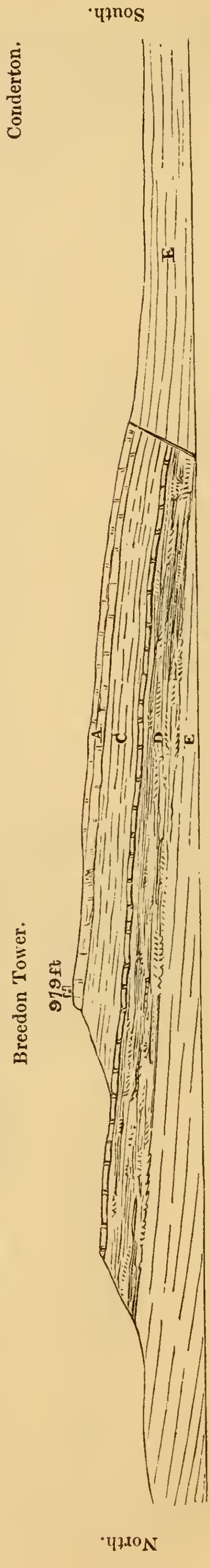
Fig. 2.—*Section across the Cotteswold Hills and Vale of Moreton.*

Distance about 15 miles.



G.O. Great Oolite.
A. Inferior Oolite.
B. Inferior Oolite Sand.
C. Upper Lias.
D. Marlstone.
E. Lower Lias.

Fig. 3.—*Section across Breedon Hill.*—Scale 2 inches to 1 mile.



A. Inferior Oolite.
C. Upper Lias.
D. Marlstone.
E. Lower Lias.

and Stanley Hills, are capped by Oolite. The highest formation on Dumbleton is Upper Lias; and Dixon and Taddington Hills are composed of Marlstone. The strata of Dumbleton and Oxenton Hills are affected by faults which have doubtless contributed to their preservation. The strata of the remaining outliers, however, are not apparently faulted, and the immediate cause of their stability appears to have arisen from the protection which was afforded them by the relative position of Breedon Hill.

The position of this principal outlier, with reference to the others, and to the headland which terminates in Notting Hill, is nearly N.N.W.; and on each side, where no protection from the north appears to have been afforded, the ancient sea has made a clean breach, having excavated the Valley of Winchcomb on the east, and denuded the Vale of Gloucester on the west; it therefore appears that Breedon Hill has acted the part of a breakwater to the area south of it, moderating the action of the sea along that line of country, from which circumstance, in conjunction with several others hereafter to be noticed, it may be inferred that the destructive action of the sea, whether in the form of northerly currents or as breakers impelled by violent winds, has acted with greatest energy from the north or north-west directions.

Two other outliers known as Churchdown and Robinswood Hills occur at the south-west extremity of our District. Churchdown is unprotected from the north, and therefore its preservation cannot be accounted for on physical grounds similar to those stated above. That it has been preserved, while the strata which once surrounded it have been swept away, is to be accounted for from the fact of the thickness of the Marlstone capping its summit, and the degree of hardness which this rock has attained. In that locality it was probably stronger than anywhere around, and hence it has resisted more successfully the action of the sea. The thickness of the rock-bed at Churchdown is 10 ft. 4 in.*; and some of the bands are very hard; and, as far as I have been able to observe, there is no place along the flank of the escarpment near Cheltenham where it is of equal thickness or strength; hence in that neighbourhood Marlstone platforms are both few and of small extent. The development of the Marlstone rock may therefore be considered as fully sufficient to have maintained the outlier; and Robinswood Hill may have remained standing from a similar cause, combined with the protection afforded by the Churchdown outlier.

Causes which have contributed to the preservation of the Headlands, and the formation of the Valleys.—On viewing the Ordnance Map, it will be observed, that the majority of the headlands project in a northerly direction. (See fig. 1.) The elevated plateau between the Vales of the Severn and of Moreton-on-the-Marsh is itself an extensive headland, which (as I shall presently endeavour to prove) formerly stood forth unsubmerged by the waters which deposited

* See 'Murchison's Geology of Cheltenham,' edited by Messrs. Buckman and Strickland, p. 39.

the Estuarine Drifts. I shall now endeavour to advance reasons sufficient to account for the following facts:—1st. Why this peninsula, terminating in Ebrington Hill, has been preserved, while the contemporaneous strata which once overspread the Vale of Moreton have been swept away; and, 2nd. Why this, together with the majority of the headlands of the Cotteswold Hills, project in a northerly direction.

I believe there is evidence to prove that the principal headlands are in lines of gentle synclinals; while the lateral valleys which bound them run in the directions of anticlinal axes, or have a quaquaversal arrangement of the strata. When a series of comparatively hard and indestructible beds rest upon a much thicker series of strata of an opposite character, and preserve an approximate horizontality, it is evident that, when a slight elevation or anticlinal arrangement of the beds has been produced along a line of country, the axis will create a line of least resistance, and that a valley will be formed when the area is subjected to the action of the sea; and conversely, that a corresponding synclinal axis will produce a line of greatest resistance, tending to the formation of a headland under the same circumstances. Under such conditions do the headland of Ebrington Hill and the Vale of Moreton appear to have originated.

The strata of the Cotteswold Hills are, in general, except when in proximity to lines of fault, so nearly horizontal, that the existence of a dip must often be proved rather by a process of reasoning than by actual observation of the bedding, as seen in natural sections and quarries. Now, it is well known, that in cases of escarpments the ledges range parallel to the strike of the rocks, and consequently that the flanks have an aspect in an opposite direction to the dip of the beds. Hence we conclude from analogy that the flanks of the peninsula of Ebrington Hill dip towards the centre;—along which there must therefore be a synclinal axis. In the present instance, however, we are not driven to deduce the existence of a synclinal altogether from analogical inference. Along the eastern escarpment there is decided evidence of a westerly dip, because the lower beds of the Oolite occupy a higher level along the ridge than they do in the centre of the area to the westward; and the same phænomena are generally observable with regard to the beds along the opposite side of the peninsula.

If it be allowed that a synclinal axis exists along the peninsula of Ebrington Hill, it follows, almost necessarily, that an anticlinal traverses longitudinally the Vale of Moreton. (See fig. 3.) I have not had the opportunity of examining the oolitic ridge which bounds the vale along the eastern side, but we may safely conclude that a slight dip to the eastward is maintained along its flank. As the vale is some ten miles in width at its widest part, a dip in opposite directions of one degree would elevate the beds about 500 feet* in the centre of the vale above their present position along the flanks; and the base of the Oolite would be placed at an elevation

* Let θ = angle of inclination = 1°; r = radius = 5 miles or 8800 yds.; and x = answer. Then $x = (\log r + \log \sin \theta) - \log \cos \theta = 153{\cdot}6$ yds. or 460·8 ft. (nearly).

of about 900 feet above the present centre of the vale. On the supposition that this was the position the beds formerly occupied, their subsequent destruction is sufficiently accounted for upon the principles already enunciated.

The headland which terminates in Notting Hill, west of Winchcomb, has probably originated in the combination of a synclinal arrangement of the strata with the protection afforded by the outliers which acted as breakwaters against the force of the Glacial Sea driving from the north.

The Valley of Bourton-on-the-Water appears to have originated in the existence of an anticlinal traversing its centre from north to south. Along the western flank, at Clapton, the Oolite has a very decided dip to the westward of 4° or 5°. On the eastern side, the dip is perceptible in a quarry of Oolite, and is about 3° east.

The headland on the eastern flank of the Bourton Valley has probably been preserved rather by the position which the high ground of Stow-on-the-Wold occupies with regard to it, than from the strengthening effect of a synclinal; though it is not improbable that the beds of which it is formed possess in addition a synclinal arrangement.

The Vale of Winchcomb also appears to present an instance of an anticlinal valley; for, while engaged in tracing geological boundaries along its western side, I could not but observe a decided inclination of the beds towards the south-west.

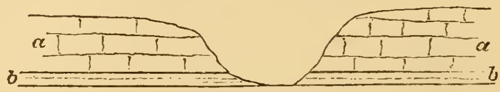
It therefore appears that, though the strata of the Cotteswold Hills and the valleys by which they are surrounded have a general dip towards the south, yet the district is traversed by a series of gentle rolls, with north and south axes, and that the anticlinals have produced *lines of weakness*, originating valleys; and the synclinals *lines of strength*, originating headlands.

Valleys of Domes or Quaquaversals.—Besides the valleys I have already referred to, there is another class which appear to have resulted in quaquaversal or dome-shaped arrangements of the strata. This arrangement we infer to exist, when we find in a certain part of a valley much lower beds reaching the surface than occur further up or lower down; and it is evident that the lithological characters and mutual arrangement of the rocks composing the district under consideration would, on the occurrence of a quaquaversal, produce an area of weakness tending to the formation of a valley; and to these weakening causes must be added the probable production of fissures, and slight faults occasioned by the swelling up of the strata.

The Valley of Painswick offers a good illustration of a quaquaversal; as also those of Northleach, Turkdean, Andoversford, Taddington, Guiting Power, and the long narrow gorges which extend from Compoden Ashes to Hinchwick Farm, and from Kate's Britton to Tainton.

As a particular instance, I may mention the Valley of Chedworth, south of Northleach (figs. 4 & 5). It consists of a longitudinal gorge, widening in the centre, and extending westward for a distance of one mile and a half from the valley of the Coln. At or near its entrance, the base of the Great Oolite (*a*), resting on the Fuller's Earth (*b*), nearly reaches the bed of the brook. As we ascend towards

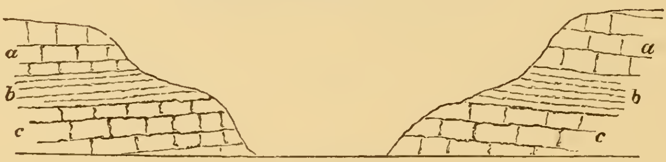
Fig. 4.—*Chedworth Valley.*
(Section at the entrance.)



Level of Brook.

the village, lower beds successively arrive at the surface; until after passing over about 30 feet of Fuller's Earth, we reach the Inferior Oolite (*c*). At the village, about 50 feet of this formation compose

Fig. 5.—*Chedworth Valley.*
(Section through the centre.)



Level of Brook.

a. Great Oolite. *b.* Fuller's Earth. *c.* Inferior Oolite.

the banks of the brook; whence continuing our course, we meet with higher beds, until at the top of the gorge we again reach the Great Oolite. It is therefore evident that in the centre there exists a dome-shaped structure of the strata; the brook forming a datum-line slightly inclined.

Valleys in lines of dislocation.—A third class of valleys are those which have originated in, or the directions of which have been locally marked out by, lines of fault. In this place it would be superfluous to describe the manner of the formation of such valleys. It will be sufficient to enumerate several localities where they occur. They are as follows:—Cranham, west of Painswick Hill; Painswick Slade, Cubberley, Winston Wood, Eyeford, Hawling Lodge near Naunton, and Burford. When no valley occurs along a line of fault, a feature is generally present, formed of a ridge of the harder beds along the upcast side.

There is a fourth kind of valley, represented by a few narrow ravines, especially in the districts occupied by the Great Oolite, the origin of which cannot be referred to any of the above causes. Some of these contain brooks which are dry throughout the greater part of the year, and are too insignificant to be supposed capable of having excavated any portions of the gorges through which they run. The formation of these, and indeed all the valleys of the Cotteswold Hills, must be considered as entirely due to marine agency acting at several successive periods; the most ancient dating, perhaps, as far back as the period of the upheaval of the Chalk, when about to form basins for the Tertiary formations; and at a certain period of the Glacial Epoch the appearance of the country must have been quite unique, when these long sea-reaches, like so many canals, extended for miles into the heart of a country which was itself unsubmerged. Some of these ravines appear to be very similar to the Valley of Yedmandale in Yorkshire, described by Mr. Sorby in the Journal of the Society*.

Meteoric Phænomena, and the Tabular Platforms of Marlstone.— It is seldom that an arrangement of the rocks occurs which tends to throw light upon the meteoric influences of former ages. There are, however, some physical features in the district under consideration of so uniform a character, that we can scarcely suppose them to be accidental; and I submit, though with considerable diffidence, that they appear to throw light upon these subjects; that, in fact, the directions and magnitudes of the tabular Marlstone areas afford evidence that, at the period when they were in course of formation, winds from the *north* and *west* were the most prevalent or powerful.

The tendency which the Marlstone has of forming platforms is, as described in the 'Geology of Cheltenham†,' "due to its being immediately overlaid by the shales of the Upper Lias, which from their softness have undergone a greater amount of denudation, leaving the hard stratum of marlstone projecting from the sides or capping their summits."

Such being the case, it follows that the more rapid the denudation, and consequently the more powerful the denuding agency, the larger will be the tabular areas formed; and that they will project in the direction from which the forces have acted with greatest effect.

I herewith present, in a tabulated form, several particulars, viz. the locality, direction, and length of all the Marlstone platforms of the district, from half a mile in length and upwards; omitting those of Breedon Hill, as the fault, to which I have already referred, has prevented the formation of platforms on the south side; and consequently no comparison can be made in this particular case.

Localities, Directions, and Lengths of the Marlstone Platforms.

Locality.	Direction.	Length.	Locality.	Direction.	Length.
		In miles.			In miles.
Upton Leonards......	N.	$\frac{3}{4}$	Hitcote Comb ...	N.	$\frac{2}{3}$
Dowdeswell	N.	$\frac{1}{2}$	Goose Hill } Ebrington }	S.	$1\frac{1}{4}$
Gretton	N.	$\frac{1}{2}$			
Toddington Park.....	N.	$\frac{3}{4}$	Broad Campden...	NNE.	$\frac{3}{5}$
Oxenton..............	N.	$\frac{3}{4}$	Aston Magna......	NNE.	1
Dumbleton (three)..	W. N. NE.	$\frac{1}{2}$ each.	Donnington	N.	$\frac{1}{2}$ (nearly)
Winchcomb	NNE.	$\frac{3}{4}$	Little Rissington..	W.	$\frac{1}{2}$
Buckland	N.	1	Little Compton ...	W.	$1\frac{1}{4}$
Chipping Campden‡	E.	1	Chastleton	WSW.	1
Mickleton Hill	E.	$\frac{4}{5}$	Shipton	N.	$\frac{1}{2}$ (nearly)

* Quart. Journ. Geol. Soc. vol. x. p. 328.

† Second Edition, p. 38.

‡ This platform was probably formed by the action of the sea running through the strait between Ebrington and Dovers Hill.

In order to present these phænomena in a more concise form, a diagram (fig. 6) is annexed, by which it will be observed that the great majority of the platforms have a northerly bearing. The outline of the former coast has of course, in some measure, modified these directions; occasionally, perhaps, counteracting the tendency of the platforms to project northwards, especially along the Eastern flank. It is sufficiently evident, however, that there has been a greater tendency to the formation of platforms pointing northward and westward, than to their production in other directions. Taking this evidence in conjunction with the facts, that where a barrier occurs the strata immediately south of it have been less denuded than where there is none, and that along the escarpment the Oolitic as well as Marlstone headlands all point more or less towards the north, the evidence appears conclusive that the ancient sea has acted with greater energy from that direction; and when it is recollected that at the period in question it extended from the Bristol Channel to the estuaries of the Mersey and Dee*, the swell of an ancient Atlantic might have been supposed to have acted with greatest effect against the Cotteswold country from the south-west, had it not been surpassed by a more powerful aqueous agency from an opposite direction; nor does it clearly appear why the action in the one case should be so much greater than in the other, unless we suppose the greater prevalence and force of northerly winds at that period. The supposition also gains strength by analogy with the present; for north and west winds are those which now blow strongest over the districts surrounding the Cotteswold Hills.

Fig. 6.—*Diagram of the Bearings of the Marlstone Platforms.*

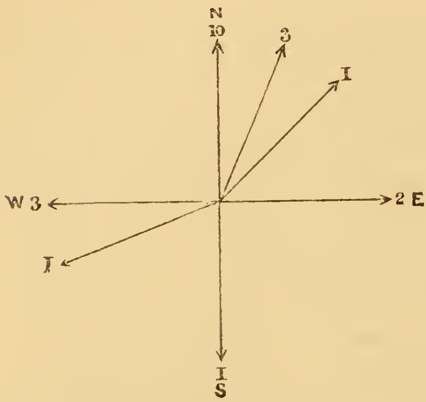
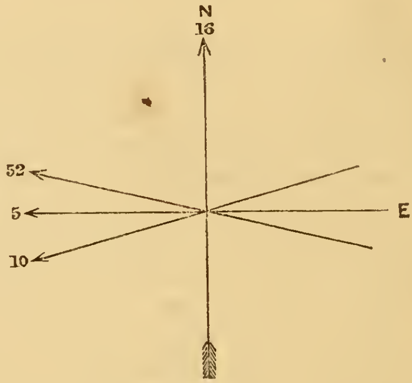


Fig. 7.—*Diagram of the Directions and Numerical Proportion of the Faults.*



Faults.—The lines of dislocation may be arranged under two systems; the first, those which point north and south; the second, those the directions of which are east and west. Of the second,

* Sir R. I. Murchison was the first to point out that the sea extended from the Cotteswolds on the east, to May Hill and the Malverns on the west; turning Wales into an island. To him also is due the term "Ancient Straits of Malvern."

the great majority point 12° N. of W. There are also a few which cannot be referred to either of these systems.

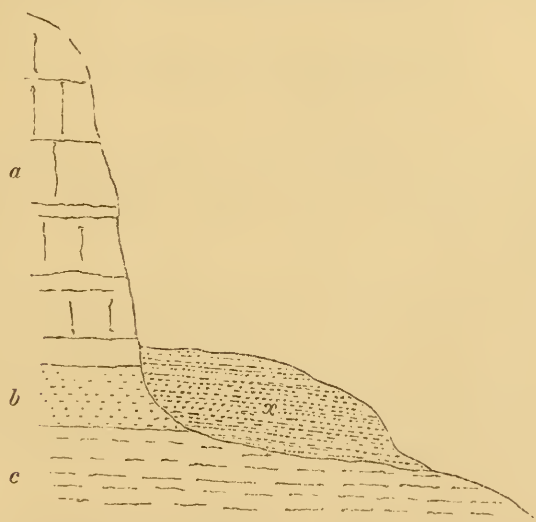
As far as the evidence goes, it tends to prove that the north faults are of earlier date than those at right angles to them, inasmuch as the second are generally terminated by the first. This, however, is a point of much uncertainty.

With regard to numerical proportion, the east and west series greatly exceeds those of other directions. They generally run in approximately straight lines, and the degree of parallelism they preserve over the entire area is most remarkable. When engaged in mapping the geological formations, I was often much assisted by the knowledge which I soon acquired of the regularity in point of direction maintained by the majority of the lines of dislocation. The opposite diagram (fig. 7) represents their directions and numerical proportions.

Diluvial and Erratic Phænomena.

Ancient Sea-beach.—The diluvial deposits of the Vale of Gloucester have already been very fully illustrated by the labours of Sir R. I. Murchison*, the late Mr. Strickland†, and Prof. Buckman‡. To their observations I have only to add, that there are appearances which indicate that an ancient sea-beach formerly extended along the base of the cliffs formed by the Inferior Oolite. In this position there are to be found patches of oolitic debris, in the state of a fine gravel, waterworn, and *stratified* more or less horizontally. The best section with which I am acquainted is at the base of the cliffs

Fig. 8.—*Section of Lechampton Hill, showing the position of the Ancient Sea-beach.*



a. Cliff of the Inferior Oolite. *c.* Upper Lias.
b. Inferior Oolite sand. *x.* Shingle-beach.

* See 'Geology of Cheltenham,' and 'Silurian System.'

† Communications to the Geological Society; and 'Geology of the line along the Gloucester and Birmingham Railway.'

‡ 'Ancient Straits of Malvern.'

on Lechampton Hill, at a height of about 700 feet above the level of the sea. It is represented in section fig. 8, p. 487. The lamination is nearly horizontal except in close proximity to the cliff. The appearance of the gravel is decidedly more that of a stratified deposit than of a mass of tumbled debris. If it were of the latter description, the fragments, instead of assuming an approximately horizontal arrangement, would have been strewn obliquely, according to the angle of friction. In other localities, false bedding is prevalent, and the apparent dip is occasionally towards the hill. Vestiges of this beach occur in the neighbourhood of Painswick, Witcomb Wood, Lyreford near Whittington, at the north end of Cleve Cloud, at Corndean, south of Winchcomb, Painswick Valley, and at the north side of Hill House Park, near Nailsworth, where the stratification is very decided from the occurrence of a thin parting of clay imbedded in the gravel, and in which the lines of stratification are apparent. Wherever exposed, this ancient shingle may generally be distinguished from tumbled debris by the fineness of grain, and its evident stratification.

This gravel is, probably, the remains of the first of a series of Beaches produced along the flanks of the hills at the period of the first* rising of the land from beneath the ancient sea; and has been almost destroyed during a subsequent submergence; for I do not believe that one elevation is sufficient to have produced all the phænomena connected with the diluvium and denudation of this country.

Fluviatile, Estuarine, and Marine Deposits.—The remaining pleistocene deposits of the Vale of Gloucester have been arranged by the authors I have mentioned under the three following heads:—

1. The Fluviatile
2. The Estuarine } Deposits.
3. The Marine

1st. The Fluviatile comprehends the deposits which border the Severn and Avon, occupying the horizontal areas which often extend for considerable distances on either side. These are the latest in respect of date†.

2nd. To the Estuarine deposits are referred certain fine-grained siliceous sands, which occur in isolated patches over the Gloucester plain, and upon which the lower portions of Cheltenham are built. These sands become associated with, and finally give place to, oolitic detritus as they approach the base of the Cotteswold Hills. The Estuarine is, I believe, the mammaliferous depository of the district; and I shall presently describe certain beds in the Vale of Moreton, which I consider to be contemporaneous.

I am informed by my friend Dr. Wright of Cheltenham, that "in cutting the Cheltenham sewer bones and horns of the fossil Ox

* Further on it is shown that the valleys were formed prior to the deposition of the northern drift, which has been deposited during a second submergence.

† See 'Silurian System.'

(*Bos primigenius*) and a large human lower jaw were found in drift-gravel beneath 12½ feet of undisturbed drift-clay,—a fact which shows that our Vale has been much changed since man has lived in these parts. The specimens are in good preservation, and are now in the Museum of the Philosophical Institution."

Were these statements made by a less accurate observer than Dr. Wright, I should be very sceptical concerning their accuracy. From the depth at which the human jaw occurred, we cannot suppose that the individual of whom it formed part was buried by his fellow man; and its occurrence with the remains of the fossil Ox appears to prove that they were contemporaneous. If this "undisturbed drift-clay" be of estuarine formation, it would appear that a much larger area of the plain of Gloucester has been submerged since Man has been introduced than is at present the case. A subsidence of 80 feet would submerge Gloucester and Tewkesbury, and of 120 feet, a considerable portion of Cheltenham, with the locality where these remains were found. There appears, therefore, evidence in favour of the supposition that Gloucestershire has been elevated at least 120 feet during the Recent Period.

3rd. The Marine deposits are of earlier date than the last, and include the clays, sands, and gravels referable to the Glacial Epoch, and commonly designated "Northern Drift."

This deposit attains a greater development in a northern direction towards Birmingham and Shrewsbury. Associated therewith are boulders of granite and other rocks, which decrease in size and quantity towards the south; thus proving, as has been remarked by Sir R. Murchison, their northerly origin.

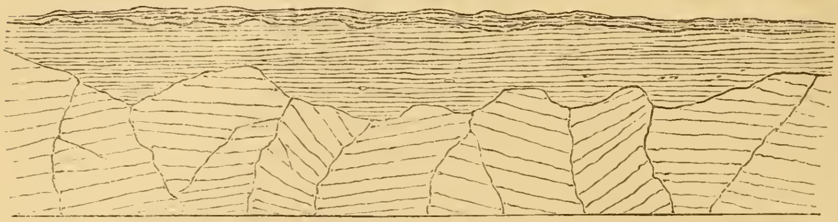
Warp-Drift.—The drift of the Vale of Moreton and the Cotteswold Hills may be arranged into four divisions,—with the addition of the "Warp-Drift" to those already enumerated. Its position in the series is between the Fluviatile and the Estuarine formations.

The Warp-Drift is a deposit of brown sandy loam, very variable in thickness, and seldom or never exceeding 6 or 8 feet. It covers the estuarine or fluvio-marine gravels in the valleys, and rises on the higher grounds to a height of at least 600 feet. Though this loam has generally been considered a *drift* in the usual sense of the term, I am by no means certain that it may not be a soil derived from the decomposition of the substrata.

The following section (fig. 9), taken in a quarry near the Cross-hands Inn, east of Adlestrop, represents the Warp-Drift resting on Great Oolite, which is very much disturbed and broken, as is generally the case over the district. I have estimated the position of this quarry to be between 600 and 700 feet above the sea.

Over the western portion of our district, where the Northern Drift has never been spread, a superficial covering of brown loam, seldom more than one foot in depth, may generally be found, reaching positions of about 1000 feet elevation. Whether this loam, which forms the only soil in such localities, is to be referred to the Warp-Drift, or to the decomposition of the local formations, I am not prepared to say. There are, however, indications tending to throw the balance of evidence on the side of the latter supposition, and this view is in

Fig. 9.—*Section of the Warp-Drift, resting on Great Oolite, at Compton Hill.*



a. Warp-Drift; of brown loam, varying in thickness from 1 to 4 feet; and containing a few pebbles probably derived from Northern Drift.
b. Thin-bedded sandy oolite; forming lower portion of the Great Oolite formation.

accordance with the fact, that the soils vary rapidly in composition and appearance upon every change in the substratum.

Dr. Voelcker has also arrived at the same conclusion, founded upon analyses of the soils taken from several formations in the neighbourhood of Cirencester. Some of the results he has kindly placed at my disposal, and they will be found appended to this paper.

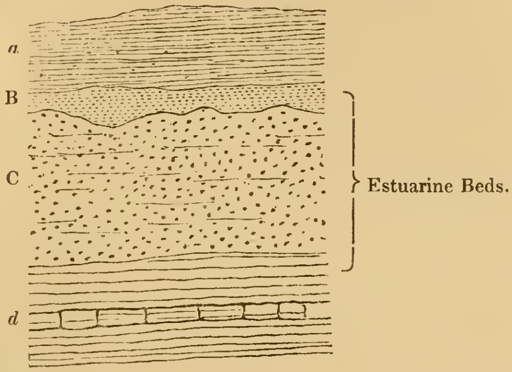
Estuarine Deposits.—The estuarine strata of the valleys which surround the hilly district on the north and east sides may be distinguished from those of the Northern Drift by the predominance of detritus derived from the waste of local oolitic rocks, either broken up and stratified by the action of the estuarine sea itself, or carried down the slopes from the higher grounds by brooks. These accumulations occupy only the valleys and plains, but their stratification cannot be referred to the agency of the present streams.

Fragments of rocks which have been transported from a distance are generally to be found scattered through the estuarine gravels, but their presence will readily be accounted for when it is recollected that the greater portion of the country was overspread by Northern Drift previous to the estuarine period, and from this deposit these far-fetched pebbles have, in all probability, been derived. Indeed, there is reason for concluding that during this "second stationary" period a considerable portion of previously formed Northern Drift was re-stratified, and may in this sense be considered estuarine. Accumulations referable to the estuarine period occur in the Vale of Bourton, at Paxford, and along the valleys of the Evenlode and Stroud, and overspreading the flat districts of the Oxford Clay to the south of Cirencester. In this last-mentioned neighbourhood, along with the oolitic gravel, chalk-flints occur, derived from the waste of the chalk-escarpments to the south and east. Everywhere these gravels contain remains of extinct mammalia, and in Stroud Valley they are remarkably numerous *.

* Some of these remains are in the possession of Mr. Carpenter, of Caincross; and a tusk of a fossil elephant in the Museum of the Royal Agricultural College, Cirencester, must originally have measured about 14 feet in length.

About eight years ago, during the formation of the Oxford, Worcester, and Wolverhampton Railway, a cutting was made through gravel, referable to estuarine origin, near the village of Ascott. The cutting is now covered by grass, but the following section (fig. 10) is exposed in a gravel-pit at its extreme end.

Fig. 10.—*Section of the Estuarine Beds at Ascott, Oxfordshire.*



a. Warp-Drift; soil passing downwards into brown sandy loam, with a few pebbles, and varying from 6 inches to 7 feet.
B. Fine yellow and brown sand.
C. Fine gravel, composed principally of fragments of local rocks, but occasionally of those of more distant origin, as slate, flint, and grits.
d. Lower Lias Shale, with a bed of blue limestone charged with fossils, about 1 foot thick.

At 9 feet from the surface in the cutting, the skeleton of a large mammal was found. It was described to me as being about 18 feet in length without the head, which was not obtained. From the description I received of the tusks, which were curved and measured 9 feet from the tip to the base; and, from an inspection of two of the teeth, I concluded the skeleton to have been that of the *Elephas primigenius*. The navvies were continually digging up portions of the skeleton for five weeks before they were aware what they had found *.

In the Lias Clay beneath were the vertebræ of *Ichthyosaurus*, and in the superficial gravel, above the skeleton of the Elephant, human remains, probably of very ancient date, were discovered; and thus, in a series of deposits of only 20 feet in aggregate thickness, relics characteristic of three great epochs in the earth's history were entombed in the order of their relative ages.

My endeavours to obtain shells from these gravels have been ineffectual; but it is probable they are the equivalents of the estuarine and mammaliferous deposits of the Vale of Gloucester and the Thames Valley, and with those lately described by Mr. Trimmer as occurring in the neighbourhood of Peterborough. According to this supposition they are to be included in the second stationary, or

* The greater portion of the skeleton is supposed to be in the possession of J. Taunton, Esq., formerly Engineer of the line. Two teeth were shown to me by Mr. Lardner of Ascott, to whom, as also to the Rev. F. E. Lott, I am indebted for information on the subject.

second elephantine period, intervening between the elevation of the erratic tertiaries, and the distribution of the Warp-Drift over their denuded surfaces *.

Northern Drift.—This is the most ancient pleistocene formation of the district, and attains an elevation of between 600 and 700 feet above the level of the sea on the oolitic hills south of the Vale of Moreton. Deposits belonging to the Northern Drift Series at Mickleton Hill, and Aston Magna have already been described by Mr. G. E. Gavey before the Society †; and the height which they attain at Mickleton Hill is 490 feet; and, as I am informed by Mr. Howell, of the Geological Survey, that he found no erratic pebbles on the high oolitic ground to the N.E. and S.W. of the less elevated ridge through which the Oxford Railway passes, it would appear, as Mr. Gavey observes, that "the gravel, sand, and clay (of Mickleton Hill) formed the bed of a channel communicating between Moreton and Evesham Valleys, and having Dovers and Campden Hills on the west, and Ebrington Hill to the east."

At Adlestrop there is another section in Northern Drift, 12 feet deep. It consists of alternating beds of coarse red sand, clay, and gravel composed of the following kinds of rock:—

Yellow chalk-flints, in great abundance.
Rounded white and coloured quartz.
Large pieces of gritty sandstone.
Fragments of slate.

At Oddington there are several pits in coarse siliceous red sand and gravel, containing similar fragments of rock. The sand is occasionally blackened by coal-smut.

A bed of gravel 12 feet deep, similar to the last, occurs above Langley Mill near Ascott, at an elevation of about 80 feet above the Mammaliferous deposits which occupy the valley of the Evenlode, and which I have attempted to describe as being of later date. In this and the other gravels I searched carefully for shells, but without success.

The sands of the Northern Drift are always coarser than those of the estuarine period; and the absence of granitic fragments, so abundant in the gravels of Salop, Worcester, and Staffordshire, is worthy of remark. Mr. Howell informs me that he has never met with any in the Valley of Moreton. I therefore consider that almost all the Northern Drift of this part of the country has been derived from the debris of the rocks of the Midland counties. The sands have been apparently derived from the waste of the New red sandstone; the quartzose pebbles are identical in appearance with those which form the conglomerates of that formation; the grits and pieces of chert are doubtless from the Carboniferous rocks; and the fragments of slate may have been derived from the Atherstone and Charnwood Forest rocks. While the oceanic current was spreading the debris of Cumberland and the border-counties of Scotland over

* Quart. Journ. Geol. Soc. vol. ix. p. 295; and vol. x. p. 244.
† Ibid. vol. ix. p. 29.

the central districts of England, and the debris of the central districts over the more southerly portions of the country, another current appears to have travelled westward, bringing the detritus of the Chalk, and mixing it with the fragments of rock derived from Northern sources, and thus occasioning the prevalence of pieces of chalk and chalk-flints in the drift of Nottingham, Leicester, and Gloucestershire.

I have to record the occurrence, near the southern termination of the Vale of Moreton, of three erratic boulders at the villages of Bowl and Frescot, and on the same parallel as Cheltenham. They are subangular blocks of Millstone Grit. Two of them are of a fine variety, and the third of a coarser grain. The surfaces are uneven, but I did not observe them to be scratched or polished; these phænomena being confined to blocks newly disinterred from diluvial deposits. The diameter of the largest is 3 feet, of another $2\frac{1}{2}$ feet. The transportation of these blocks can scarcely be referred to other agency than that of ice, and it would therefore appear that bergs occasionally wandered as far south in the Vale of Moreton as the longitude of Cheltenham. Boulders have not been found south of Tewkesbury in the Valley of the Severn.

The "Boulders of Marlstone" mentioned by Mr. Gavey as occurring at Mickleton Hill cannot be considered as erratic boulders in the sense in which the term is usually received. These blocks of marlstone have evidently not been carried to a distance from their original position, as the higher portion of Mickleton Ridge is composed of the Marlstone formation. It would, I think, be for the advantage of geological description were the term *boulder* confined to blocks of rock which are supposed to have been transported from a distance by the agency of ice.

The higher portions of the Cotteswold Hills included between the Vales of Moreton and Gloucester appear never to have been overspread by Northern Drift. The peninsula which terminates in Ebrington Hill, has either been above the level of the glacial sea during the deposition of the drift,—an improbable hypothesis,—or else its scarped cliffs have formed a barrier to the transport of northern detritus. In crossing the district from the western escarpment above Cheltenham towards the east, we meet with no erratic pebbles until we arrive at Stow-on-the-Wold, where in the Moreton Road, at an estimated height of 500 feet, we find the following section:—

	ft.	in.
1. Brown loam	1	0
2. Soft white oolitic sand	0	5
3. Pebble bed; containing rounded grey and white quartz, black chert, flints, and grits, &c.	0	2
4. Reddish-brown loam	0	6

South of Stow, the western limit of the Northern Drift is very well defined. The line follows the western flank of the Bourton Valley, thence trends along the southern bank of the Windrush River, nearly as far as Burford, whence it strikes southwards for several miles. The line then extends westward to within a mile or two south of Cirencester,—being indicated by the occurrence of quartz-pebbles; and is finally lost beneath the newer oolitic gravels which I have arranged under the head of the Estuarine Deposits (see Map, fig. 1, p. 479).

The drift has evidently been carried along the Moreton Valley, and swept over the high grounds to the south, which are not only lower than the Cotteswold Hills to the west, but also do not present to their progress a precipitous barrier.

Transported fragments diminish numerically the farther south we proceed from the Moreton Valley. They have been strewn over hills and valleys, quite independently of the form of the ground; and it is possible that shore-ice was to some extent an agent in raising the fragments from lower to higher levels, after the manner described by Mr. Darwin.

From the knowledge we now possess of the nature and position of the estuarine deposits, we have an index to the distribution of land and sea over our district during the period of their deposition. This ancient sea swept around the western flanks of the Cotteswolds, extending in the form of long bays and reaches far into the interior of the country. Ebrington Hill was an island, separated from the mainland by Mickleton Strait, and the waters spread over the Vale of Gloucester to the flanks of the Malverns. This was "the ancient Strait of Malvern," and above its waters the Islands of Bredon, Dumbleton, Oxenton, Churchdown, and Robins Wood stood forth unsubmerged*. The sea also covered the Vale of Moreton, the eastern escarpment forming a coast-line, though much less bold and lofty than that on the western side, and thence extended southward over the Oolitic hills from Burford to Cirencester, and as far south as the escarpment of the Chalk.

Conclusions.—It would appear that, in order to explain all the phænomena of the denudation and the post-tertiary or pleistocene accumulations of the district, it is necessary to suppose the following vertical movements of the land:—*A first elevation*; dating, perhaps, as far back as the commencement of the Tertiary epoch, during which the more marked physical features were produced, accompanied with an enormous destruction of Secondary rocks. This was followed by a *submersion*, which appears to have been only partial, during which the Northern Drift, with ice-transported boulders, was spread over the area under water. Next, *a second elevation*; towards the close of which the estuarine mammaliferous gravels were formed along the valleys, and round the flanks of the hills. During this latter elevation the relative positions of land and sea occurred which have been described above, the period finally terminating with the introduction of the present physical features of the country†.

* Mr. Howell informs me, that he found no drift on Bredon Hill, nor did I observe any on the outliers between Bredon and the Oolitic escarpment.

† If it can be proved that the "Warp-Drift" is in reality a deposit of trans-

APPENDIX.

Composition of SOILS *from the* COTTESWOLD HILLS. By Dr. AUGUSTUS VOELCKER, of the Royal Agricultural College, Cirencester.

No. 1.—From the College Farm. A heavy reddish-brown loam; 1½ foot deep; off Great Oolite. (Good wheat soil.)

Water	10·254
Organic matter and water of combination	6·943
Insoluble siliceous matter	37·091
Soluble silica (soluble in dilute caustic potash)	14·018
Oxides of iron and alumina	12·754
Lime	10·440
Magnesia	·195
Potash	·967
Soda	·309
Phosphoric acid	·659
Sulphuric acid	·234
Carbonic acid and loss	6·156
	100·000

No. 2.—Poor soil; 6 inches deep, resting on Great Oolite. (Air-dried state.)

Organic matter and water of combination	6·339
Insoluble siliceous matter	28·947
Oxides of iron and alumina	9·311
Carbonate of lime	58·566
Potash and soda	1·032
Phosphoric and Sulphuric acids	traces
Magnesia	traces
	100·195

No. 3.—Soil; resting upon yellow clay.

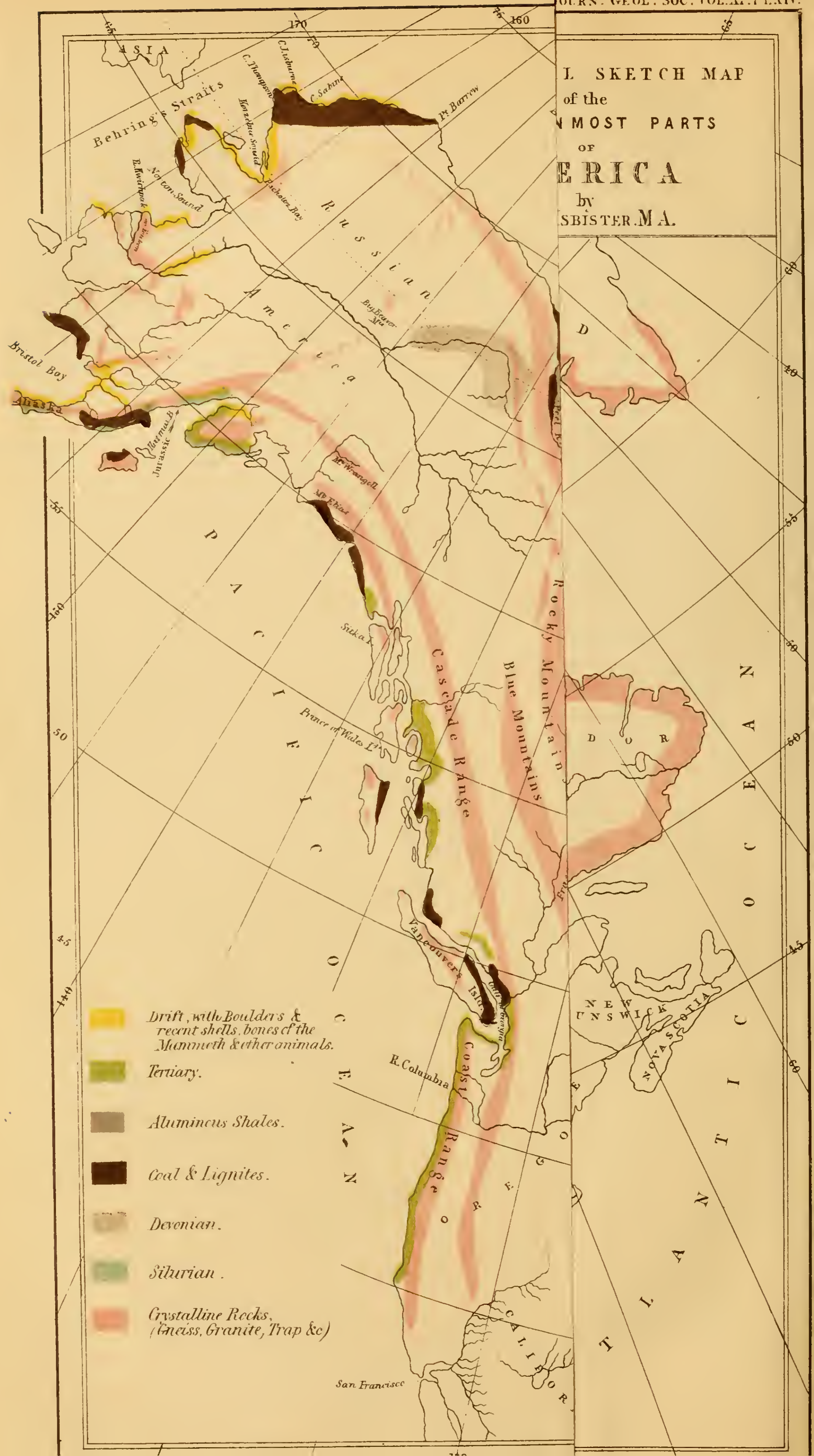
Moisture	9·26
Organic matter and water of combination	3·17
Insoluble silicates	66·47
Soluble silica	1·16
Oxides of iron and alumina	15·32
Carbonate of lime	4·12
Carbonate of magnesia	·24
Alkaline salts	·22
Loss	·04
	100·00

ported detritus, it would be necessary to infer another submersion of the land to a depth of 700 feet, in addition to those mentioned above; but, as there is strong evidence for considering the "Warp-Drift" to be merely the product of decomposition, it would be rash to infer a third submersion on such grounds alone.

No. 4.—Blue clay, from the Forest Marble. (This soil is greatly improved by top-dressing with burnt clay.)

Moisture		2·37
Water of combination, and a little organic matter		5·38
Carbonate of lime	Soluble in dilute muriatic acid.	31·38
Carbonate of magnesia		2·04
Oxides of iron and alumina		11·90
Potash ·35. Soda ·18		·53
Magnesia in a state of silicate	Insoluble in dilute acid.	1·52
Potash in a state of silicate		1·29
Alumina		7·43
Silica		36·16
		100·00

Remarks on the above Analyses.—Dr. Voelcker is of opinion that the soils of the Cotteswold Hills are the products of the decomposition of the strata on which they rest. It may, however (supposing this hypothesis true), appear surprising that there is not a greater amount of carbonate of lime in soils which rest on limestone rocks; but the fact is, that a large proportion of this constituent is being constantly dissolved and carried away into the substrata by the infiltration of rain-water charged with carbonic acid. This theory, as to the origin of these soils, is also in unison with the observations of Professor Buckman, who has so fully illustrated the mutual relations subsisting between the soils and subsoils, and the changes in the one consequent on the changes in the other. We may therefore consider it as an established fact, that the soils of the Cotteswold Hills cannot be considered as a "Drift," derived from aqueous deposition, but as being due solely to atmospheric agency.


L SKETCH MAP
of the
NMOST PARTS
OF
ERICA
by
SBISTER. M.A.
ASIA
Behring's Straits
C. Thompson
C. Lisburne
C. Sabine
Pt. Barrow
Kotzebue Sound
Norton Sound
Eschscholtz Bay
Russian America
Bristol Bay
Aliaska
Jurassic
Mt. Wrangell
Mt. Elias
Sitka
Prince of Wales Id.
Cascade Range
Rocky Mountains
Blue Mountains
Vancouver's Isld.
R. Columbia
Coast Range
OREGON
CALIFORNIA
San Francisco
PACIFIC OCEAN
ATLANTIC OCEAN
NEW BRUNSWICK
NOVA SCOTIA
Drift, with Boulders & recent shells, bones of the Mammoth & other animals.
Tertiary.
Aluminous Shales.
Coal & Lignites.
Devonian.
Silurian.
Crystalline Rocks, (Gneiss, Granite, Trap &c)

May 16, 1855.

E. H. Hargraves, Esq. was elected a Fellow.

The following Communications were read :—

1. *On the* Geology *of the* Hudson's Bay Territories, *and of portions of the* Arctic *and* North-Western Regions *of* America; *with a Coloured Geological Map.*

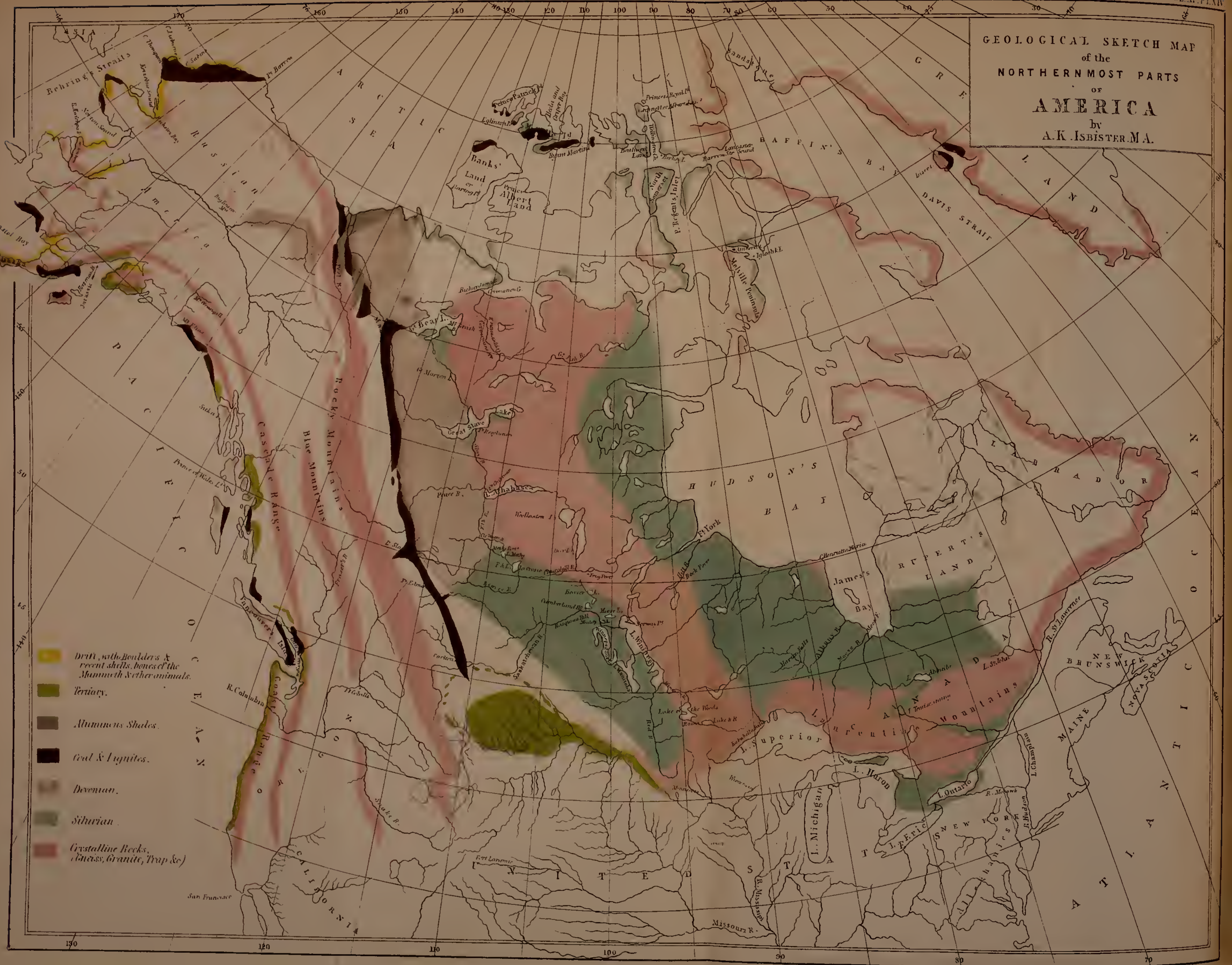
By A. K. Isbister, M.A., M.R.C.P. &c.

[Plate XIV.]

[Contents.]

Introduction.—In submitting to the Society a Geological Map of this extensive region, with a few explanatory remarks, my object has been to recapitulate very concisely the various observations of the geologists and travellers who have explored, and of the naturalists who have examined the organic remains of, this portion of the American Continent, and to present as completely as possible the results which have been hitherto attained in the study of its geological formations. The numberless difficulties inherent in such an undertaking, embracing a range of country so vast and so difficult to explore, or even to obtain access to, must necessarily render any attempt of this nature very imperfect; but I have been induced to undertake it in the belief that, in the absence of any general view of the geological structure of this extensive but interesting region, even the most cursory classification of its formations might be useful to those employed in developing the structure of the crust of the earth,—the more especially as it is not probable that the attention of practical geologists will soon be directed to this distant and almost inaccessible field of investigation.

To render the present attempt as complete as the state of our


GEOLOGICAL SKETCH MAP
of the
NORTHERNMOST PARTS
of
AMERICA
by
A. K. ISBISTER. M.A.
Drift, with Boulders & recent shells, bones of the Mammoth & other animals.
Tertiary.
Aluminous Shales.
Coal & Lignites.
Devonian.
Silurian.
Crystalline Rocks, (Gneiss, Granite, Trap &c)
ARCTIC SEA
PACIFIC OCEAN
ATLANTIC OCEAN
BAFFIN'S BAY
DAVIS STRAIT
GREENLAND
HUDSON'S BAY
RUPERT'S LAND
LABRADOR
CANADA
NEW BRUNSWICK
NOVA SCOTIA
MAINE
NEW YORK
CALIFORNIA
UNITED STATES
OREGON
Russian America
Behring's Straits
Rocky Mountains
Blue Mountains
Cascade Range
Coast Range
Laurentian Mountains
James's Bay
Banks' Land
Prince Albert Land
North Somerset
Melville Peninsula
L. Athabasca
Great Slave Lake
Gt. Bear L.
L. Winnipeg
L. Superior
L. Huron
L. Michigan
L. Erie
L. Ontario
R. St. Lawrence
R. Columbia
Missouri R.
R. Mississippi
San Francisco
Bristol Bay
Alleghanies

knowledge will admit, I have carefully studied all the published documents and the geological collections relating to the subject to which I have been able to obtain access. And I have myself resided for many years in various parts of the territory, which, I may add, I have traversed from one extremity to the other,—from the borders of the United States to the Arctic Ocean in one direction, and from the frontiers of Russian America to Hudson's Bay in the other.

The titles of the publications to which I have referred are indicated below, and may be considered as presenting a bibliographical view of what is known of the geology of this part of America.

LIST OF WORKS RELATING TO THE GEOLOGY OF THE NORTHERN PART OF NORTH AMERICA.

North-West Coast and Russian America.

Geology of the United States Exploring Expedition under the command of Commodore Wilkes. By James D. Dana. New York, 1850.

Geological Appendix to Captain Beechey's Voyage to Behring's Straits in the ship "Blossom." By Dr. Buckland. London, 1839.

Beitrag zur Kenntniss der orographischen und geognostischen Beschaffenheit der Nord-West Küste Amerika's. Von Dr. C. Grewingk. St. Petersburg, 1850.

Exploration and Survey of Peel's River; a portion of the chain of the Rocky Mountains and the country west of McKenzie's River. By A. K. Isbister. Journal of the Royal Geographical Society for 1846.

Hudson's Bay Territories and Arctic Regions.

Topographical and Geological Appendices to the Narratives of Sir John Franklin's First and Second Journeys to the Shores of the Polar Sea. By Dr. Richardson. And Note on the Fossils. By Prof. Jameson. London, 1825 & 1828.

Observations on the Rock Specimens collected during the First Polar Voyage of Captain Parry. By Charles König. London, 1824.

Notes on the Geology of the Countries discovered during Captain Parry's Second and Third Expeditions. By Professor Jameson. London, 1826.

Geological Appendix to the Narrative of an Attempt to reach the North Pole by Sir Edward Parry, in the year 1827. By Professor Jameson. London, 1828.

Geological Appendix to Dr. Scoresby's "Journal of a Voyage to the Northern Whale Fishery, including Researches and Discoveries on the East Coast of Greenland." By Professor Jameson. Edinburgh, 1823.

Discovery and Adventure in the Polar Seas and Regions: Edinburgh Cabinet Library; with a Chapter on Arctic Geology. By Sir John Leslie, Professor Jameson, and Hugh Murray. 1832.

Voyage of Discovery for Exploring Baffin's Bay. By J. Ross. 1819. Appendix on the Rock-specimens. By Dr. M'Culloch.

Journal of Captain Penny's Voyage to Baffin's Bay and Barrow's Straits, in search of Sir John Franklin. By Dr. P. C. Sutherland. With an Appendix on Geology. By J. W. Salter. London, 1852.

Arctic Silurian Fossils. By J. W. Salter. 1853. Quart. Journ. Geol. Soc. vol. ix.

On the Geological and Glacial Phænomena of the Coasts of Davis's Straits and Baffin's Bay. By P. C. Sutherland, M.D. 1853. Quart. Journ. Geol. Soc. vol. ix.

Rink, H. Geology of West Greenland. Trans. Roy. Soc. Denmark, 1852. (Om den geographiske Beskaffenhed af de Danske Handelsdistrikter i Nordgrönland.)

Steinhauer on the Geology of Labrador. 1814. Trans. Geol. Soc. vol. ii.

Bayfield, on the Geology of the N. Coast of the St. Lawrence. 1837. Trans. Geol. Soc. 2nd Series, vol. v.

On the Geology of Lake Huron. By Dr. Bigsby. 1824. Trans Geol. Soc. 2nd Series, vol. i.

On the Geology of the Lake of the Woods [and Rainy River]. By Dr. Bigsby. 1852. Quart. Journ. Geol. Soc. vol. viii.

On the Geology of Rainy Lake, South Hudson's Bay. By Dr. BIGSBY. 1854. Quart. Journ. Geol. Soc. vol. x.

On the Drift of the Lake of the Woods and South Hudson's Bay. By Dr. BIGSBY. 1851. Quart. Journ. Geol. Soc. vol. vii.

Narrative of the Arctic Land Expedition to the Mouth of the Great Fish River. By Captain BACK, R.N. Appendix on Geology. By W. H. FITTON, M.D. London, 1836.

Journal of a Boat Voyage through Rupert's Land and the Arctic Sea, in search of the Discovery Ships under Sir John Franklin. By Sir JOHN RICHARDSON. London, 1851.

On some points of the Physical Geography of North America. By Sir J. RICHARDSON. 1851. Quart. Journ. Geol. Soc. vol. vii.

Report of a Geological Survey of Wisconsin, Iowa, and Minnesota, and incidentally of a portion of Nebraska Territory [including the Red River of Lake Winipeg]. By DAVID DALE OWEN. Philadelphia, 1852.

The chief sources of information, however, on which I have relied in confirmation of my own observations are the valuable Memoirs of Mr. Salter on Arctic Silurian Fossils, published in the Quarterly Journal of the Geological Society, vol. ix., and in the Appendix to Dr. Sutherland's Journal of Capt. Penny's Voyage, and the extensive researches and the numerous able publications of the great Arctic traveller Sir John Richardson, to whom science is indebted for nearly all that is known of the natural history of the vast region surrounding Hudson's Bay.

The collections of rock-specimens and minerals brought to England by the expeditions of discovery through this territory, to which Sir John Richardson was attached, and the various Arctic expeditions by which its northern shores have been traced, as well as by those recently engaged in the search for Sir John Franklin, are very extensive, and throw much valuable light on the mineral structure of the various formations which prevail in the northern regions of America. It was not, however, until within the last few years that any considerable collection had been made of the *organic remains* belonging to these formations, by which alone their relative ages and their true characters can be determined. Some of the fossil remains alluded to have been described and figured by Mr. Salter in the papers already referred to, others by Dr. Dale Owen, of the U.S. Geological Survey, Dr. Buckland, and others; and some (as will be subsequently noticed) have been described, though only incidentally and in general terms, by Sir John Richardson, Mr. Sowerby, the late Mr. König of the British Museum, and the late Professor Jameson of Edinburgh. A considerable number remain still undescribed in the Museum of the Edinburgh University, the British Museum, the Museum of Practical Geology in Jermyn Street, and the Museum of Haslar Hospital, or are mentioned for the first time in the present paper.

An examination of these specimens leaves no doubt of the existence of a vast development of palæozoic deposits, extending with little intermission (so far as is known) from the northern frontiers of Canada and the United States to the farthest point to which our researches have extended in the Arctic Ocean, and from Hudson's Bay on the east to near the Rocky Mountains on the west,—presenting altogether a geological horizon of a grandeur and extent unequalled probably in any other part of the world, largely as the researches of Sir Roderick Murchison, Sir Charles Lyell, and others have shown such formations to be developed in Russia and the United States.

A slight sketch of the chief physical features of this wide region will demonstrate the remarkable symmetry and unbroken condition of its sedimentary deposits, and to what an unusual degree they have apparently been exempted from those igneous disturbances which have complicated the geological structure of many other countries of far less extent in other parts of the world.

Territories East of the Rocky Mountains.

Physical Features; and Range of the Crystalline Rocks.—Separated from Canada by the great granitic range of the Laurentine or Canadian Mountains, which form the division between the hydrographic basins of these northern regions and those of the St. Lawrence and its great lakes, the Hudson's Bay Territories may be considered as forming one vast plain, diversified only by a single low granitic ridge running northwards from the west end and almost the whole north shore of Lake Superior as far as Great Bear Lake, in a direction nearly parallel with the range of the Rocky Mountains. This low belt of crystalline rocks (see Map, Pl. XIV.) averages about 200 miles in breadth, and is evidently the northern continuation of the Laurentine range, which, after extending uninterruptedly along the northern frontiers of Canada until it comes in contact with the northern spurs of the Alleghanies near the mouth of the St. Lawrence, is deflected northwards in a direction again nearly parallel with the Rocky Mountains through Labrador and along the shores of Hudson's Straits and Baffin's Bay until it finally disappears beneath the limestones of Lancaster Sound and Barrow's Straits. The striking correspondence between the direction of this granitic range, as thus traced, and the general contour of Hudson's Bay will be at once obvious from an inspection of the Map (Pl. XIV.), and would appear to point out this vast mass of crystalline rocks as the probable axis of elevation of the great movement by which the Hudson's Bay Territories, as well as Labrador and the lands and islands along the west coast of Baffin's Bay, were first upheaved from the primeval ocean under which they once reposed. The grand chain of the Rocky Mountains may be considered also as forming a new axis of elevation, at nearly an equal distance farther west, upheaving in a similar manner the wide-spread strata which repose on its flanks.

The existence of lines of division, pursuing a parallel course, in a general meridional direction, like those just mentioned, is one of the most prominent general circumstances hitherto ascertained respecting the geology of this part of America. The course of the Rocky Mountain chain, from the Sierra of Mexico in lat. 30° to its termination on the coast of the Arctic Sea in lat. 69°, is about N. by W., with very little deviation anywhere. This is also the general direction of the rugged and lofty coast-range of Labrador and Baffin's Bay, as well as of the west coast of Greenland.

By carrying the eye over the map from point to point along the western edge of the crystalline belt running through the Hudson's Bay Territories, it will be seen that the average direction is the same; though, as it proceeds northwards it inclines slightly towards the Rocky Mountains, which, it is to be observed however, begin here to lose their continuity; several of the western ranges being found to deviate from the general direction of the chain, and to develope themselves in irregular masses through the interior of Russian America.

We possess little reliable information respecting the structure of the mountain ranges of Labrador (on the east) or of the Rocky Mountains (on the west) north of the forty-seventh parallel, where they were crossed by Lewis and Clarke, in 1805, and no organic remains (so far as I am aware) from either locality. Sir John Richardson, who is in possession of all the information respecting the Rocky Mountain range, collected from the traders of the Hudson's Bay Company and from the botanists Douglas and Drummond, who crossed it between the sources of the Elk and Peace Rivers, describes the eastern slopes as consisting of conglomerate and sandstone, to which succeed limestone and clayslates, probably of Silurian age, and granite. This view is to some extent borne out by the section of this range given by Marcou, at Fort Laramie, in lat. 42°, from the Surveys of the United States' geologists. Farther north, where the chain was explored by myself, near its termination in the Arctic Sea, the prevailing formations were found through their organic remains (as will be subsequently noticed) to be referable to certain members of the Carboniferous series, corresponding probably to the Mountain Limestone of English geologists. From the highest part of the range, near latitude 55° N., where it attains an elevation of 16,000 feet above the sea, the four largest rivers of North America—the Missouri, the Saskatchewan, the Mackenzie, and the Columbia take their rise. It may be added, that these four feeders of opposite oceans not only take their origin from the same range of mountains, but three of them almost from the same hill,—the head-waters of the Columbia and the Mackenzie being only about "two hundred yards" apart, and those of the Columbia and the Saskatchewan, not more than "fourteen paces." It may be mentioned also as a singular fact, that one branch of the Mackenzie, the "Peace River" of Sir Alexander Mackenzie, actually rises on the western side of the Rocky Mountains within 300 yards of another large river flowing into the Pacific, the Tacoutchetesse, or Fraser's River, which discharges itself into the Gulf of Georgia, opposite Vancouver's Island.

Central Plateau of Crystalline Rocks.—Marcou, in his recently published Geological Map of the United States, has traced the crystalline formation of the Laurentine Mountains a considerable distance to the westward of Lake Superior, where it appears to form the chief constituent of the low watershed which separates the waters of the

Missouri from those of the Saskatchewan and other rivers flowing into Hudson's Bay.

The zone of crystalline rocks, chiefly gneiss, with granite and trap, previously alluded to as extending for a very great distance in a north-west direction from Lake Superior, is likewise very little elevated for the greater part of its extent above the surrounding country. Sir John Franklin, on his first overland expedition to the shores of the Polar Sea, crossed this granitic chain nearly at right angles to its line of direction in proceeding from Hudson's Bay to Lake Winipeg, where it was 220 miles wide; it has been since crossed at various other points, and traced nearly along its entire length to the Arctic Sea. We are thus in possession of the requisite data for mapping its course and extent, and indicating its general features with considerable accuracy. Branching off from the Laurentine ranges, it assumes a north-westerly direction from the Lake of the Woods (where it first comes in contact with the limestones which underlie the prairies on the west), until it reaches Lake Winipeg, along the eastern side of which it is then continued for about 280 miles in nearly a N.N.W. direction. From Norway Point at the north end of Lake Winipeg to Isle à la Crosse, a distance of 420 miles in a straight line, the western boundary has, according to Sir John Richardson, a W.N.W. direction. For 240 miles from Isle à la Crosse to Athabasca Lake, its course turns in a somewhat irregular outline northward, enclosing the whole of that lake with the exception of its western extremity. Thence it is continued to MacTavish Bay in Great Bear Lake, a distance of 500 miles in a general direction of about N.W. by W., and is marked, according to Sir John Richardson, "by the Slave River, a deep inlet on the north side of Great Slave Lake, and a chain of rivers and lakes, including Great Marten Lake, which discharge themselves into that inlet." From Great Bear Lake to the sea it follows the general course of the Coppermine River, its termination being marked by the mouth of that stream in lat. 71° 55′ N. and long. 120° 30′ W.; or perhaps more correctly by Richardson's River, a little to the west of it. In this part, for the first time, the chain rises to the altitude of hills, marked on the Map as the Copper Mountains, which attain in some parts a height of 800 feet above the bed of the river. The slight elevations composing the main portion of the chain seldom rise, as has been already observed, much above the level of the surrounding country, giving to the entire range the character of a low swampy plateau of crystalline rocks, covered by an immense network of small lakes and swamps, connected by narrow and tortuous channels. The low rugged knolls of granite and gneiss, round which these channels wind, "have mostly," says Sir John Richardson, "rounded summits, and they do not form continuous ridges, but are detached from each other by valleys of various breadth, though generally narrow and very seldom level. When the valleys are of considerable extent, they are almost invariably occupied by a lake, the proportion of water in this district being very great; from the top of the highest hill on the Hill River thirty-six lakes are said to be visible. The small elevation of the chain may be inferred from an examination of the Map,' which shows that it is crossed by several rivers that rise in the Rocky Mountains, the most considerable of which are the Churchill, and the Saskatchewan or Nelson Rivers. These great streams have, for many hundred miles from their origin, the ordinary appearance of rivers in being bounded by continuous parallel banks, but on entering the primitive district, they present chains of lake-like dilatations, which are full of islands and have a very irregular outline. Many of the numerous arms of these expansions wind for miles through the neighbouring country, and the whole district bears a striking resemblance, in the manner in which it is intersected by water, to the coast of Norway and the adjoining part of Sweden. The successive dilatations of the rivers have scarcely any current, but are connected with each other by one or more straits, in which the water-course is more or less obstructed by rocks, and the stream is very turbulent and rapid. The most prevalent rock in the chain is gneiss; but there are also granite and mica-slate, together with numerous beds of amphibolic rocks."

The entire length of this remarkable plateau, from Lake Superior to its termination on the Arctic Sea, may be estimated at somewhat more than 1500 miles. Such an enormous extension of crystalline and eruptive rocks, nowhere assuming the character of a mountain district, is a remarkable example of the tranquil operation of an upheaving force exerted over an immense area, yet with a limited and regulated intensity, and a constancy of direction which render it worthy of attention, not only as a striking geological phænomenon, but as serving, perhaps, to throw some light on the dynamical conditions under which those vast sedimentary deposits which have excited the astonishment of geologists in America from their unparalleled extension have been originally upheaved.

It may be mentioned also as another remarkable circumstance in connexion with this granitic tract, that it is along its western margin, in the line of its junction with the limestones and other secondary deposits which extend between it and the Rocky Mountains, that all the great lakes of America are found. If we regard Lake Erie and Lake Michigan as expansions respectively of Lake Ontario and Lake Huron (being evidently component parts of the same lake-basins), we shall find the following series of great lakes—Lake Ontario, Lake Huron, Lake Superior, Lake Winipeg, Athabasca Lake, Great Slave Lake, Marten Lake, and Great Bear Lake, succeeding one another in a N.N.W. direction along the line of fracture, and invariably bounded to a greater or less extent on one side (generally the northern or eastern) by crystalline rocks, and on the opposite side by limestones and other secondary formations; the northern coast-line being moreover indented nearly in the same general bearing by Coronation Gulf, where, as already stated, the line of crystalline rocks terminates. It is to be observed, however, that the rivers connecting these lakes run generally wholly in one formation or in the other.

Silurian Basin of Hudson's Bay.—The granitic tract just described is bounded to the eastward by a narrow belt of limestone, beyond which there is a flat swampy and partly alluvial district, forming the shores of Hudson's Bay. The west coast of the bay is everywhere extremely low, and the depth of water decreases so gradually on approaching it, that in seven fathoms of water the tops of the trees on the land are just visible from a ship's deck. Large boulder-stones are scattered over the beach, and sometimes form shoals as far as five miles from shore. A low and uniformly swampy aspect characterizes the surrounding country for several miles inland. The upper soil presents a thin stratum of half-decayed mosses, immediately under which we find a thick bed of tenacious and somewhat shaley bluish clay containing boulder-stones. Beyond this occurs an extensive deposit of limestone, completely encircling Hudson's Bay, and following the course of the crystalline rocks to the extreme limit of our researches in the Arctic Sea.

Dr. Conybeare, in his Report on Geology, to the British Association for 1832, had noticed the great similarity between the fossils brought to England by the Arctic Expeditions of Parry and Franklin, and those of the Silurian formations of our own country. The Geological Notices appended to the Narratives of those Expeditions by Professor Jameson, Mr. König, and Sir John Richardson, who had the advantage of Mr. Sowerby's assistance in examining the organic remains, had previously led to the same view; and it may now be considered as finally established by Mr. Salter's examination and description of the extensive collections from the Arctic Regions *, brought to England by the recent expeditions in search of Sir John Franklin. The formation described by Dr. Sutherland as extending along the shores of Wellington Channel and Barrow's Straits, and considered by Mr. Salter to belong to the Upper Silurian group, has since been identified, through its organic remains, at several points along the coasts of Hudson's Bay. Recognized by Mr. Logan at Lake Temiscamang, and at Lakes Abbitibie and St. John, on the northern edge of the Laurentine Mountains, it has been successively identified along the Moose and Albany Rivers flowing into James's Bay, at Marten's Falls †, and along the northern edge of the granitic plateau, thence to York Factory, along the Great Fish River, of Sir George Back ‡, at Igloolik §, and along both shores of Prince Regent's Inlet ||, to which last-mentioned locality Mr. Salter's investiga-

* Quart. Journ. Geol. Soc. vol. ix. p. 313.

† By Sir John Richardson and Mr. Barnston. "Boat Voyage through Rupert's Land," vol. ii. ‡ Dr. Fitton and Mr. Stokes. § Professor Jameson.

|| Sir Roderick Murchison, 'Siluria,' p. 428. I cannot omit, in this sketch of the geology of so large a portion of the North American Continent, to refer to the very accurate discrimination and description of its leading features contained in the recently published work of Sir Roderick Murchison on 'Siluria.' To this important work, and to the long series of researches of which it is the fruit, the geologists of America must feel under the highest obligation, not only for the clear and comprehensive view it exhibits of the whole phænomena of Palæozoic rocks throughout that continent, but for the important and valuable aid it affords to the explorer and investigator of its organic remains, by the establishment of a definite and perspicuous standard of comparison and reference, by which its geological formations can be identified and described.

tions bring us down. The extreme points here indicated are Lake Temiscamang, in lat. 47° 19′ N., and the shores of Wellington Channel, between 77° and 78° N., giving the enormous range of 30 degrees of latitude, over which, as far as our present information reaches, the Silurian formation extends uninterruptedly without any important variation, so far as is known, either in its mineralogical constitution or its stratification. The fossils from this district hitherto submitted to Mr. Salter's examination belong exclusively to the Upper Silurian. They are comprised in the following list; and most of them are figured in the Appendix to Dr. Sutherland's Journal of Capt. Penny's Expedition.

Crustacea.

1. Encrinurus lævis, *Angelin?*
2. Proetus, sp.
3. Leperditia Balthica, *Hisinger* sp., var. *arctica*, Jones.

Mollusca.

4. Lituites, sp.
5. Orthoceras Ommaneyi, *Salter.*
6, 7. ——, 2 species.
8, 9. Murchisonia, 2 sp.
10. Euomphalus, sp.
11. Bellerophon nautarum, *Salter.*
12. Modiola (or Modiolopsis).
13. Strophomena Donnetti, *Salter.*
14. ——, sp.
15. Orthis.
16. Spirifer crispus, *Linn.* sp.?
17. ——, sp.
18. Chonetes lata, *Von Buch?*
19. Pentamerus conchidium, *Dalm.*
20. Rhynchonella Phoca, *Salter.*
21. —— Mansonii, *Salter.*
22. —— sublepida, *De Vern.*
23, 24. ——, 2 sp.
25. Atrypa reticularis, *Linn.* sp.

Encrinites.

26. Actinocrinus, sp.
27. Crotalocrinus, sp.

Corals.

28. Ptychophyllum.
29. Strephodes Pickthornii, *Salter.*
30. —— ? Austini, *Salter.*
31. Favistella reticulata, *Salter.*
32. —— Franklini, *Salter.*
33. Fenestella, sp.
34. Favosites polymorpha, *Goldfuss.*
35. —— Gothlandica, *Linn.* sp.
36, 37. ——, 2 sp.
38. Columnaria Sutherlandi, *Salter.*
39. Halysites catenulatus, *Linn.* sp.
40. Syringopora, sp.
41. Heliolites (Porites).
42. Cystiphyllum, sp.
43. Cyathophyllum, sp.
44. Clisiophyllum, sp.
45. Aulopora, sp.
46. Cœnites (Limaria), sp.
47. Calophyllum phragmoceras, *Salter.*
48. Arachnophyllum Richardsonii, *Salter.*

Mr. König describes the limestones from which these remains have been obtained as of an ash-grey or yellowish and grey colour, often fœtid, and sometimes crystalline or compact, strongly resembling the Transition limestones of Gothland, and some of the fœtid varieties of the Mountain Limestone of Derbyshire. He mentions also that it is filled with zoophytes and shells; and in some parts is quite made up of the detritus of Encrinites, the fragments of which are so comminuted that the rock might readily be mistaken for a granular limestone.

A small collection of fossils * recently procured by the writer from

* The fossils were collected by Dr. Roderick Kennedy, the Medical Officer at Moose Factory.

James's Bay (the southern extremity of Hudson's Bay), which have been submitted to Mr. Salter, but not yet named, exhibit the same general Upper Silurian character with those above quoted. They comprise specimens of the same Corals (*Favosites, Cyathophyllum, Clisiophyllum,* and *Favistella*), the universal *Atrypa reticularis, Pentamerus oblongus,* several Spirifers and *Orthidæ,* and an *Orthoceras.* Mr. Barnston, of the Hudson's Bay Company's Service, who has resided for upwards of twenty years in various parts of the district under notice, and whose qualifications as an observer are highly spoken of by Sir John Richardson, has traced the Silurian rocks from James's Bay to Marten's Falls, near the source of Albany River, at the eastern edge of the granitic plateau, which would give an average breadth of about 200 miles for the formation in this part. The boat-route from Lake Winipeg to York Factory crosses the limestone belt at right angles to its course at Rock Portage, and its breadth is there found to diminish to less than 100 miles. The average width of the formation may perhaps be estimated at about 150 miles.

The mineral structure of the rocks forming the northern shores of America has been so fully and minutely investigated and described by Prof. Jameson, Mr. König, Dr. Fitton, and Sir John Richardson, that I shall here, as well as in the notices of the other formations of this territory, confine myself exclusively to the examination of their organic remains, referring the reader for every necessary information on the mineralogical character of the rocks in which they are found to the valuable publications of those authors.

Silurian Basin of Lake Winipeg.—To the westward of the plateau of crystalline rocks, and following its course for a considerable distance northward, lies an extensive deposit of horizontal limestone, underlying the wide prairie country which extends towards the Rocky Mountains. Lake Winipeg, which is situated on the line of junction of the two formations, is a long and narrow sheet of water, 230 geographical miles long, and about 40 wide; and, with its associated lakes (Moose Lake, Muddy Lake, Winnepegoos, and Manitoba Lakes), receives, through its affluents—the Saskatchewan, the Red River, and other streams—a wide extent of prairie drainage. The commercial route from Lake Superior up to this point lies almost wholly within the granitic tract, touching on Silurian deposits only at the mouth of Rainy River and at one of the south-western arms of the Lake of the Woods, where Dr. Bigsby has detected a few organic remains indicative of the Upper Silurian formation *. The Winipeg flows wholly within the granitic district, and has the lake-like dilatations and other characteristics of the streams which traverse the crystalline tract. When we descend to Lake Winipeg, we come upon epidotic slates, conglomerates, sandstones, and trap-rocks, which bear a close resemblance to those of the mining district of Pigeon Bay on

* The following list is given by Dr. Bigsby: a small *Phacops*, small *Orthocerata*, minute Encrinital columns, *Favosites Gothlandica, Cyathophyllum, Murchisonia, Pentamerus Knightii, Leptæna, Avicula, Atrypa,* and *Spirifer.* Quart. Journ. Geol. Soc. vol. viii. p. 405.

Lake Superior. After passing the straits of Lake Winipeg, we have granitic rocks on the east shore and Silurian rocks on the west and north, the basin of the lake being mostly excavated in the limestone. The granite and gneiss which form the east shore of Lake Winipeg strike off at its N.E. corner, and, passing to the north of Moose Lake, go on to Beaver Lake, where the boat-route again touches upon them. The extension of the limestone in a westerly direction from Lake Winipeg has not been ascertained; but it has been traced as far up the Saskatchewan as Carlton House, where it is at least 280 miles in breadth. Beyond this it is either succeeded or covered by cliffs of calcareous clay, which bear some resemblance to those found along the banks of the upper portions of the Missouri, together with saliferous marls and beds of gypsum.

Skirting the base of the Rocky Mountains a remarkable lignite formation is met with, which is said to extend through the valley of the Mississippi and of Mackenzie River as far north as the Arctic Sea.

The limestone of Lake Winipeg, which undoubtedly covers a vast tract of country, may in general be characterized as compact and splintery, and of a yellowish-white colour, passing into buff, and sometimes of an ash-grey, mottled, or banded with patches of light brown. In the district between Lake Winipeg and the Saskatchewan, more particularly examined by the Arctic Expeditions of Franklin and Back which passed through it on their way to the Arctic Sea, the limestone strata were found to be almost everywhere extensively exposed, and to be remarkably free from intrusive rocks. Professor Jameson enumerates *Terebratulæ*, *Orthocerata*, *Encrinites*, *Caryophyllitæ*, and *Lingulæ*, as the organic remains brought to England by Franklin's First Expedition; Mr. Stokes and Mr. Sowerby examined those fossils which were procured on the Second Expedition, and found amongst them *Terebratulites*, Spirifers, Corallines, and *Maclurites*. The *Maclurites* were probably the *Maclurea magna* of Le Sueur and Hall. Sir John Richardson has recently brought home from the same quarter a fine specimen of the *Receptaculites neptunii*,—a fossil, which, though it occurs abundantly in some of the Devonian beds of the Eifel, is with the Maclurite characteristic in Canada, as in New York, of the Lower Silurian.

Along the southern shores of Lake Winipeg and in the Valley of the Red River, where the limestone rises in solid ledges from the surrounding prairies, and has been extensively quarried for building purposes, it has been distinctly identified as belonging to that formation by Dr. Dale Owen, Director of the Geological Survey of Wisconsin and Minnesota, who in the course of his explorations visited the small colony settled there by the Hudson's Bay Company. In his recently published Report, Dr. Dale enumerates the following fossils procured by him from the quarries at Red River and from Lake Winipeg:—

1. Favosites basaltica.
2. Coscinopora sulcata.
3. Chætetes lycoperdon.
4. Pleurorhynchus, sp.
5. Ormoceras Brongniarti.
6. Leptæna sericea ? †
7. —— alternata.
8. —— planoconvexa ?

9. Calymene senaria.
10. Pleurotomaria lenticularis?
11. —— muralis †.
12. Orthis, sp. †
13. Lingula, sp. †
14. Terebratula, sp. †
15. Cytherina? †
16. Syringopora.
17. Pleurorhynchus?
18. Cephalic shield of a Trilobite allied to *Illænus arcturus* †.
19. Pustulated cephalic shield of an Illænus †.
20. Conularia, sp.
21. Several specimens of the shield of Illænus crassicauda.

NOTE.—Those marked † are figured in Dr. Owen's Atlas of Illustrations.

Many of these, Dr. Owen states, "are identically the same fossils as occur in the lower part of 'Formation No. 3.' in Wisconsin and Iowa, in the blue limestones of Indiana, Ohio, Kentucky, and also in the Lower Silurian of Europe. The *Coscinopora* is precisely the same as the coral which is particularly characteristic of the lower beds of the Upper Magnesian Limestone of Wisconsin. The specimens of *Favosites basaltica* cannot be distinguished from those which abound in the Upper Magnesian Limestone of Wisconsin and Iowa and the Lower Coralline beds of the Falls of the Ohio."

It has been noticed that the limestones of this formation are distinguished by two different tints of colour. From the following analyses of the two varieties published by Dr. Owen, it would appear that they differ also considerably in their mineralogical character.

Analysis of the Compact Limestone from Red River, containing *Leptæna*.		Spotted and banded Limestone, containing *Coscinopora*.	
Carbonate of Lime	53·7	Carbonate of Lime	78·1
Carbonate of Magnesia	40·5	Carbonate of Magnesia	17·8
Insoluble matter	0·8	Insoluble matter	1·0
Alumina, Oxide of Iron, and Manganese	4·0	Alumina, Oxide of Iron, and Manganese	1·4
Water and loss	1·0	Water and loss	1·7
	100·0		100·0

It has been stated that none of the fossils from the Hudson's Bay Basin hitherto submitted to Mr. Salter belong to the lower division of the Silurian. It is proper to observe, however, that Mr. Salter has expressed some doubt of the age of the limestone of Igloolik, Melville Peninsula, and Amherst Island, amongst the organic remains of which Professor Jameson and Mr. Stokes detected some Trilobites, a Maclurite, and a Coral, which last fossil from the description given of it may have been a *Receptaculites*; and it may be added, that Marcou, apparently on the authority of Mr. Logan, classes the limestones of Lakes Abbitibe and St. John as Lower Silurian. The limestones of the Kakabeka Falls were identified by himself as belonging to that division. The insufficiency of geological explorations, and the want of published documents, render it impossible as yet to define with any approach to accuracy the limits of the two great divisions of the formation in this part of America, while it may be safely asserted, however, that under one or other of its forms the Silurian formation attains probably a wider development in the Hudson's Bay Territories than in any other part of the world in which its existence has been hitherto ascertained. Sir John Richardson has detected it in the hollows of the granitic plateau, and he expresses a belief that it will be found to occupy all the valleys of that extensive district.

Devonian Formation of the Elk or Mackenzie River.—The extent of the Silurian formation of Lake Winipeg northward has not been accurately ascertained. Limestones very similar in character have been traced on Beaver River, the most westerly feeder of Churchill River, and situated midway between the Saskatchewan and Elk Rivers. The canoe-route does not touch upon this river, which has its outlets in one of the south-western arms of Lake La Crosse; but it is observed that the country on entering Sandy Lake along the line of communication near this part suddenly changes its aspect. Banks of loam, sand, and rolled blocks of a fine quartzose sandstone are found along the channels of the rivers; and shortly after emerging from the granitic district through which the route lies for the greater part of the distance from Cumberland House to Fort Isle-à-la-Crosse, we come upon a formation of quite another character, occupying the basins of the Elk River and its affluent the Clear-water.

The Elk River, the most southerly feeder of the Mackenzie, originates in the Rocky Mountains, as already stated, near the northern sources of the Saskatchewan; and its bed, which forms with that stream two sides of an equilateral triangle, with its base resting on the western edge of the crystalline plateau, is not separated by any marked ridge from the Saskatchewan prairie country, which appears to extend with little interruption as far as the next great tributary of the Mackenzie, the Unjigah or Peace River. It is separated from the Churchill or Mississippi River system, having its outlet in Hudson's Bay, by the carrying-place of Portage La Loche, a plateau of about ten miles in breadth, which forms the dividing ridge between the waters flowing into Hudson's Bay and those flowing into the Arctic Sea. Portage La Loche has at its highest point an elevation of about 60 feet above the sources of the Churchill River system; but it presents on the side of the Clear-water River a sudden and precipitous descent of 656 feet, disclosing a deep layer of sand, enclosing masses of sandstone, of about 600 feet in depth; the whole reposing upon an extensive formation of limestone which lines the whole bed of the Clear-water as far as its junction with the Elk River. The deposits of sand and sandstone alternate with thick beds of bituminous shale, in some parts more than 150 feet in depth. These bituminous deposits form the distinguishing feature of the formation now under notice, and are developed to an enormous extent, having been traced at intervals along the whole length of Mackenzie River as far as the shores of the Arctic Sea. Springs and pits of fluid bitumen are of common occurrence, and along the banks of Elk River in particular the shale beds are so saturated with this mineral as to be nearly plastic. The whole formation bears a decided resemblance in its lithological character to the lower members of the "Erie Division" of the United States' geologists, which M. de Verneuil considers to be equivalent to the Devonian formation of Europe *. I have been enabled, through the kindness of Mr. S. P. Woodward, to examine the collection of fossils from this district in the British Museum; and although, from the poverty of organic remains (a circumstance characteristic of the formation also in the United States), the collection is a very small one, there can be no hesitation in assigning the bituminous deposits of the Elk and Mackenzie Rivers to the epoch of the Marcellus shales, and the associated limestones, of the New York Survey.

The most characteristic fossil of the bituminous beds is a small Pteropodous shell, thickly disseminated through the substance of the shale, apparently the *Tentaculites fissurella* of Hall, associated with *Strophomena mucronata, S. setigera,* and *Orthis limitaris,* of the same author; at least they cannot be distinguished from his figures of those fossils from the Marcellus shales.

Two Corals from the associated bituminous limestone are, according to Mr. Woodward, characteristic of the same epoch, namely a *Strombodes* (of Hall), having its cysts filled with bitumen, and a *Favosites,* very like the common *F. polymorpha* of the Plymouth marbles. From the underlying limestones of the Elk River, Sir John Richardson collected several specimens of *Productus* (among them *P. subaculeatus*), an *Orthis* resembling *O. resupinata, Terebratula reticularis,* a *Posidonomya,* and a *Pleurotomaria.* There is a very fine and well-preserved *Rhynchonella* amongst the collection, remarkable for retaining the original chestnut-coloured bands of the shell.

Other Formations of the Mackenzie River Basin.—Silurian rocks of Great Slave Lake and River (*Onondago Salt Group of Vanuxem and Hall*?).—After passing through Lake Athabasca, the Elk River is joined by the Unjigah or Peace River, the largest tributary of the Mackenzie, and the united streams, under the name of Slave River, proceed onwards to Slave Lake along the edge of the district of crystalline rocks, flowing sometimes through limestone, at other times over granite, and sometimes between the two. The mouths of Slave River open into Slave Lake between the limestone and granite. The limestones along the banks of this stream are, like those of the Elk River, highly bituminous; but they are chiefly remarkable from their association with extensive beds of compact greyish gypsum, in connexion with extremely copious and rich salt-springs. Where they approach the crystalline rocks, they are found, like those of Lake Winipeg, to be highly magnesian,—a circumstance which may deserve attention with reference to the hypothesis of *dolomization,* which regards the introduction or development of magnesia as subsequent to the deposition of the calcareous matter, and as connected with the proximity of masses containing that earth and heated to a very high temperature. Among the fossils collected from this district which are in the British Museum are *Spirifer crispus,* Dalm.?, *Rhynchonella phoca,* Salter, *Atrypa lævis,* Vanuxem, *Atrypa reticularis,* an

* Bulletin Soc. Géol. Fr. 2 Sér. vol. iv. p. 646.

Orthis, two small Spirifers, like *S. trapezoidalis*, Dalm. and *S. pisum*, Sow., and fragments of an Encrinital stem like that of *Actinocrinus*. Sir George Back, on his expedition down the Great Fish River, collected some fragments of Corals along the south shore of Slave Lake, which were considered by Mr. Stokes and by Mr. Lonsdale to belong some to *Catenipora escharoides*, and one to the genus *Stromatopora* of Goldfuss, and probably to his species *S. polymorpha*. From the circumstance of these fossils being chiefly Upper Silurian, it has been conjectured, with every appearance of probability, that the salt-springs may belong to the "Onondago Salt Group" of the "Helderberg division" of the New York system.

Carboniferous Series (*Mountain Limestone*?).—Some of the organic remains procured by Sir John Richardson on a previous expedition from other points along the Mackenzie River would appear to indicate an ascending order in some of the deposits of that district from the Devonian limestones and the shales containing *Tentaculites* into beds of Carboniferous, or perhaps more recent age. In some specimens from the limestone* of the "Ramparts" in the lower part of Mackenzie River, brought to England in 1826, Mr. Sowerby discovered *Terebratula sphæroidalis*, together with a species common in the carboniferous limestone of Nehou in Normandy, some *Producti*, and a Coral of the genus *Amplexus*. From other parts along the banks of the same river several *Terebratulæ* were procured, one resembling *T. resupinata*, one *Spirifer acutus*, a *Cirrus*, some Crinoidal remains, and Corals,—a somewhat perplexing assemblage, if they were all collected from the same spot. Most probably some of the specimens had been derived from the boulders and transported fragments with which this part of the country is covered.

Lignite Formation.—The difficulty of deciding upon the age of the beds through which the lower part of Mackenzie River flows, is increased by the occurrence among them of a Lignite-formation, covered in parts by deep beds of sand, capped by boulders and gravel. The soft friable shales forming the bank of the river near its termination in the Arctic Sea are also strongly impregnated with alum. These aluminous shales cover a large portion of the delta of Mackenzie River, are continued along the banks of Peel's River to the foot of the Rocky Mountains, and have been traced for a considerable distance along the coast, and also along the shores of Great Bear Lake. The aluminous shale is constantly associated with the bituminous formation, into which it often passes.

The lignite-formation is still more extensively developed; and, as the occurrence of coal in any form in these high latitudes is a

* The limestone of the "Ramparts," which appears again lower down at a spot called the "Narrows," is continued in a westerly direction to the Rocky Mountains, the lower elevations of which are composed of it in that portion of the range through which Peel's River takes its course. It has all the characters of the Mountain Limestone of English geologists,—a formation extensively developed in Russian America, where, as will be subsequently noticed, it has been clearly identified by its organic remains.

question of much interest, I shall here state briefly the results of Sir John Richardson's observations and inquiries on the subject, to which he has given much attention.

The Mackenzie traverses very obliquely the basin in which the lignite-formation is deposited, while Bear Lake River cuts it more directly across; and it is at the junction of these two streams that the formation is best exposed. It there consists of a series of beds, the thickest of which exceeds 3 yards, separated by layers of gravel and sand, alternating with a fine-grained friable sandstone, and sometimes with thick beds of clay, the interposing layers being often dark, from the dissemination of bituminous matter. "The coal, when recently extracted from the bed," says Sir John Richardson, "is massive, and most generally shows the woody structure distinctly; the beds appearing to be composed of pretty large trunks of trees, lying horizontally, and having their woody fibres and layers much twisted and contorted, similar to the White Spruce now growing in exposed situations in the same latitude. Specimens of this coal examined by Mr. Bowerbank were pronounced by him to be decidedly of coniferous origin, and the structure of the wood to be more like that of *Pinus* than *Araucaria*; but on this latter point he was not certain. It is probable that the examination of a greater variety of specimens would detect several kinds of wood in the coal, as a bed of fossil leaves, connected with the formation, reveals the existence at the time of various dicotyledonous trees, probably *Acerineæ*, and one of which appears to belong to the Yew tribe." . . . . . "Different beds, and even different parts of the same bed, when traced to the distance of a few hundred yards, present examples of 'fibrous brown coal,' 'earth-coal,' 'conchoidal brown coal,' and 'trapezoidal brown coal.' Some beds have the external characters of a compact bitumen; but they generally exhibit on the cross fracture concentric layers, although from their jet-like composition the nature of the woody fibres cannot be detected by the microscope. Some pieces have a strong resemblance to charcoal, in structure, colour, and lustre. Very frequently the coal may be named a 'bituminous slate,' of which it has many of the lithological characters; but, on examination with a lens, it is seen to be composed of comminuted woody matter mixed with clay and small imbedded fragments resembling charred wood. From the readiness with which the coal takes fire spontaneously, the beds are destroyed as they become exposed to the atmosphere, and the bank is constantly crumbling down; so that it is only when the debris have been washed away by the river that good sections are exposed *."

* With reference to the southern portion of this coal-field, where it is exposed in the valley of the Saskatchewan, Sir George Simpson, Governor of the Hudson's Bay Territories, has the following remarks, in his 'Narrative of an Overland Journey round the World,' vol. i. p. 162:—

"Near Fort Edmonton a seam of coal, about 10 feet in depth, can be traced for a very considerable distance along both sides of the river. This coal resembles slate in appearance; and, though it requires a stronger draught of air than that of an ordinary chimney, yet it is found to answer tolerably well for the blacksmith's forge. Petrifactions are also found here in abundance, and at the Fort there was

Formations similar to that found on Mackenzie River extend southward along the eastern base of the Rocky Mountains, as far as the Saskatchewan River. Sir John Richardson gives a detailed account of the various localities between these two points in which beds of coal have been exposed,—all pointing to the existence of a vast coal-field, skirting the base of the Rocky Mountains for a very great extent, and continued probably far into the Arctic Sea, where, as is well known, lignite, apparently of a similar character, has recently been discovered by Captain M^cClure in the same general line with the localities above mentioned*. In the coal of Jameson Land, lying in north latitude 71° (on the east side of Greenland), and in that of Melville Island, in latitude 75° north, Professor Jameson found plants resembling those of the coal-measures of Britain; and similar remains have been more recently discovered by Mr. Dana in the coal-fields of Oregon and Vancouver's Island. These facts are sufficient of themselves, as is remarked by Sir John Richardson, to raise a world of conjecture respecting the condition of the earth when these ancient fossils were living plants. If the great coal-measures, containing similar vegetable forms, were deposited at the same epoch in distant localities, there must have existed when that deposition took

a pure stone which had once been a log of wood about 6 feet in length and 4 or 5 in girth, the resemblance being so complete as even to deceive the eye."

Sir Alexander M^cKenzie traced the same formation along the upper parts of the Peace River; and it has been found by the traders of the Hudson's Bay Company at several intermediate points along the same general line; leading to the conclusion that the formation in question is continuous and uninterrupted.

* Similar deposits to those discovered by Capt. M^cClure have been found in the New Siberian Islands, and are thus described in Wrangell's Polar Voyages:—" Of these [speaking of the deposits of fossil wood in the New Siberian Islands] Hedenström observes in another place, 'On the southern coast of New Siberia are found the remarkable Wood Hills. They are 30 fathoms high, and consist of horizontal strata of sandstone, alternating with strata of bituminous beams or trunks of trees. On ascending these hills, fossilized charcoal is everywhere met with, covered apparently with ashes; but, on closer examination, this ash is also found to be a petrifaction, and so hard that it can scarcely be scraped off with a knife. On the summit another curiosity is found, viz. a long row of beams, resembling the former, but fixed perpendicularly in the sandstone. The ends, which project from 7 to 10 inches, are for the greater part broken. The whole has the appearance of a ruinous dyke.' Lieut. Anjou, who likewise examined these Wood Hills, says, 'They are merely a steep declivity, 20 fathoms high, extending about five wersts along the coast. In this bank, which is exposed to the sea, beams or trunks of trees are found, generally in an horizontal position, but with great irregularity, fifty or more of them together,—the largest being about 10 inches in diameter. The wood is not very hard, is friable, has a black colour and a slight gloss. When laid on the fire, it does not burn with a flame, but glimmers, and emits a resinous odour.' "—(Narrative of an Expedition to the Polar Sea, by Admiral F. von Wrangell, of the Russian Imperial Navy, in 1820–23. (Edited by E. Sabine) Introd. p. cxviii.)

The " charcoal " and " ashes " are no doubt the result of the spontaneous combustion of the lignite, as is the case with the lignite deposits at Bear Lake and other parts of the Hudson's Bay Territories, where they take fire on being exposed to the air, and have been observed burning for the last hundred years. The Wood Hills in the New Siberian Islands are in the same general line with the lignite extending along the Rocky Mountains, and with the wood deposits discovered by Capt. M^cClure.

place a similarity of condition of the North American Continent from latitude 75° down to 45°.

Elevatory Movements; and Pleistocene deposits.—Into such questions, however, as the above, or into the discussion of the various hypotheses by which the elevations and depressions of the surface of these vast territories may be accounted for, it is beyond the province of the present paper to enter; nor, in the present state of our knowledge, would a summary of this kind admit of the necessary elucidation. I shall merely say, that, adopting the opinion of Sir John Richardson and the geologists of the United States, that "the eastern portion of the continent was first elevated, and that the older rocks on the west were subsequently overlaid by newer deposits," I consider that the great mass of the underlying formations surrounding Hudson's Bay are wholly palæozoic, and that the currents or waves of translation, if such there were, must have had an easterly direction in these latitudes, and gained strength as they rolled towards the Atlantic, when they swept away wholly or partially the fossiliferous deposits that covered the older rocks of Hudson's Bay, Canada, and the eastern parts of the United States; the former extent of the newer rocks being indicated by the patches which remain. The only recent formations overlying the Silurian rocks, which have been hitherto discovered along the eastern coasts of Arctic America, are patches of pleistocene deposits, with marine shells of existing Arctic species (*Mya truncata*, *Saxicava rugosa*, &c.); the whole crowned by an immense profusion of boulders and erratic blocks. The country forming the Hudson's Bay Territories is too flat for the immense erratic formation extending over every part of it to be explained by reference to the motion of glaciers; and I think it is more probably due to the action of icebergs and floating masses of ice, still so common along these coasts, and which are without doubt performing at the present day precisely a similar office, in strewing the bed of the ocean in which they are found with the fragments transported from the adjacent shores*.

With reference to the character of the pleistocene or drift formation, it may be mentioned that as we ascend the rivers of this region, especially along the basins of Lake Winipeg and its affluents in the prairie districts, the sandy and clayey deposits are found to abound with land and freshwater shells, such as *Unio*, *Helix*, *Pupa*, &c., of species now living on the borders, or in the beds of the rivers and lakes. The cliffs containing those shells are often raised more than 100 feet above the present levels of the banks of the streams, and appear to be ancient lake- or river-terraces; leading to a belief that, great as is the present extent of freshwater surface in the North

* In the Appendix to Dr. Scoresby's 'Journal of a Voyage to the Northern Whale Fishery,' Professor Jameson enumerates among the specimens found on an iceberg near Cape Brewster the following:—

1. Transition clay-slate.	4. Hornblende mica-slate.
2. Slaty talcose granite.	5. Gneiss.
3. Granular felspar.	6. Basaltic greenstone.

American Continent, it was at one time still greater, and that the existing series of lakes, from the St. Lawrence northward, were perhaps anciently united in one or more vast freshwater seas, having their western margins indicated, perhaps, by the peculiar elongated strip occupied by the lignite-formation previously described, which presents precisely the appearance which would result from a long line of shelving beach, piled with masses of drift-wood accumulated through long successive periods, similar to what is now found covering the shores of the inland lakes and portions of the coasts of the Arctic Seas.

It has been stated as an exemplification of the wide changes which would result from a comparatively small alteration in the present level, even of such mountainous districts as Canada and the North-eastern States of the Union, that "a subsidence of 400 feet would cause the waters of Lake Ontario to flow through the valleys of the Mohawk and Hudson into the Atlantic, and at the same time convert Lake Champlain into a maritime strait, thereby forming islands of the States of New York, New England, and Maine, and of the British Colonies of New Brunswick and Nova Scotia." A subsidence of one-fourth of that amount in the prairie districts of the Saskatchewan, continued to Great Bear Lake, would carry the waters of the Missouri and the upper portions of Churchill and Mackenzie Rivers into Lake Winipeg, and convert the plain country bordering on the Rocky Mountains into an inland sea. Even at the present level the Missouri has, twice within the last thirty years, inundated the valley of the Red River, flowing into Lake Winipeg; while it is a common occurrence for the country through which the lower part of the Saskatchewan flows to be laid under water for a distance of 200 miles above its outlet by an ordinary spring-flood. About forty years ago, in a season remembered especially for the land-floods, a gentleman in the service of the Hudson's Bay Company was drowned on the Frog Portage (the low watershed which separates the Saskatchewan and Churchill Rivers), by his canoe upsetting against a tree in passing from one stream to the other.

The raised beaches of Lake Superior, rising in four or five successive terraces to the height of more than 100 feet above the present surface of the water, and which have attracted the attention of Professor Agassiz and the geologists of the Canadian Survey, appear to point to the existence at some former period of a much greater body of water in this lake, at least, than is at present contained in it, and are to some extent therefore confirmatory of the view now suggested.

The Eocene basin of the Upper Missouri, with its very marked character of freshwater deposition, is stated by Marcou to extend along the upper waters of the Saskatchewan as far as Mackenzie River. I have no knowledge of any such formation myself, although in the unexplored territory west of the Winipeg basin there is undoubtedly ample room for its development. Its existence, if established, would lend additional probability to the inference deducible from the circumstances previously noticed *.

* The views here suggested are not to be considered as prejudging the question so ingeniously developed by Mr. W. Hopkins, and supported by the late Prof. E.

Territories West of the Rocky Mountains.—Physical Features.— "The great contrast between the east and west sides of the Rocky Mountains has been often mentioned,—the one abounding in sandstone with argillaceous limestones, *without* volcanos or volcanic rocks, while on the other side recent igneous rocks prevail (basalts, basaltic lavas, and trachytes) *, and the sandstones are comparatively of small extent." This remark, which I quote from the learned and beautiful work of Professor Dana, 'The Geology of the United States Exploring Expedition under Commodore Wilkes,' will prepare the reader for the examination of a country of a different character from what has above formed the subject of investigation.

The grand features of the country on the Pacific side of the Rocky Mountains arise from the development of three ranges of mountains, intersecting the country in a direction parallel with the general course of the coast-line. Three of these are north and south ranges,—the Coast Range, the Cascade Range, and the Blue Mountain Range. The first lies near the coast, the second 130 miles inland, and the third 350 miles from the sea.

The Cascade Range is much the most extensive of the three, and even rivals the Rocky Mountains in the height of some of its peaks. It may be traced, according to Professor Dana, far into California, and northward into Russian America; retaining throughout a direction nearly parallel with the coast. It terminates northward, according to Grewingk, in the lofty volcano of Mount Wrangell, in lat. 62° N., where it blends with the lateral volcanic range, forming the remarkable promontory of Aliaska. The main body of the Cascade Range, in Oregon, is seldom over 5000 or 6000 feet in elevation.

The Blue Mountains form the western boundary of the Valley of the Snake River (of Lewis and Clarke), flowing into the Columbia. Immediately to the north of this river, as far as Fort Colville, they are interrupted by an extensive level tract; but to the north of Fort

Forbes, respecting the probability of the passage of the Gulf Stream at some former period up the valley of the Mississippi (Quart. Journ. Geol. Soc. vol. viii. p. 89, &c.),—a theory of the highest interest and importance in accounting for the changes of temperature and climate on the surface of our globe, and which, though based by its author upon purely physical considerations, is in harmony with all the geological facts and evidence which have come under the writer's notice.

The age of freshwater accumulations and deposits suggested in the text comes much nearer to our own times.

* Dr. Grewingk, in his Map of Russian America, assigns the localities of fifty-eight active volcanos on the North-west Coast of America. They lie in a line running from the north end of Prince of Wales Island, in lat. 56° N., following the course of the coast through the peninsula of Aliaska and the Aleutian Islands. Many of their summits rise into the region of perpetual snow. The line in which the volcanic peaks of Aliaska lie, when prolonged to the eastward, strikes the Big Beaver Mountains on the Yukon. On the side of the Atlantic, modern volcanic rocks occur in Jan Mayen's Island only, whose principal mountain, Beerenberg, rises 6870 feet above the sea.

I have been recently informed that the Basquiau Hills, which lie to the south of Cumberland House, on the Saskatchewan River, are volcanic, and that an eruption has been observed there within the last year. The report requires confirmation. No other example is known of the existence of a volcano in any part of America east of the Rocky Mountains.

Colville there is a range of heights, which extends along the north branch of the Columbia River, and may be considered a part of the same general chain.

The short western slope of the continent from the Rocky Mountains to the Pacific differs from the eastern in its river-valleys being all more or less transverse,—the rivers flowing through passes or gorges of the intersecting ranges. The peculiar wing-like projection in the north, towards Asia, is evidently due to the volcanic chain of Aliaska, which runs at right angles to the Rocky Mountains. The great transverse valley of the Yukon (the Kwichpack of the Russian geographers) lies to the north of it. The Yukon is a river of great magnitude, probably the largest river in America flowing into the Pacific, not excepting the Columbia. For a considerable part of its course it flows to the north, but afterwards nearly due west, through a country which, as far as can be judged from the descriptive notices of it hitherto collected, closely resembles the valley of the Mackenzie, with some of the affluents of which it is in fact connected; so that here, as in other parts of the Rocky Mountain Chain, the rivers falling into opposite seas interlock at their origin. One or more low chains of mountains, formed by the lateral spurs of the Rocky Mountains, are prolonged along the Arctic Coast, north of the Yukon, giving origin to several small rivers between the mouth of the Mackenzie and Point Barrow.

Oregon Territory.—Our acquaintance with the geology of this district is very limited, and does not extend beyond the portion of country between the Coast Range and the sea, explored by the Expedition of Commodore Wilkes. From Mr. Dana's researches it appears to be occupied chiefly by the tertiary formation, which is found at various places from Puget's Sound to San Francisco along the coast-section of Oregon. The rocks of this formation are soft sandstones, more or less argillaceous and schistose, and clay-shales, either firm or crumbling, together with tufa and conglomerate. The sandstones and shales have been denuded on a vast scale. Although the rocks are nearly or quite horizontal wherever examined, there are no plains on the coast-section excepting those of alluvial origin. Mr. Dana considers that the Coast Range, by which the Pacific coast was elevated, was formed while igneous action was going on in the interior, where the frequent changes of the river-basins and other indications of a similar kind afford evidence of extensive and very recent volcanic disturbance.

The fossils collected by Mr. Dana were examined by the eminent conchologist Mr. T. Conrad, who assigned them to the geological æra of the Miocene. They are comprised in the following list.

Mammal.

1. Vertebra of a Cetacean.

Fishes.

1. Vertebra of a species of Shark.
2. —— of a species allied to *Tregla*.
3. ——, cast of; species not distinguishable.

Crustacea.

Callianassa Oregonensis. Balanus.

Mollusca.

Mya abrupta.
Thracia trapezoides.
Solemya ventricosa.
Donax? protexta.
Venus bisecta.
—— angustifrons.
—— lamellifera.
—— brevilineata.
Lucina acutilineata.
Tellina arctata.
—— emacerata.
—— albaria.
—— nasuta.
—— bitruncata.
Nucula divaricata.
—— impressa.
Pectunculus patulus.
Pectunculus nitens.
Arca devincta.
Cardita subtenta.
Pecten propatulus.
Terebratula nitens.
Dolium petrosum.
Sigaretus scopulosus.
Natica saxea.
Bulla petrosa.
Crepidula prærupta; and sp.
Rostellaria indurata.
Cerithium modiale.
Buccinum? devinctum.
Fusus geniculus.
—— corpulentus.
Nautilus angustatus.
Teredo substriata.

Echinoderms.

Galerites Oregonensis (n. sp.).

Foraminifera, 3 sp.

Plants.

Abies? robusta; Leaves of Lycopodium?, Taxodium, Smilax, and others.

The plants were found near the mouth of Fraser's River, and indicate probably the commencement of the deposits of the Carboniferous æra, which are largely developed in the neighbouring island of Vancouver, and along the coasts and islands of Russian America.

The interior of Russian America, like that of Oregon, is unexplored; but, in the work of Grewingk (Beitrag zur Kenntniss der orographischen und geognostischen Beschaffenheit der Nord-West Kuste Amerika's), and in the Geological Appendix to Capt. Beechey's Voyage to Behring's Straits, by Dr. Buckland, we have a tolerably complete account of the chief formations occurring along the coast, and on the neighbouring islands, from 52° N. lat. to Behring's Straits.

The only representatives of the palæozoic rocks in this part of America, hitherto discovered, are the Mountain Limestone, and other members of the Carboniferous series, which are found covering the flanks of the mountains here bordering immediately on the sea, and prolonged into a dense archipelago of volcanic islands, several of them containing active volcanos, which skirt the entire coast from the parallel of 50° northward.

Dr. Grewingk has given in the Transactions of the Mineralogical Society of St. Petersburgh, for 1848–9, a complete list of the organic remains hitherto discovered in Russian America, including those described in the Appendix to Captain Beechey's Voyage. They afford evidence of the existence of the following formations,—the Carboniferous, Jurassic, Tertiary, and Drift, which have been traced in detached sections along the coast; leaving much still to be desired, however, before a complete and connected view of the geological structure of this portion of the American Continent can be obtained.

Fossils of the Carboniferous Formation.—The limestones of this formation, which have been traced at several points along the coast (see Map, Pl. XIV.), are most extensively developed in the N.E. extremity of the Continent, where they occupy the greater part of the coast-line from the north side of Kotzebue Sound to within a few miles of Point Barrow, and form the chief constituent of the lofty and conspicuous headlands of Cape Thompson, Cape Lisburn, and Cape Sabine. Near the last-named cape a vein of excellent coal is exposed, which burns with a good heat and a bright flame. The limestone is, according to Dr. Buckland, scarcely distinguishable from the Mountain Limestone of Derbyshire. Some specimens brought to England by Captain Beechey were found to contain *Lithostrotion basaltiforme* (*Cyathophyllum basaltiforme*, Phil. G. Y.), *Flustra*, *Productus Martini*, *Dentalium*, several varieties of *Terebratula*, and a great abundance of Encrinital fragments, with the detritus of which the rock was in many places almost entirely made up. To these Dr. Grewingk adds, from the collections of Russian explorers, *Cyathophyllum flexuosum*, Goldf., *Turbinolia mitrata*, His., *Cyathophyllum dianthum*, Goldf., and *Sarcinula*, together with some *Spiriferi*, *Orthidæ*, and *Terebratulæ*.

Remains of Coniferous plants, belonging to the genera *Abies* and *Taxodium*, and of some Ferns, among which is *Neuropteris acutifolia*, have been discovered among the islands along the S. coast of Aliaska.

A specimen of *Catenipora escharoides*, found in a rolled fragment on the island of Sitka, would appear to indicate the existence of Silurian deposits in the neighbourhood; but no organic remains from rocks of this formation *in situ* have hitherto been discovered.

Jurassic Fossils.—Four fossils found in Katmai Bay, on the south coast of the promontory of Aliaska, have been referred by Dr. Grewingk, on the authority of M. Wosnessensky, Curator of the Zoological Museum of the Academy of Sciences of St. Petersburgh, to the Jurassic formation. They include a new species of Ammonite, *A. Wosnessenskii*, *Ammonites biplex*?, Sow., and fragments of *Belemnites paxillosus* and *Unio liassinus*. Myen (Nov. Act. Phys. tom. xvii. pl. 47. figs. 1 & 2) figures an *Ammonites biplex* from some Jurassic deposits at the foot of the volcano of Maipu, in the Andes, S. of Valparaiso, which cannot be distinguished from the specimen from Aliaska. It may be doubted, however, whether upon such scanty evidence the existence of deposits of Jurassic age in these high latitudes can be considered as established; no other indication of the existence of this formation having been hitherto discovered in any part of North America north of the United States.

Tertiary Fossils.—Traces of the Tertiary formation have been discovered at various points between Oregon and Aliaska, but not beyond. This striking and well-marked division of the coast may, therefore, be considered, in the present state of our information, to be the northern limit of the extensive Tertiary formation along the shore of the Pacific. The fossils enumerated by Dr. Grewingk include some well-known species of the Tertiary age in Europe; among which may be mentioned *Cardium Grœnlandicum*, Chemn., *C. multicostatum*, *Venerupis Petitii*, Desh., *Mya arenaria*, *Tellina edentula*, Sow., *Astarte corrugata*, *Mytilus Middendorffi*, and *Ostrea longirostris*, Lamk. Some new species of the same genera are added by Dr. Grewingk, together with some forms of *Saxicava*, *Pectunculus*, *Nucula*, *Pecten*, *Crassatella*, and *Venus*.

Fossils of the Drift.—Organic remains of the Pleistocene or Drift Period appear to be much more numerous on the west than on the east side of the Rocky Mountains. The cliffs and sand-banks, wherever they have been examined along the coast, abound with recent shells of the genera *Cardium*, *Venus*, *Turbo*, *Murex*, *Solen*, *Trochus*, *Mytilus*, *Mya*, and *Tellina*. Fossil remains of *Mammalia*, especially those of the Mammoth, are likewise abundant. Teeth of this animal have been discovered on the banks of several rivers north of Mount St. Elias; and there is a celebrated locality at Escholtz Bay, in Kotzebue Sound, where the thawing and wasting of the frozen cliffs is continually exposing the bones and tusks of Mammoths and other quadrupeds. Dr. Buckland, in his interesting account of the specimens collected at this place during Captain Beechey's Voyage, enumerates fragments of bones of Mammoths and of the *Urus*, the leg-bone of a large Deer, and a cervical vertebra of some unknown animal, different from any that now inhabit Arctic America. Along with these were found also the skull of a Musk-ox and some bones of the Rein-deer, in a more recent condition than the others. Similar remains, including those of the Mammoth, have likewise been discovered, according to Dr. Grewingk, at Cape Nugwuljinuk, at Bristol Bay, and at Norton Sound, as well as in the Pribulon Islands, and lastly at Unalaschka.

The vast profusion of the bones and tusks of the Mammoth in Siberia and the adjacent islands is well known, and it is a somewhat remarkable circumstance that no similar remains have as yet been detected in the corresponding latitudes of America to the east of the Rocky Mountains. None have hitherto been found, according to Sir John Richardson, in the Hudson's Bay Territories, though the annual waste of the banks and the frequent land-slips would have revealed them to the natives or fur-traders had they existed even in small numbers. They are rare also, or altogether wanting, in Canada; but in the Valley of the Mississippi the "bone-licks" are well known as most extensive, and as furnishing the remains of many new species of quadrupeds. In whatever way the circumstance may be accounted for, it seems to confirm the opinion to which most American geologists have arrived, that the countries on the eastern and western sides of the Rocky Mountains have been elevated at different periods and under different geological conditions.

2. *On the* Geology *of* Georgia, United States. By W. Bray, Esq.

[Communicated by the President.]

(Abstract.)

In this communication the author gave a sketch of the distribution of the alluvial, tertiary, cretaceous, palæozoic, and crystalline formations of the State of Georgia, through which he had lately travelled.

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3. *On the* Geology *of* New Zealand; *with Notes on its* Carboniferous Deposits. By Charles Forbes, Esq., Assistant Surgeon, H.M.S. Acheron.

[Communicated by Sir H. De la Beche, F.G.S.]

(Abridged.)

Coast-line of South and Middle Islands.—In a country in most places so difficult of access, and so thickly wooded, as New Zealand, little more can be done than simply to specify the names, and as nearly as possible the relative positions, of the various rocks which present themselves along the sea-coast; for, with the exception of an occasional landslip, there are no other means of arriving at a knowledge of the geological formation of the country. The water-courses are either precipitous torrents, or gentle streams flowing through alluvial deposits; in no case showing a regular and well-defined series of sedimentary rocks. The nearest approach to such a section was found at the foot of Mount Grey in Port Cooper Plains; it will be alluded to hereafter.

The rocks which appear to be the fundamental rocks of the Middle Island, are—granite, gneiss, mica-slate, clayslate, and other metamorphic schists, with rocks of igneous origin, including basalt, amygdaloid, porphyritic lavas, volcanic tuffs, obsidian, serpentine, and greenstone (jade). Associated with these on the sea-coast are carboniferous deposits, made up of limestones (generally fossiliferous), sandstones, grits, shales, and seams of lignitic and imperfectly formed coal, covered in most places by a remarkable deposit of gravel, composed of water-worn pebbles, which are chiefly, and in some places entirely, of white quartz. This deposit in many places is several hundred feet in thickness. It is found in Massacre and Blind Bays, at the Wairoa Plain, and again covering the plains from Port Cooper district to below Otago. The quartz-pebbles not only cover the coal-beds at Massacre Bay, but are imbedded in the coal; as is also the case in the lignite of Otago, which is directly overlaid by this pebble-deposit.

The centre of the Island is occupied by a chain of mountains composed of crystalline and metamorphic rocks. As far as is known, the former show themselves only in the extreme south and south-west. Stewart's Island and Roubouki are composed almost entirely of a dense blue-coloured granitic rock, containing hornblende in the place of mica. The Bluff, a bold promontory on the opposite side of the Straits, is composed of the same rock. In Stewart's Island this rock is penetrated and altered by the intrusion of trap-dykes, of from 1 to 3 feet in width, passing through it, and ramifying as they ascend.

To the northward of the Bluff an extensive plain stretches along the sea-coast in a N.E. direction, and also to the N.W. as far as Jacob's River, where the level country ends. The coast then assumes a high and broken outline, the hills rising to an elevation of from 2000 to 3000 feet. Long tracks of elevated land run parallel with the coast, and have the appearance of horizontal ridges; behind them singular dome-shaped hills arise, as if from inland plains or valleys; in some places the top of the dome is, as it were, cut smooth off, leaving a flat tabular top.

Beyond Windsor Point, and towards West Cape, the coast assumes a different character, consisting of long low spurs of yellow stratified sandstone, stretching seaward. The cliffs are in some places 500 feet high, and at Preservation South Head, North Entrance, the formation is very well seen. The sandstone cliffs at Preservation Harbour very much resemble those in the neighbourhood of Sydney and Newcastle, N.S.W., and contain coal. Rounding the South Head, a broken rocky point appears, which exhibits a good section of the formation, consisting of strata of quartzose grit, fine sandstones, shale, coal*, and a bluish trap-rock with a slaty fracture,—all dipping N.E. at an angle of 45°. The faintest traces, however, of coal are only to be seen here; apparently the thinning-out of the uppermost seams. Proceeding along the beach about 300 yards, after passing over great masses of sandstone, intermixed with water-worn boulders of a coarse flesh-coloured granite, a sandy beach is reached, and there the seams of coal are found running transversely across the sand from low-water mark towards the cliffs of sandstone which form the sea-face of the island, Preservation Island as it is called, on which the coal shows itself. What the thickness of these beds may be, where they are covered and protected by the overlying sand, there are no means of judging; where they show themselves on the beach and sides of the cliffs, they appear to be merely the thinning-out of the beds or a basin-shaped deposit of limited extent, for at the North Head, distant about one mile, they again show themselves in the same way. It is thus seen that as they rise on the cliffs on either side, they become gradually lost in the thinnest veins.

The first vein of any size which occurs on the beach is of a variable thickness, of from 6 to 10 inches. The shales which accompany the coal are of the same average thickness; they are hard and contain vegetable impressions. Above them lies a considerable thickness of grey pepper-coloured sandstone, all overlaid by a coarse quartzose grit, in which are imbedded ironstone nodules, with fragments and thin seams of carbonaceous matter. Between the several seams of coal there is a thickness of about 30 yards of shale and sandstone.

No limestones were found, nor fossiliferous strata of any kind, whereby to determine the age of the deposit.

* For the character of this coal see further on, p. 528.

The mountains which bound the view inland, rising in rugged peaks precipitously from the sea to the height of 3000 feet, and many of them entirely destitute towards their summits of all traces of vegetation, are composed of a coarse flesh-coloured granite, and are part of that series of mountain-ranges which form, no doubt, the axis of elevation of the south-west and western coasts. Resting on their flanks are metamorphic rocks; and a dark blue trap with a slaty fracture forms numerous islands in the harbour, and immediately underlies the coal-deposits.

The sandstones of Preservation Harbour are continued into Chalky Bay, where the white surfaces of the decomposing cliffs appear like the chalky cliffs of the English Channel, and hence the name of the bay. From Chalky Bay to Milford Haven, the formation of the coast is one uniform succession of lofty rugged mountains; peak rising above peak as far as the eye can reach inland. The coast, trending to northward and eastward, is cut up into numerous harbours, running at right angles with the line of coast, which are separated by precipitous ridges of from 2000 to 4000 feet elevation, running in a N.W. to a S.E. direction. These harbours, which are of immense depth, in some places 200 fathoms, vary from half a mile to about two miles in width at the mouth, and penetrate from eight to fifteen or twenty miles into the interior. A transverse ridge, following the line of coast, seems to have existed throughout, for in all, the depth of water is much less at the mouth, and in many of them one or two islands lie across the mouth. The ravines or cracks forming these rift-like harbours are no doubt to be ascribed to an elevating force, the axis of which exists in the south-west point of the Island, inland from Dusky and Chalky Bays. The mountains rise precipitously from the sea, covered with a thick vegetation two-thirds of the way up. Where the timber ceases, a coarse wiry grass succeeds; and immense masses of bare rock form the summits. Where the mountains meet, at the heads of the harbours, the torrents, which constantly flow over their weather-worn faces, have formed a level plain of limited extent, formed by the detritus and boulders washed down from the decomposing rocks. A thick growth of timber and underwood covers these plains, and affords shelter to the Kiwi, the Kakapo, and the Weka. Mountain-torrents, running over immense boulders of granitic and igneous rocks of various kinds, bring down the finer particles and deposit them in the sea, filling up the harbours and affording a limited anchorage.

The rocks that are found in all these harbours are identical, and are granitic rocks of various kinds (containing in some cases large square crystals resembling garnet in colour), gneiss, mica-slate, micaceous schists abounding in garnets, slaty metamorphic rocks, hornblende-rock, which forms the great mass of Breaksea Island, and many rocks of the same character, passing one into the other. At the entrance of the harbours, on each side, are found the slaty metamorphic rocks tilted at a high angle, dipping to the N.W. towards the head of the harbour, and at the head, where the ridges join, these are found to rest on the granitic and other crystalline rocks.

At Milford Haven, the mountains rise bare and precipitous to the height of 6000 feet. Indications of copper have been met with; and here the "ponamoo" of the natives, the jade or nephrite of mineralogists, is found.

To the northward of Milford Haven, the coast-line changes its character, the mountain-ranges trending off to the N.E., leaving in some places, as at Jackson's Bay, a level tract between their base and the sea-coast; and, as we advance still farther to the northward, fine valleys, surrounded by undulating grassy hills, present themselves. Considerable streams are said to run through these valleys, but none are navigable.

Approaching Cape Farewell in the neighbourhood of South Wanganni, we come upon a carboniferous formation, consisting of beds of sandstone and limestone (both fossiliferous), shales, and beds of coal*. This formation occupies the whole of the N.W. extremity of the Island, extending across to Massacre Bay, where the coal crops out on the sea-beach, under a line of cliffs composed of clay and gravel. Beds of shale alternate with the coal; some of the seams of the latter are 4 feet in thickness, dipping to the eastward. Immediately overlying the uppermost seam of coal is a layer of gravel, composed of water-worn pebbles of a beautiful white quartz; and this, as has been already stated, is found overlying all the carboniferous deposits in the island. The fossils found in the limestone and sandstones are apparently of the tertiary period; *Terebratula*, *Ostrea*, *Pecten*, and *Cardium* are amongst the most common.

Quartz-rock occurs in detached masses in the neighbourhood; but the basement rock of the district appears to be granitic, made up of fragments of an older rock, mixed with large crystals of hornblende: this is found extending from Torrent Bay to near Motowaka.

At the head of Blind Bay, the Waimea Plain extends between the ridges of mountains which stretch away to the south-west, and, like all the plains of New Zealand (Middle Island), is formed by an immense deposit of gravel. This consists of water-worn pebbles and boulders of quartz and trap, with some yellow clay; the quartz in some instances is beautifully coloured. A thin covering of loam overlies the gravel, and the soil is generally poor, except in the neighbourhood of the Waimea River, where there is a fertile alluvial deposit. In the neighbourhood of Nelson, a fossiliferous sandstone is found, and seams of lignite and shale occur.

Passing Nelson, along the eastern side of Blind Bay, the slate formation which characterizes the whole south side of Cook's Straits begins,—clay-slates, traps, intruded masses of serpentine, veins of quartz, &c. At Nelson and Greville Bay, an immense boulder-bank, running parallel with the coast-line, crosses each harbour; at Nelson it is some miles in length. It is difficult to account for this, otherwise than by conceiving it to be the remains of a ridge of hills which have been worn down by the action of the weather; and such ridges are actually to be seen running in the same direction along the coast. In all the harbours of the south side of Cook's Straits,

* For the character of this coal see further on, p. 528.

a yellow clay-slate occurs, in some places intersected by veins of quartz. In Port Underwood the slate is blackish-blue, and approaches somewhat to roofing-slate.

From Port Underwood to Cape Campbell, a plain of the same character as the Waimea is found. Towards the limestone country of Cape Campbell, grassy downs are the prevailing features of the country. The limestone which occurs there resembles chalk, contains flints, and is fossiliferous; a large species of *Arca* and another of *Cardium* often occur. The bones of the Moa are often found here. To the southward of Cape Campbell the great range of the Kaikoras mountains approaches the sea; but a narrow belt of the chalky limestone continues to form the sea-coast down nearly to Double Corner, where the limestone is replaced by a calcareous and sometimes sandy shell-rock, and by a tertiary blue clay with shells. The limestone is associated with a white sandstone, and with a lignitic deposit which exists a short distance inland. From Double Corner, the Port Cooper Plains extend to the southward, bounded inland by a range of mountains, thirty to fifty miles distant from the sea-coast. Here again the same gravel formation exists, covered by alluvial deposits in the neighbourhood of the rivers. The plains are much cut up by immense dry water-courses, down which the mountain-torrents must at one time have rushed in great floods. The rocks found in these river-beds are quartz (of different colours), jasper, slates, and granitic and trap rocks.

In ascending the bed of the river Kohai to the foot of Mount Grey, which lies about ten miles inland, and has an elevation of about 3000 feet, the first cliffs which were met are composed of beds of coarse sand, or fine gravel, alternating with argillaceous deposits. At one cliff, about 40 feet high, the gravel, composed of angular fragments of trap-rocks, occurred both above and below a coarse slightly cohesive sandstone; the strata dipping to the S.E. About two miles farther up, the cliffs rose to the height of from 300 to 400 feet, and were composed of a coarse sandy gravel. The pebbles in the bed of the river were now mixed with masses of white sandstone, and of puddingstone or conglomerate, formed by the cementing together of small pebbles by the oxide of iron. Here we found, on the right bank, a stratum of hard blue clay, containing an immense number of marine shells; *Ostrea, Mytilus, Cardium, Turritella, Cerithium, Terebratula, Ancillaria, Voluta,* &c. were in great abundance. The clay-bed was 18 inches thick, lying under a thickness of 20 feet of coarse sandstone, with a dip to the S.E. at an angle of 35°.

Proceeding along the bed of the river, in which were many specimens of silicified wood, we found this shelly deposit occurring both on the right and on the left banks; but, although the shells themselves were identical, there was a remarkable difference in the conditions of their imbedding. The shells on the right bank appear to have been deposited in blue mud, which has now become, from their decomposition, and by the pressure of the overlying masses of sandstone (in some places 400 feet in thickness), a dense hard blue limestone; while on the left bank, the shells are deposited in a sandy mud, lying upon and covered by strata of irregularly worn pebbles of trap. The shells themselves are very friable, powdering away in the hand, but leaving a perfect cast in the matrix. While the cliffs on the right hand rise to a height of 400 feet, nowhere on the left do they exceed 100. These shelly deposits are now ten miles inland, and are at an elevation of 300 feet above the sea-level. The mode in which they have been deposited gives a striking example of many changes in the nature of the sea-bottom succeeding each other, at apparently regular intervals, for each bed has the same average thickness. The shells have been deposited in a blue clay exactly like what at the present day forms the bottom of nearly all the harbours of New Zealand, while the alternating beds containing no shells are made up of an arenaceous clay.

Up towards the foot of Mount Grey, the bed of the stream gradually becomes narrower, and is obstructed by great boulders of a white sandstone, made up of fine particles of white quartz. Mount Grey appears to be composed of an arenaceous rock, much altered by heat, but the specimens obtained were not good, inasmuch as all the rocks which appear at the surface in New Zealand have been repeatedly under the action of fire (from bush fires).

The bed of the River Caratai leaves the S.W. flank of Mount Grey, and we found the cliffs precipitous, averaging from 100 to 300 feet, and composed of imperfectly stratified layers of sand and greenish mud. These beds have a dip to the N.W., and they overlie a seam of lignite, 4 feet thick, dipping in the same direction. The lignite resembles charred wood; in many places it is so perfect, that the bark remains entire; while in others the central portion of the stems has become infiltrated with sand and mud. Over these stratified beds there is a layer of gravel, in some places 100 feet thick, lying unconformably. This gravel forms the substratum throughout the plain. The greater part of the plain must at no very ancient date have been covered by dense forest; isolated patches only, at intervals of from four to eight miles, now remain; successive fires have gradually diminished their limits. Beds of semi-carbonized wood are found in the alluvial deposit at the mouth of the Wai Makredi, the principal stream north of Banks's Peninsula.

Banks's Peninsula is a mass of lofty mountains, consisting of metamorphic slates, traps, basalt, tuff, porphyry (claystone-porphyry with felspar crystals), obsidian, scoriæ, &c. The soil is a yellow arenaceous clay, and in it are imbedded many specimens of the Moa. There is abundant evidence to prove that at a very recent period the peninsula was an island; it is connected to the mainland by a very narrow neck, and this neck is merely a succession of lagoons, very slightly elevated above the sea-level. These lagoons are almost continuous with the great Waihora Lake, which extends round the south-west of the peninsula. Inland, about two miles, there is a chain of sand-hills, having all the appearance of once having formed the sea-shore; and this chain extends in a semicircle from the mouth of the Wai Makredi to the Waihora Lake. These facts immediately in connexion with the peninsula, combined with the shelly deposits already described at the foot of Mount Grey, prove that a considerable elevation of the land has taken place, and that a very slight depression would again convert the peninsula into an island.

From the peninsula to Otago the plains extend almost in an uninterrupted level. Breaking gradually into undulating hills, they terminate in the slaty district of Otago. The coast-line of this district has been examined by Mr. Walter Mantell*.

The rocks found along the harbour of Otago are porphyries, traps of various kinds, hornblende-rock, and yellow clay-schist; the decomposition of the latter rock forms the substratum of the superficial vegetable mould. Inland there is an open country, composed at first of undulating hills, covered with fern and grass, terminating in a series of grassy plains, which, running between lofty hills, present the appearance of having at one time been arms of the sea. On a hill overlooking the first of these plains there is a lignitic deposit, at a considerable elevation, and showing itself on both sides of the hill; it appears to be almost horizontal, and is overlaid by quartz-gravel, pebbles of which are also imbedded in the lignite. This lignite is supposed to have some connexion with the coal found at the Molyneux River, sixty miles to the south; but no opportunity occurred to investigate this point.

Sandstones underlie the lignitic deposit; shales, clay, and quartz-gravel cover it. Twenty miles to the south, slates, traps, and shelly limestones are found. In the immediate neighbourhood a schistose rock is found in detached masses on the hill-side.

A broken undulating country extends from this point to Jacob's River, already alluded to; the rocks entering into its formation have not been examined.

North Island.—The North Island of New Zealand, in its geological formation, differs considerably from the Middle and South Islands. It is the centre of both extinct and active volcanic agency. To the north, in the neighbourhood of Auckland, volcanic hills with perfect craters abound, the face of the country is covered with scoriæ, and evidence of elevation of the land exists.

The Great Barrier and Kau-wow Islands are rich in copper. Metamorphic rocks, trap, and conglomerate are the prevailing rocks. In the centre of the Island, active volcanic action exists; hot lakes and springs are numerous, and earthquakes frequent.

The coast-line of the north side of Cook's Straits is chiefly composed of metamorphic clay-slate, but there are also traps; and at Cape Palliser there are said to be fossils 200 feet above the present sea-level. The tertiary blue clay with shells is also found in this island, and appears to extend from Wanganni to the Waidrop Plain, in a south-east direction; the shells are identical with those of the Middle Island.

The coal found at Waikato is of a very inferior quality, and of much the same character as the Massacre Bay coal. (For particulars of its combustion see further on, p. 529.)

* Quart. Journ. Geol. Soc. vol. vi. p. 319, &c.

Notes on the Coal.—Particulars of the combustion of the different specimens of coal obtained are given below. The mode of combustion adopted was not perhaps the best; but it was the only convenient one on board ship, and it gave the general character of each variety, and comparative results. There is no evidence whatever to lead to the hope that true coal—coal anything like that of the coal-fields of Great Britain—exists in New Zealand. All that has been found partakes of the character of that of the tertiary deposits of Europe and elsewhere. One specimen only has been obtained from the North Island: it has much the same character.

Coal from Preservation Island.

This coal is of a different character from, and apparently of a better description than, any of the other coals found in New Zealand, and presents more the appearance of a true bituminous coal; its colour is black, with a somewhat vitreous lustre; fracture irregular; it soils the fingers, and feels heavy in the hand; in some specimens great quantities of pyrites may be seen, but there is little or no sulphurous odour during its combustion. It inflames readily, and burns with a good, strong, persistent flame: 210 grains, burned in a crucible under the blow-pipe, gave a residue of good cinder weighing 106 grains.

Coal from the Neighbourhood of Motopipi, Massacre Bay.

1. This coal is of a jet-black colour, with a vitreous lustre; laminar in its structure; irregular in its cross fracture; exceedingly hard and difficult to break; some portions of it crepitating when inflamed, and showing distinct evidences of the presence of bituminous matter by caking and throwing out jets of gas, in the same manner as the bituminous coal of Newcastle, N. S. W. When the flame of the blow-pipe is applied, it does not kindle very readily; but, when kindled, it burns with a strong, clear, and persistent flame —a considerable quantity of inflammable gaseous matter being given off. Slight sulphurous odours were perceptible on the first application of the flame, but instantly disappeared. The smoke was without peculiar odour, and of a light yellow colour. The time required to consume 210 grains of this coal under the blow-pipe was very considerable,—much longer than that required for any other specimen of coal as yet obtained in New Zealand, and examined under the same circumstances. During the combustion, a white ash is formed on the surface; and, after all the volatile and inflammable matters have been dissipated, a friable cinder remains, mixed with a black charcoal-looking powder, which continues under the blow-pipe to give a strong, clear, white light, with considerable heat. The residue amounted to 96 grs.

2. The quality of this coal is very inferior; it is light, and of a greyish-black colour externally; fracture somewhat resembling that of Cannel coal, but with a vitreous lustre; it does not soil the fingers. When immersed in water, it crepitates loudly, and crumbles rapidly

to pieces; under the blow-pipe it burns slowly with a feeble yellowish flame, much smoke, and strong sulphurous odour. The flame is not persistent, and the residue is a coarse brownish-black cinder. If the flame of the blow-pipe be continued, the cinder gradually smoulders away, leaving a brownish-white powder mixed with some semi-carbonaceous particles: 210 grains were burned in an earthen crucible, a residue of 12 grains of this powder was the result. The specimen of the Massacre Bay coal, which was tested in this manner, was part of a mass which had been taken two years before, from a depth of 8 feet below the surface, during the whole of which time it had been exposed to the action of salt water and to the atmosphere, conditions which must have had a very detrimental effect upon its quality.

Coal from Waikato, West Coast, Northern Island.

This coal occurs in seams lying in contact, both above and below, with a yellowish argillaceous sandstone. Its colour is a greyish-black; it is somewhat vitreous in the fracture. A piece of trap-rock, taken from a ravine 200 feet below the coal, and some nodules coated with oxide of iron, accompanied the specimens.

On submitting the coal to the flame of the blow-pipe, it burns with a clear yellowish flame, a moderate quantity of volatile matter escaping in the form of smoke; no sulphurous or other peculiar odour is perceptible. The flame is not persistent, the carbonaceous and volatile inflammable matters being quickly consumed or dissipated, leaving a cinder, which, while under the blow-pipe, gives a clear white light, without smoke, forming at the same time a small quantity of white ash.

This coal in its general characters resembles the Massacre Bay coal; but, judging from the results of the combustion of the specimens now under consideration, it appears to be of a better quality, and more fitted for general use, than any we have seen from Massacre Bay. Circumstances, however, having reference to the local position of the respective beds whence the specimens of each have been derived, may in a great measure explain the chief differences observed, namely, more especially the absence in the Waikato coal of any traces of sulphur; its more rapid ignition when brought in contact with flame; when ignited, its burning with less smoke, and with a clearer, stronger, and better flame; and leaving a greater residue of carbonaceous matter. It is much inferior to a specimen of coal from Newcastle, N. S. Wales, which was experimented on. The following are the results of the combustion, under the blow-pipe, of nearly equal weights of each variety of coal alluded to, care having been taken that the conditions of the combustion in each case should be as nearly alike as possible:—

From Massacre Bay	210 grs.	..	residue 12 grs.
,, Waikato	210 ,,	..	,, 32 ,,
,, Newcastle (N. S. W.)	220 ,,	..	,, 126 ,,

Coal from Saddle Hill, Dunedin.

This coal appears to be a variety of lignite or brown coal; its colour is brownish-black, with a faint lustre on the surface; its fracture is earthy, imperfectly conchoidal; it somewhat resembles the Bovey coal of Devonshire. It is found near the top of a saddle-shaped hill, in a horizontal bed, which is exposed to the depth of 10 feet, covered by strata of soft shales about 4 feet thick in all; the whole covered by the yellow clay soil which is almost universal in the district. In the coal-seam water-worn pebbles of quartz of an elongated form have been found. Masses of a schistose rock, of a greyish-fawn colour, are found on the hill side, but there is no sufficient section by which to form an opinion of the nature of the subjacent rocks.

Under the flame of the blow-pipe this coal takes fire readily, burning with a rather feeble yellowish-red flame, and a greyish-coloured smoke, which is soon dissipated, leaving a charcoal-like cinder, which gives a clear reddish-white light, and considerable heat. This cinder gradually disappears under the continued action of the blow-pipe, a small quantity of white ash forming on its surface. A peculiar odour, somewhat sulphurous, at times was perceptible. The residue of 210 grs., thus consumed, resembles a coarse powdery charcoal, and weighs 28 grs., 182 grs. being volatilized in the process.

In the results of the examination of this coal, there is a close approximation to that from Waikato, the differences being as near as can be judged, that in the latter there was a greater quantity of smoke and less heat developed than in the former; the amount of residue may be considered as alike in both, 4 grs. being all the difference between them.

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4. *On the* Geology *of the* Port Nicholson District, New Zealand. By James C. Crawford, Esq.

(Communicated by the President.)

[Abridged.]

In the southern end of the Northern Island, metamorphic or greywacke rocks bound the shores of the harbour of Port Nicholson, and constitute the range, from 500 to perhaps 2500 feet high, running to the N.N.E. from Port Nicholson, and forming abrupt mountains with precipitous and narrow gorges. The stratification is irregular, contorted, and sometimes nearly perpendicular. The rock is frequently siliceous, sometimes argillaceous, and is often traversed by veins of quartz and by igneous rocks. This range is continued also to the S.S.W. in the Middle Island, on the other side of Cook's Straits, and appears to form its central ridge.

Between the greywacke range at Port Nicholson and the western coast are tertiary sands and clays, probably resting on the greywacke rocks. This country is low and level, until reaching Wanganni, 110 miles from Wellington. The level of the country from thence to Taranahi is higher, forming cliffs, in which the strata are distinct and fossil trees are found protruding from them.

On the east also, and abutting against the range, are stratified tertiary beds of sand and clay with lignite in the Wairarapa valley.

Further to the east occurs a fossiliferous limestone, which rises into mountain ranges, bounding the Wairarapa valley, and appears to be also of tertiary date, but older than the former.

The low coast-country of the western coast is bounded on the shore by a strip of sand-dunes, thrown up by the constant N.W. gales, and varying in breadth from one to eight or ten miles. In 1841, the author observed at Manawatu a number of living trees several miles inland, buried halfway up their stems in blown sand. The rivers on this coast all form bars at their mouths, and flood the surrounding country to greater or less extent; and the Ruamahunga River, draining the Wairarapa Valley (east of Port Nicholson), a district about sixty miles in length, is dammed up several times annually by the accumulation of sand and shingle at its mouth in Palliser Bay, from the effect of the violent S.E. gales. From this cause the two lakes into which the river expands near its termination are being silted up by the muddy water of the river. The lower part of the valley of the river Hutt or Haeretonga, comprising about 8000 acres, is entirely alluvial. This river, which flows from the greywacke range into Port Nicholson, is subject to frequent floods, and pours vast quantities of detritus into the harbour.

Presumed rise of the land in recent times.—At the height of about 10 feet above high-water mark, the rocks of Port Nicholson Harbour bear a honeycombed appearance attributable to former sea-action. The site of the greater part of the town of Wellington is a terrace which has evidently been formed by debris brought down by small streams and torrents from the hills, and spread out by the action of the waves which washed the shore. The highest part of the terrace is between 80 and 100 feet above the present high-water mark. In Tasman's Gulf also a progressive rise of the land is apparent; much land being in process of reclamation at Wakapuaka, to the eastward of Nelson.

Fluctuation in the height of the land, observes the author, is to be looked for in New Zealand, for earthquakes are extremely frequent, coming from the direction of Tongariro, the great central volcano of the island, and decreasing in energy as they recede from that point. The author considers that it would be well worth the attention of geologists to watch the level of the land in New Zealand. A tunnel which he cut horizontally from high-water mark to drain Burnham Water in the Peninsula, near Wellington, will form a good mark in that locality.

Sydney, May 1848.

[*Note.*—The geological characters of several localities in New Zealand are noticed in Dieffenbach's 'Travels in New Zealand,' 2 vols. 1843, and Swainson's 'New Zealand,' 1853.—Ed.]

5. *On the* Fossil Cranium *of* Dicynodon tigriceps, Owen, *from* South Africa. By Prof. Owen, F.R.S., F.G.S.

(This communication will be published in full in the 4th Part of the 7th vol. of the Society's "Transactions.")

[Abstract.]

In this paper Professor Owen described in detail the cranial bones of a large species of *Dicynodon** from South Africa. The specimens described were transmitted by A. G. Bain, Esq., to England in 1849, and are now in the British Museum. The skull surpasses in size that of the largest walrus, and resembles that of the lion or tiger in the great development of the occipital and parietal ridges, the strength of the zygomatic arches, and the expanse of the temporal fossæ,—all indicating the possession of the temporal (biting) muscles as largely developed as in the most powerful and ferocious of the carnivorous mammalia. Hence Prof. Owen names this species *Dicynodon tigriceps*. Like the smaller forms of *Dicynodon*, already described by the author, this species has two long, curved, canine tusks in the upper jaw; the jaws being otherwise destitute of teeth.

May 30, 1855.

The Rev. J. Knowles and James M'Cann, Esq., were elected Fellows.

The following communications were read:—

1. *Notice of the Occurrence of a* Tidal Phænomenon *at* Port Lloyd, Bonin Islands. By P. W. Graves, Esq., H.M. Consul-General for the Sandwich Islands.

(Communicated from the Foreign Office, by order of the Earl of Clarendon.)

[Abstract.]

At Port Lloyd, west side of Peel Island (one of the Arzobispo or Bonin Islands, lat. N. 27° 20′, long. E. 141° 45′), on the morning of the 23rd December, 1854, a sudden rise of tide occurred to the height of 15 feet above high-water mark. It then immediately receded, leaving the reefs entirely bare, and Ten Fathom Hole, in which our vessel was anchored, was turned into a complete whirlpool. The tide continued to rise and fall during the night at intervals of fifteen minutes, gradually lessening in force until evening, when it subsided nearly to its usual level. On the evening of the 25th, the waters were again agitated, and rose to the height of 12 feet, and so continued during the night. On the morning of the 26th the tides became regular.

The force of the reflux was such that the "What Cheer" was dragged from her anchorage, and was carried out of Ten Fathom Hole at the rate of 8 miles an hour, just clearing the rocks which lay

* For the description of this genus and the species previously recognized by Prof. Owen, see Trans. Geol. Soc., 2nd Ser., vol. vii. p. 59.

only some fifteen feet on each side of her, and barely escaping destruction.

The houses of the residents were more or less injured, and some entirely swept away.

During the whole time of the occurrence of this phænomenon, the sky was clear, the wind light and the barometer at 29·90. There was no apparent oscillation of the earth.

The islands themselves seem to have undergone great changes in former times, being covered with detached boulders and numerous caverns, some of which are of great extent. There are also evidences of the island having been formerly at a lower level (at least to the extent of 50 feet), from the uniform ridges of coral and shells which I observed at that height. Pumice-stone also abounds, and the residents informed me that some years ago the sea was covered with the evidences of volcanic agency, which they said came in from seaward.

I was also told by the residents that these "bores" occurred at intervals of two or three years, but they have never known the tides during such phænomena to rise over four feet.

Sulphur Island, which is an active volcano, and which lies in lat. N. 24° 48′, long. E. 141° 13′, is supposed by some to be the cause of these disturbances.

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2. *On the Possible* Extension *of the* Coal-Measures *beneath the* South-eastern Part *of* England. By R. Godwin-Austen, Esq., F.R.S., F.G.S.

(The publication of this Paper is deferred.)

[Abstract.]

From the valley of the Ruhr to that of the Scheldt, near Valenciennes, there extend for 170 miles from east to west a continuous series of productive coal-measures, which are placed on the north edge of a mass or ridge of older formations, the principal part of which is known as the Ardennes. From Valenciennes the coal-beds, covered up by later formations, trend to the north-west, by Douay, Bethune, and St. Omer, to Calais, beneath which last-named place the coal-measures have been met with in boring for water.

Along the Ruhr the coal-measures have a visible breadth of at least sixteen miles, and extend far away beneath the cretaceous deposits of Westphalia. From Aix-la-Chapelle to Namur they contract in width, owing to a series of folds which they have undergone from pressure between the ancient ridge and an isolated tract of palæozoic rocks in Central Belgium to the north, which the author described in detail. From Mons, westward, they expand again,—an important consideration with regard to the speculations in this paper.

The author observed that these speculations mainly rested on the correct restoration of the boundaries of land and water areas in palæozoic times; and remarked that it was not until we ascended as high as the Upper Palæozoic deposits that we met with evidences of definite hydrographical areas; and that many terrestrial surfaces of the Carboniferous period have remained such ever since.

Mr. Godwin-Austen pointed out that in palæozoic times there existed a main north and south ridge, traversing what is now Western Europe, and extending from Scandinavia to North Africa. To the westward of this old range there was another tract, also running north and south, even then bounded to the west by the Atlantic valley, and now traceable in the northern and western portions of the British Isles.

From very early times there was an increase of land from the western or Atlantic tract towards the present European area by the successive elevation of the palæozoic sea-beds. This took place along E. and W. lines, one of which became the axis of an elevation which is distinctly traceable through a long series of geological changes.

In bringing forward the evidences of these palæogeographical conditions of Western Europe, and in treating more especially of the E. and W. ridge above alluded to, the author first remarked that he regarded the absence, in France, of the Upper Silurian series as having been caused by an E. and W. barrier, cutting off the communication with the Upper Silurian zoological group of Shropshire and Scandinavia, and constituting a division between two hydrographical areas,—in the northern of which the true Upper Silurian fauna had its development,—and in the other, what the author regards as its southern equivalent, namely the Rhenane and Devonian group; and he showed that there was evidence of this barrier in the shingle-beds of the Lower Silurian both in northern France and in Cornwall, which point to a neighbouring E. and W. coast-line; in the half arch of cleavage of the chlorite schists of the Prawle, proving the existence of an elevated E. and W. range of old rocks, now locally destroyed, and replaced by the English Channel; and in the occurrence of an elevatory axis, ranging east and west along the southern shores of Devonshire, which has been proved from independent reasonings.

In the unconformity of the Old Red Sandstone and the Culm-series of the west of England, one with the other, and both with the Silurian and older rocks, the author observes relations which always exist towards the original limits of formations, and finds clear indications of a neighbouring old coast-line, and of land which has long disappeared. The author refers much of the Old Red series to a lacustrine origin (as suggested by Dr. Fleming and Dr. Mantell), in connexion with the western or Atlantic land-area. It indicates an abundant vegetation on a considerable extent of land-surface of this period; as is also seen in deposits of rather earlier date in the Boulonnais. The conglomerate character of the Old Red series appears not to pass the old east and west ridge. The author, however, does not lay much stress on the relations of the Old Red Sandstone, which he is inclined to regard, not as a separate formation, but as a perhaps contemporaneous equivalent of the Marwood series.

Passing over the disposition of the Mountain Limestone formation, the author proceeds to consider the relation of the Coal-beds to this old east and west ridge. He traces this old ridge of crystalline rocks, whether bare or overlaid by secondary and tertiary deposits, from the valley of the Ruhr, by Aix-la-Chapelle, through the Ardennes and the south of Belgium, by Liège, Namur, and Valenciennes, and accompanied with the palæozoic formations lying on its northern flank; the contour of the old coast-line being more or less clearly evidenced by the lithological conditions of the conglomerates, grits, sandstones, &c., of the littoral or deep-sea deposits. The existence of this ridge to the westward is proved by the chalk axis of elevation through Artois (passing to the north-west at a considerable angle to the eastern part of the ridge), and by the denudation of the Boulonnais and of the Weald of Kent and Sussex; whilst further to the west, at Frome, in Somerset, the identical series exposed in the Boulonnais emerges again, in similar unconformable relations; and Devon and Cornwall, as already stated, supply evidence of the western extremity of this old ridge, which united the two great north and south ranges of land, and formed an extensive gulf-like configuration of this western European area in palæozoic times.

It was along the inner (southern and western) borders of this somewhat semicircular indentation (open apparently to the north) that the great Coal-formation had its origin. In other words, the Rhenish and Belgian coal-beds are the remains of a succession of fringing bands of dense vegetation occupying a continuous tract of coast-line. Regarding these in connexion with the Midland and Northern coal-measures of England, the extensive range of a vast littoral band of swamps and forests becomes defined.

The Carboniferous land must have had some considerable vertical elevations, and a vast expanse of continuous horizontal surface at very slight elevations above the sea-level. The coal, for by far the most part, is the product of a vegetation which grew on the spot on which it is now found. At the æra in question the central gneissic plateau of France was a terrestrial area, with lakes and rivers, and supporting a rich Coal-vegetation, the remains of which are preserved in the original depressions in which they were accumulated. This old land-surface was connected with another in the Spanish peninsula. Towards the Vosges, also, there was an extension of land, and there we find two distinct levels of coal-growth surfaces. The Vosges, the Schwartzwald, and the Odenwald then constituted a continuous tract, and the Saarbruck coal, with its numerous reptiles, was formed under lacustrine conditions.

Crossing the Hundsrück and the Ardennes, we find the great Belgian coal-field to present very different conditions. It takes its part in the sequence of palæozoic rocks, aud is formed of a series of marine sedimentary strata, alternating almost indefinitely with terrestrial surfaces.

With regard to the Boulonnais coal-series, the author referred to his former communication on the subject, which shows that it belongs to the Mountain Limestone series, below the geological horizon of the Franco-Belgian coal. This latter, or true coal-measure series, is not presented in the Boulonnais denudation (which represents a part of the old east and west ridge), but probably underlies the Oolitic rocks in the neighbourhood of the Marquise district.

The author then proceeded to point out the relation of the overlying strata to the old palæozoic east and west ridge, and its accompanying coal-measures; and he showed that the Oolites were evidently affected by the presence of the ridge, and so also were the Cretaceous deposits, especially the Lower Greensand, which puts on decided littoral characters in the south-east of England.

From the foregoing considerations the author deduced the following inferences:—1. That the physical configuration of Western Europe at the Upper or true Coal-measure period indicates the probable continuity of a band of the littoral coal-growth from the midland and south-west parts of England to the south of Belgium. 2. That there may also exist a lower stage of coal-deposits, extending somewhat west of the Boulonnais, and of equal value. 3. That the influence of the old axis of flexure on the distribution of the Oolitic and Cretaceous groups favours the presumption that there are no very thick series of overlying strata interposed between the Coal-measure series and the present surface. 4. The Upper Coal-measures may be regarded as occupying a line on the north of the Weald denudation, or conforming generally to the direction of the valley of the Thames; whilst the lower series may occur on a line coincident with the northern chalk-escarpment of that denudation.

June 13, 1855.

Dr. G. D. Gibb was elected a Fellow; Dr. C. F. Naumann, of Leipsic, was elected a Foreign Member.

The following communications were read:—

1. *On the Occurrence of numerous Fragments of* FIR-WOOD *in the Islands of the* ARCTIC ARCHIPELAGO; *with Remarks on the* ROCK-SPECIMENS *brought from that Region.* By Sir RODERICK IMPEY MURCHISON, D.C.L., F.R.S., V.P.G.S., Director-General of the Geological Survey.

ON the present occasion I cannot attempt to offer any general, still less any detailed description of the rocks and fossils of the north-western portion of that great Arctic Archipelago whose shores were first explored by Parry and Sabine. The specimens they brought home from Melville Island, and which were described by Mr. König, first conveyed to us the general knowledge of the existence there of fossiliferous limestones and other rocks analogous to known European types in Scandinavia. Since those early days, the voyages of Franklin, and of the various gallant officers who have been in search of our lamented friend, have amplified those views, and have shown us that over nearly the whole of the Arctic Archipelago these vast islands possess a structure similar to that of North America. We shall soon, I believe, be made acquainted with the characters of the specimens collected by the expedition under Sir Edward Belcher, who is preparing a description of the natural-history products of his survey.

My chief object now is to call attention to the remarkable fact of the occurrence of considerable quantities of wood, capable of being used for fuel or other purposes, which exist in the interior, and on the high grounds of large islands in latitudes where the dwarf willow is now the only living shrub.

Before I allude to this phænomenon, as brought to my notice by Capt. M'Clure and Lieut. Pim, I would, however, briefly advert to a few rock-specimens collected by the latter officer in Beechey Island*, Bathurst Land, Eglinton Island, Melville Island, Prince Patrick's Island, and Banks's Land, where he joined Capt. M'Clure,—specimens which we ought to value highly, seeing that they were saved from loss under very trying circumstances.

From this collection, as well as from other sources to which I have had access, as derived from the voyages of Parry, Franklin, Back, Penny, Inglefield, and the recent work of Dr. P. Sutherland, I am led to believe that the oldest fossiliferous rock of the Arctic region is the Upper Silurian, viz. a limestone identical in composition and organic contents with the well-known rocks of Wenlock, Dudley, and Gothland.

No clear evidence has been afforded as to the existence of Devonian rocks, though we have heard of red and brownish sandstone, as observed in very many localities by various explorers, and which possibly may belong to that formation. Thus, in North Somerset, to the south of Barrow Straits, red sandstone is associated with the older limestones. Byam Martin Island was described by Parry as essentially composed of sandstone, with some granitic and felspathic rocks; and, whilst the north-eastern face of Banks's Land is sandstone, its north-western cliffs consist (as made known by Capt. M'Clure) of limestone. But whilst in the fossils we have keys to the age of the Silurian rocks, we have as yet no adequate grounds whereon to form a rational conjecture as to the presence of the Old Red Sandstone, or Devonian group.

True Carboniferous *Producti* and *Spiriferi* have been brought home by Sir E. Belcher from Albert Land, north of Wellington Channel; and hence we may affirm positively, that the true Carboniferous rocks are also present. Here and there bituminous schist and coal are met with; the existence of the latter being marked at several points on the general chart published by the Admiralty. With the palæozoic rocks are associated others of igneous origin and of crystalline and metamorphosed character. Thus, from Eglinton Island to the south of Prince Patrick's Island, first defined by the survey of Capt. Kellett and his officers, we see concretions of greenstone, associated with siliceous or quartzose rocks and coarse ferruginous grits; and in Princess Royal Island, besides the characteristic Silurian limestones, there are black basalts and red jaspers, as well as red rocks, less altered by heat, but showing a passage into jasper.

* The reader is referred to the Geological Sketch-Map, Pl. XIV. (*vide supra*, p. 497), illustrating Mr. Isbister's paper on the Geology of the Northernmost parts of America, for a general view of the distribution of the crystalline rocks, Silurian limestones, and coal-bearing deposits of the Arctic lands.

Highly crystalline gypsum was also procured by Lieut. Pim from the north-western shores of Melville Island. In the collection before us we see silicified stems of plants, which Lieut. Pim gathered on various points between Wellington Channel on the east and Banks's Land on the west. Similar silicified plants were also brought home by Capt. M'Clure from Banks's Land; and, through the kindness of Mr. Barrow, to whom they were presented, they are now exhibited, together with a collection made by Capt. Kellett, which he sent to Dr. J. E. Gray of the British Museum, who has obligingly lent them for comparison.

I had requested Dr. Hooker to examine all those specimens which passed through my hands, and I learn from him that he will prepare a description of them, as well as of a great number from the same region, which had been sent to his father, Sir W. Hooker, associated, like those now under consideration, with fragments of recent wood.

Of Secondary formations no other evidence has been met with except some fossil bones of Saurians, brought home by Sir E. Belcher, from the smaller islands north of Wellington Channel; and of these fossils Sir Edward will give a description. Of the old Tertiary rocks, as characterized by their organic remains, no distinct traces have, as far as I am aware, been discovered; and hence we may infer that the ancient submarine sediments, having been elevated, remained during a very long period beyond the influence of depositary action.

Let us now see how the other facts, brought to our notice by the gallant Arctic explorers who have recently returned to our country, bear upon the relations of land and water in this Arctic region during the quasi-modern period, when the present species of trees were in existence.

Capt. M'Clure states that in Banks's Land, in latitude 74° 48′, and thence extending along a range of hills varying from 350 to 500 feet above the sea, and from half a mile to upwards inland, he found great quantities of wood, some of which was rotten and decomposed, but much of it sufficiently fresh to be cut up and used as fuel. Whenever this wood was in a well-preserved state, it was either detected in gullies or ravines, or had probably been recently exhumed from the frozen soil or ice. In such cases, and particularly on the northern faces of the slopes where the sun never acts, wood might be preserved any length of time, inasmuch as Capt. M'Clure tells me he has eaten beef, which, though hung up in his cold larder for two years, was perfectly untainted.

The most remarkable of these specimens of well-preserved recent wood is the segment of a tree, which, by Capt. M'Clure's orders, was sawn from a trunk sticking out of a ravine, and which is now exhibited*. It measures 3 feet 6 inches in circumference. Still more interesting is the cone of one of these fir-trees which he brought home, and which apparently belongs to an *Abies* resembling *A. alba*, a plant still living within the Arctic circle. One of Lieut. Pim's

* Through the kindness of Mr. John Barrow, to whom it had been given, this wood, with some silicified stems, has been presented to the Museum of Practical Geology.

specimens of wood from Prince Patrick's Island is of the same character as that just mentioned, and in its microscopical characters much resembles *Pinus strobus*, the American Pine, according to Prof. Quekett, who refers another specimen, brought from Hecla and Griper Bay, to the Larch.

In like manner Lieut. Pim detected similar fragments of wood two degrees further to the north, in Prince Patrick's Land, and also in ravines of the interior of that island, where, as he informed me, a fragment was found, like the tree described by M'Clure, sticking out of the soil on the side of a gully.

We learn, indeed, from Parry's 'Voyage,' that portions of a large fir-tree were found at some distance from the south shore of Melville Island, at about 30 feet above high-water mark, in latitude 74° 59′ and longitude 106°*. According to the testimony of Capt. M'Clure and Lieut. Pim, all the timber they saw resembled the present drift-wood so well known to Arctic explorers, being irregularly distributed, and in a fragmentary condition, as if it had been broken up and floated to its present positions by water. If such were the method by which the timber was distributed, geologists can readily account for its present position in the interior of the Arctic Islands. They infer that at the period of such distribution large portions of these tracts were beneath the waters, and that the trees and cones were drifted from the nearest lands on which they grew. A subsequent elevation, by which these islands assumed their present configuration, would really be in perfect harmony with those great changes of relative level which we know to have occurred in the British Isles, Germany, Scandinavia, and Russia since the great glacial period. The transportation of immense quantities of timber towards the North Pole, and its deposit on submarine rocks, is by no means so remarkable a phænomenon as the wide distribution of erratic blocks during the glacial epoch over Northern Germany, Central Russia, and large portions of our island when under water, followed by the rise of these vast masses into land. If we adopt this explanation, and look to the extreme cold of the Arctic region in the comparatively modern period during which this wood has been drifted or preserved, we can have no difficulty in accounting for the different states in which the timber is found. Those portions of it which happen to have been exposed to the alternations of frost and thaw, and the influence of the sun, have necessarily become rotten; whilst all those fragments which remained enclosed in frozen mud or ice which have never been melted would, when brought to light by the opening of ravines or other accidental causes, present just as fresh an appearance as the specimens now exhibited.

The only circumstance within my knowledge which militates against this view is one communicated to me by Capt. Sir Edward Belcher,

* "Serjeant Martin of the Artillery and Capt. Sabine's servant brought down to the beach several pieces of a large fir-tree, which they found nearly buried in the sand at the distance of 300 or 400 yards from the present high-water mark, and not less than 30 feet above the level of the sea."—Parry's Voyage for the Discovery of the North-West Passage, p. 68.

who, in lat. 75° 30′, long. 92° 15′, observed on the east side of Wellington Channel the trunk of a fir-tree standing vertically, and which, being cleared of the surrounding earth, &c., was found to extend its roots into what he supposed to be the soil.

If from this observation we should be led to imagine that all the innumerable fragments of timber found in these polar latitudes belonged to trees that grew upon the spot, and on the ground over which they are now distributed, we should be driven to adopt the anomalous hypothesis, that, notwithstanding physical relations of land and water similar to those which now prevail (*i. e.* of great masses of land high above the sea), trees of large size grew on such *terra firma* within a few degrees of the North Pole !—a supposition which I consider to be wholly incompatible with the data in our possession, and at variance with the laws of isothermal lines.

If, however, we adopt the theory of a former submarine drift*, followed by a subsequent elevation of the sea-bottom, as easily accounting for all the phænomena, we may explain the curious case brought to our notice by Sir Edward Belcher, by supposing that the tree he uncovered had been floated away with its roots downwards, accompanied by attached and entangled mud and stones, and lodged in a bay, like certain "snags" of the great American rivers. Under this view, the case referred to must be considered as a mere exception, whilst the general inference we naturally draw is, that the vast quantities of broken recent timber, as observed by numerous Arctic explorers, were drifted to their present position when the islands of the Arctic Archipelago were submerged. This inference is indeed supported by the unanswerable evidence of the submarine associates of the timber; for, from the summit of Coxcomb Range in Banks's Land, and at a height of 500 feet above the sea, Capt. M'Clure brought home a fine large specimen of *Cyprina Islandica*, which is undistinguishable from the species so common in the glacial drift of the Clyde†; whilst Capt. Sir E. Belcher found the remains of whales on lands of considerable altitude in lat. 78° north.

Reasoning from such facts, all geologists are agreed in considering the shingle, mud, gravel, and beaches in which animals of the Arctic region are imbedded in many parts of Northern Europe, as decisive proofs of a period when a glacial sea covered large portions of such lands; and the only distinction between such deposits in Britain and those which were formed in the Arctic Circle, is, that the wood which was transported to the latter has been preserved in its ligneous state for thousands of years, through the excessive cold of the region.

* Dr. Hooker informs me that all the specimens sent to him were collected in mounds of silt, rising up from the level of the sea to 100 feet or more above it; and he entirely coincides with me in the belief that the whole of this timber was drifted to the spots where it now lies.

† In Parry's 'Voyages' (page 61) we learn that a number of marine shells, of the *Venus* tribe, were found imbedded in the ravines of Byam Martin's Island; a fact which strengthens the view here adopted of the submergence of large portions of these tracts at a very recent geological epoch.

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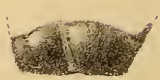

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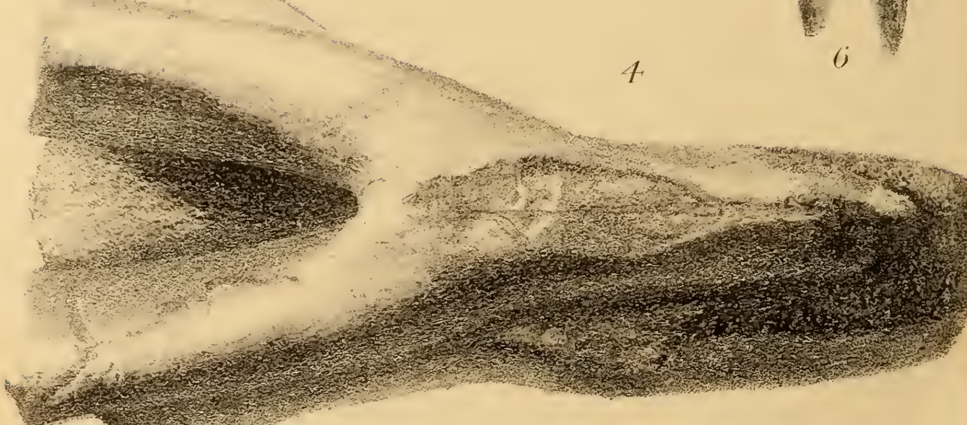
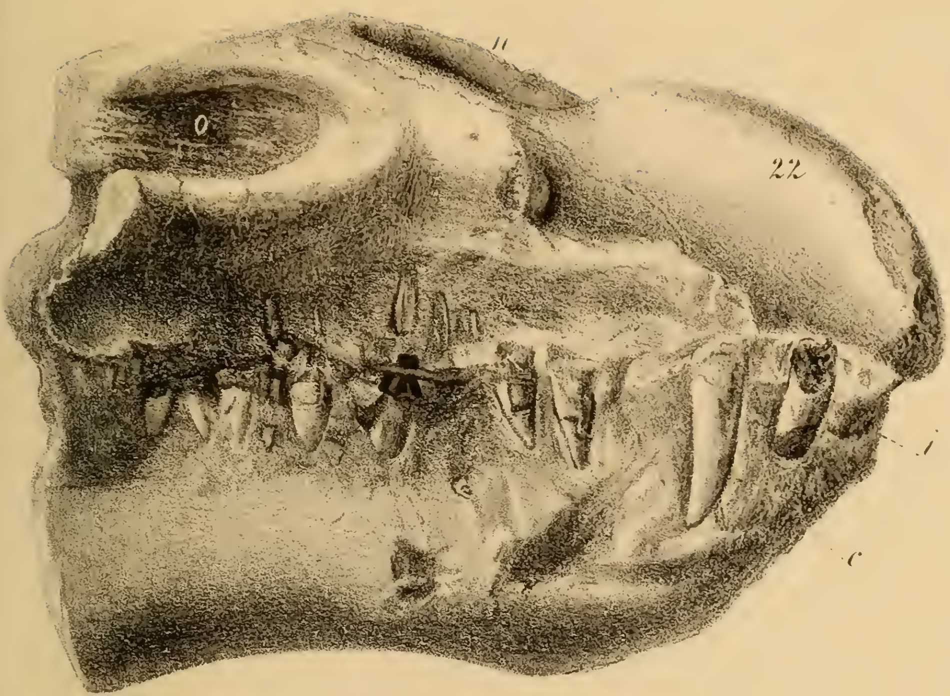


Prorastomus

2



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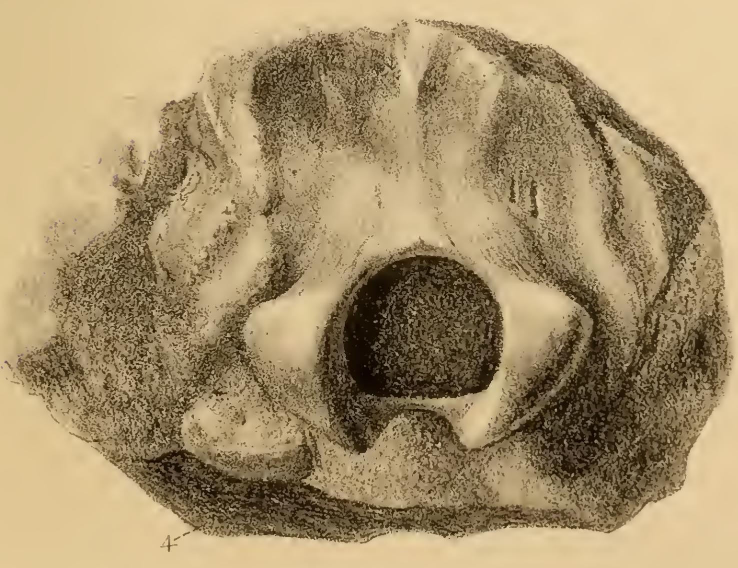

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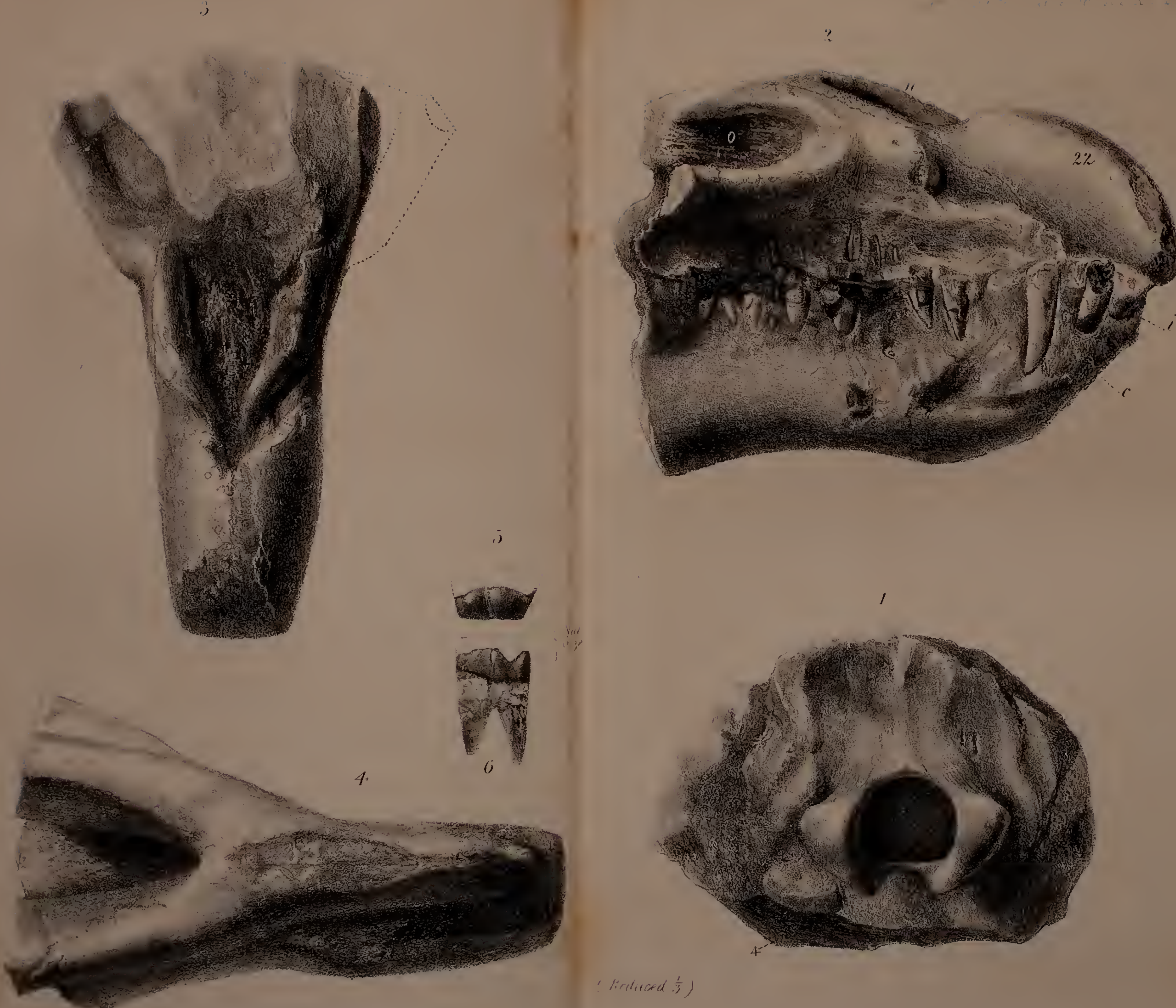

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Prorastomus sirenoïdes _ Owen

P.S.—Since the above was written, Capt. Collinson transmitted to me an instructive collection of rock-specimens, collected during his survey. Most of them show the great prevalence of crystalline rocks along the north coast of America.

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2. *On the* Remains *of* Dicynodon tigriceps, Owen, *from* South Africa. By Professor Owen, F.R.S., F.G.S.

(This paper will be published in full in the 4th part of the 7th vol. of the "Transactions.")

[Abstract.]

In this communication the author described certain vertebræ, the sacrum, the pectoral and pelvic arches, and one of the long bones of the extremities, of a large-sized *Dicynodon*, probably referable to the species *D. tigriceps*, the cranium of which Prof. Owen described in a previous paper. (See above, p. 532.)

These fossils form part of the extensive collection of Saurian remains collected and forwarded to England some years since by A. G. Bain, Esq.

From the indications afforded by the above-mentioned bones of the trunk and limbs, the author concluded that, although the *Dicynodon* was amphibious, and could doubtlessly swim well, it possessed limbs capable of active movements on land, and probably adapted to other uses.

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3. *On the* Fossil Skull *of a* Mammal (Prorastomus sirenoïdes, Owen), *from the* Island *of* Jamaica. By Professor Owen, F.R.S., F.G.S.

[Plate XV.]

The subject of the present notice was submitted to me by Henry H. Shirley, Esq.: it was found in Jamaica in a river-course which is composed of red conglomerate and sandstone, overlaid by limestone, differing from the general tertiary carious limestone of the Island and beneath it: the locality is near "Freeman's Hall Estate, between the Parishes of St. Elizabeth and Trelawney, at that central high ground or ridge which forms, as it were, the back-bone of the Island." (MS. note sent with the specimen.)

The fossil was imbedded in a nodule of hard calcareous shelly rock, which had been broken in pieces: three of the largest of these contain portions of a skull, which, on being partially cleared of the matrix, exhibited the following characters:—

An occipital portion with two condyles, and a tolerably capacious brain-case, showing its mammalian nature (Pl. XV. fig. 1); and a facial portion, figs. 2 & 3, with the fore part of the lower jaw, fig. 4, indicative of an affinity to the Manatee, but with well-marked characters distinctive from any known existing member of the Order *Sirenia*.

The foramen magnum is subcircular, a little wider across than vertically; measuring 1 inch across. The condyles are 4 lines apart at their lower ends, with the articular surface divided into two triangular facets, meeting at rather more than a right angle, along an oblique ridge, where the surfaces are continuous. In *Manatus* the occipital foramen is broader across, and the condyles are more uniformly convex, and are separated from each other by a broader basioccipital, which contributes a portion to the lower end of each condyle. The occipital surface of the fossil cranium is less bent from below upwards and forwards than in the *Sirenia*; it has not the median vertical longitudinal ridge which is seen in *Manatus*; and the superoccipital ridge appears, from the small portion preserved, to have been reflected back, so as to overhang the occipital wall, more than in any recent Manatee.

The exposed facial part of the skull includes a great part of the right orbit (fig. 2, *o*), the external nostril (*n*), the premaxillaries (22, wanting their anterior ends), and the corresponding parts of the rami, with the symphysis of the lower jaw.

The orbit is round, $1\frac{1}{2}$ inch in diameter, with the lower border continued outwards, not so far as in the Manatee, but further than in the Tapir, or in other land mammals of the same size as the fossil. The back part of the orbit is broken way, and the upper and fore parts are mutilated. I perceive no trace of lacrymal pit or foramen at or near the inner border of the orbit.

Part of the frontal bone and the nasal bones are broken away; but the anterior boundary of the nasal opening is entire: the plane of the opening is almost horizontal: the sides converge and terminate in a point, 2 inches in advance of the fore part of the orbit. I cannot satisfactorily determine the sutures of the premaxillaries; but appearances are most in favour of their extending backwards along the sides of the nostril to the orbit: in front of the nostril the premaxillaries unite to form a massive convex muzzle, which curves gently forwards and downwards, $2\frac{1}{2}$ inches in advance of the nostril; and perhaps a little more when entire.

The round orbit, turned upwards by the produced floor, the almost horizontal nostril, and massive premaxillaries are the chief features of resemblance which this skull presents to that of the *Sirenia*, and more especially of the Manatees; and the same resemblance is kept up by the long, compressed, and produced symphysis menti, fig. 4. The rami of the lower jaw are thick and rounded below; they meet at a very acute angle. The mental foramina are large, and the emerging canal deeply grooves the bone in advance of it, as in the Manatee; but the symphysis becomes more compressed than in any Manatee, forming almost a ridge at its anterior half, where it slopes from the alveolar border backwards at a very open angle with the horizontal rami, resembling the prow of a wherry (whence the generic name here proposed for the fossil *). The bone, wherever fractured, shows the dense compact structure of that of the Manatee. The most essential distinction from the Manatee is the presence of, at least, two functional

* *Prorastomus*, from Gr. *πρώρα*, a boat's prow, and *στόμα*, a mouth.

teeth, apparently an incisor, fig. 2, *i*, and a canine, *c*, in the symphysial part of the jaw. These are represented only by their fangs, which are simple and deeply implanted in the jaw; the canine vertically, the outer incisor more inclined forward: ten lines behind the canine there is a premolar implanted by two slightly diverging fangs, but with the crown also broken off, as is the case with most of the teeth in this fossil skull.

The outer side of the crown of a premolar of the left side, upper jaw, is preserved (fig. 5): it is invested by dark-brown enamel: it presents two slight prominences with a faint median longitudinal channel. The outer border of the grinding surface is almost straight: that surface is buried in the hard and brittle matrix. In a similar portion of a posterior grinder of the lower jaw, fig. 6, in another fragment of the fossil, the outer border of the crown rises in two angular lobes, somewhat answering to the end of the two transverse ridges of the crown of the tooth of the Manatee, but not accompanied by the indentation on the outside of the crown. Neither the number, kinds, nor precise modification of the crown of the teeth are recognizable in the present fragmentary fossil. It shows, however, sufficient characters to indicate it to be nearly allied, if not actually belonging, to the Sirenoid order of Mammalia, and to differentiate it from any known existing genus or species in that order. I propose to distinguish this species by the name *Prorastomus sirenoïdes*.

The bones are completely petrified, and usually closely adherent to or blended with the matrix.

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4. *Notice of the* EARTHQUAKES *at* BRUSSA*. By D. SANDISON, Esq., H.M. Consul at Brussa.

(Communicated from the Foreign Office, by order of the Earl of Clarendon.)

[Abstract.]

AFTER a lapse of six weeks since the first great shock, with a succession of others quite harmless, and when confidence was beginning to revive, the inhabitants were panic-struck on the evening of the 11th April, at 8 o'clock, by an earthquake incomparably more terrific and destructive than the former.

By its resistless force, computed of about thirty seconds' duration, almost every stone-building left standing was overturned, or irreparably shattered; and masses of rock falling from the Citadel Cliff overwhelmed a number of houses below in the Jewish quarter, where upwards of twenty persons were killed.

The loss of life in the town is variously computed up to 400 victims, chiefly Turks, but may not exceed 150, as most of the crazy and dangerous dwellings had already been overthrown, and the inhabitants had retired for the night to some kind of lodgings of comparative safety.

The earth continued in a state of incessant and most alarming tremor, accompanied with appalling subterraneous sounds, the whole

* See also Quart. Journ. Geol. Soc. vol. vii. p. 19.

night. A fire also broke out, soon after the shock, in the centre of the bazars, which, raging throughout the next day, carried devastation over a vast space covered with shops and houses to the number probably of more than 1000, consuming all the earthquake had left, to the verge of the open plain.

Some quarters of Brussa have suffered less than others, but all severely. Some are levelled with the ground, and the general aspect of the place is that of one continuous wreck.

Several of the villages around have shared in the disastrous visitation. On coming to one named Pepégik, six miles off, in the direct line to Ghio, we had to make a circuit to avoid the ruins, from under which above forty dead bodies had been dragged; and not one house remained entire. Two other Greek villages, to the right and left, a little further off (one the largest and richest in the country), had sustained no injury. Some villages in other directions were completely destroyed by the shock of the 11th.

It was ascertained by the authorities that it had caused no damage around the Lake of Apollonia, where the earthquake of the 28th February had produced such fatal effects; and Ghio, twenty-one miles to the north-east from Brussa, has stood intact throughout.

This leads to the conclusion, that the last commotion was directly under Brussa and the country within a radius of about two leagues from that centre.

New streams of boiling water have burst out from the ground at the sites of the hot mineral baths, whilst the former currents there have been greatly increased in volume.

The shocks continued up to the 21st, but were innocuous, and sometimes slightly felt here (Perá).

Perá, April 23, 1855.

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5. *On the* Section *of the* Metamorphic *and* Devonian Strata *at the* Eastern Extremity *of the* Grampians.

By James Nicol, F.R.S.E, F.G.S., Professor of Civil and Natural History, Marischal College, Aberdeen.

One of the most instructive sections of the crystalline rocks composing the Grampian Mountains is seen at the termination of that chain on the coast of Kincardineshire, between Stonehaven and Aberdeen. Having found this section to differ in some important points from the structure usually ascribed to these mountains, I now offer a short account of it to the Society. The section at p. 547 is only intended to illustrate the general position of the strata without entering into minute details.

Commencing with the southern portion of the section, the first rock is the Old Red Sandstone (*a*) forming part of the great formation which underlies the Scottish coal-field. It is well seen on the coast in this district, where it is quarried near Stonehaven. This rock is often described as evidently made up of the detritus of the mountains on the north, but its mineral characters in this place hardly bear out the statement.

The finer beds are of a dark brownish-red colour, and consist essentially of grains of quartz imbedded in a copious basis of red-coloured, earthy, and decomposed felspar. A few scales of mica appear, but this mineral is by no means abundant. In these fine-grained sandstones large boulders occasionally occur, and in some beds form almost the entire rock, which is then a true conglomerate of well-rounded boulders, from one or two inches to as many feet or even more in diameter. I collected indiscriminately numerous specimens of these boulders, both at Stonehaven, and also at Caterline Harbour, about four miles further south. Taken generally, the same kinds of rocks occurred at both localities, though in varying proportions. Thus at Stonehaven boulders of compact quartz or hardened sandstone, in some specimens with distinct rounded grains, were very abundant; at Caterline these formed a smaller, though still a large, portion of the specimens. Brown quartzose felspar-porphyries were next in number at Stonehaven; and at Caterline even more numerous than the quartz-rocks. Trap-rocks, like many still common in Scotland, ranked next at Stonehaven, but were fewer at Caterline. At the latter several rocks occurred that might be designated granite, but only one specimen was the regular compound of quartz, felspar, and mica. In all the others mica was wanting; and at Stonehaven I procured no rock to which the name of granite could properly be given. At neither did I find any specimen of gneiss or mica-slate, though these rocks form the principal part of the mountains on the north, along the base of which these conglomerates now extend for miles, and from detritus of which they are said to have been formed.

This very curious fact, of the coarse conglomerates consisting chiefly of rocks different from those on which they rest, is often seen in various parts of Scotland. Taken in connexion with the position of the strata, and with the remarkable break in the succession of the fossiliferous deposits below the Devonian, it leads to some interesting speculations to which I may afterwards advert.

Another remarkable peculiarity of these boulders was noticed in a paper in the first volume of the Journal of the Society (p. 147) by Sir W. C. Trevelyan. These rounded water-worn stones, often several inches, or even above a foot, in diameter, have, subsequently to their being imbedded in the conglomerate rock, been broken into numerous fragments, and again cemented together. They often appear as if crushed by some heavy body, which has pushed the splinters slightly out of place. The sharp angular form of the pieces proves that these boulders were not soft when they were thus acted on. They appear, however, to have been afterwards reunited by heat. Other boulders, which have their surface indented, as it were, by the pressure of a harder neighbour, must have been in a softened condition when this took place.

In the plains of Kincardineshire, a few miles from the boundary-line of the primary strata, the red sandstone is nearly horizontal, or, as at Crawtown on the coast, even dips with a slight inclination to the north. At Stonehaven, as shown in the section, the beds are almost vertical, dipping at 75° to 85° to S. 18° W. by compass (variation 27° W.). North of Stonehaven a vein of light reddish-brown felspar-porphyry, with large macled crystals of orthoclase and grains of quartz, intersects the beds. It is about 30 feet wide, and runs N. and S. nearly in the dip of the strata. Beyond this dyke the red sandstone continues dipping almost at the same angle, but with more of a westerly direction. Soon after, a mass of claystone-tufa (*t*), of a grey or reddish-brown colour, but much weathered and decomposed, appears in the cliffs. Immediately beyond this mass, the primary clayslate (*b*) of the Grampians is seen dipping at 35° to N. 18° W., and thus in the opposite direction to the red sandstone. The actual junction of the stratified rocks is not seen, as the trap-rock occurs in the interval, having apparently burst up through a fault along the line of junction.

Further north the inclination of the clayslate becomes higher, but the dip is still to the same point, and continues northerly in its whole range along the coast. The clayslate is fine-grained, of a light greenish-grey colour, with a kind of fibrous laminar structure, formed, as it were, by the interlacing of minute acicular green crystals with grains of a whitish colour. Further north it passes into a hardened sandstone or greywacke, composed of grains of quartz, agglutinated in a sparing basis of a reddish or greyish colour. This rock is in layers of about half an inch thick, somewhat undulated, and closely intersected by cross fractures. At Carron Point a great dyke, 40 feet wide, of yellow quartz or hornstone (*q*), runs N. and S. through the strata, which dip nearly conformably on both sides. This dyke is well seen in the bay south of the Point, and also in the Point itself. In the rocks near it, beds or veins of magnetite, and in some places also of pyrites, run nearly parallel to the strata.

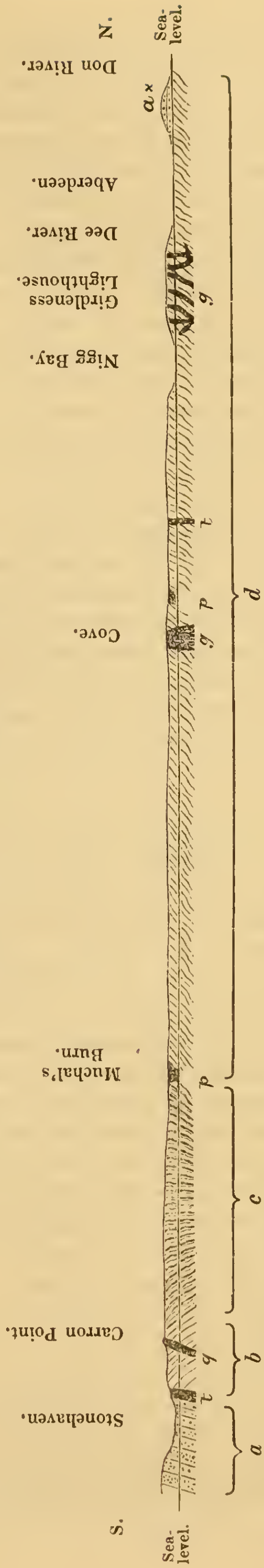
The clayslate continues for about half a mile beyond the Point, when it gives place to mica-slate (*c*). The dip of the beds is still to the north at 45° to 55°, the angle being variable from the constant convolutions of the beds. There is, however, no doubt, that the general dip is to the north, and consequently that the mica-slate overlies the clayslate. The mica-slate, where first seen, is fine-grained, light greenish-grey, and composed of quartz and fine scaly mica or chlorite. In some places it contains a considerable number of small garnets.

Further north the coast becomes so precipitous, with the sea close to the base of the cliffs, that the section cannot be followed continuously. The dip of the strata, however, appears to become more and more nearly vertical, with many convolutions, throwing the beds for short distances sometimes into one position, sometimes into the reverse, so that the same stratum appears in one part of the cliff inclined to the north, in another part to the south. Following the coast northward, it is soon evident that the general inclination of the beds is now to the south, or the reverse of that observed in the clayslate. This southerly inclination, on the whole also at low angles, predominates in the gneiss (*d*) along the coast to Aberdeen, though with many local deviations, such as may be looked for in a highly disturbed and convoluted group of rocks. At Muchal's Burn a bed of red felspar-porphyry (p) is quarried, and a similar bed is seen on the coast near Cove. At this village also a large mass of granite (g) is quarried. As we approach Aberdeen, granite-veins become more and more numerous, until near Girdleness, immediately south of the Dee, they almost form the predominant rock.

The most remarkable points in this section are,—the position of the clayslate and mica-slate, and the relation of the metamorphic strata to the Old Red Sandstone. In regard to the former, the clayslate, usually considered as the newer, and undoubtedly the less altered, rock, appears to dip under the older mica-slate. My impression is, that this is truly the case, and that, in proceeding along the coast, there is an ascending series from the less metamorphic to the more metamorphic rock. But this could not be the original position of the masses; and I can only explain the phænomenon by supposing that a complete inversion of the beds on the southern margin of the chain has taken place. In the north they regain their original position, dipping away from the great granitic axis, or rather foundation, of the country. The change of inclination also seems to be effected in a peculiar manner by the highly convoluted mica-slate and gneiss strata folding up, as it were, on themselves, and thus pushing out the upper and exterior beds, as if by great intruded wedges of rock. It is thus an instance in our own country of the fan-shaped stratification so often noticed in the Alps.

How far this inversion extends along the border of the mountains has not been determined. Near the western termination of the formations, as well seen along the Gare Loch on the Firth of Clyde,

Section of the Coast at the Eastern Extremity of the Grampians, from Stonehaven to Aberdeen.
Length of the Section about 20 miles.



a, a^*. Old Red Sandstone. b. Clayslate. c. Mica-slate. d. Gneiss. t, t. Trap-dykes. q. Quartz-dyke. p, p. Porphyry. g, g. Granite.

the mica-slate and clayslate dip outwards, or south, in regular order. In the centre of the country, in Perthshire, I observed several years ago that the strata in the outer zone of the primary rocks seemed "in some places to have been completely reversed*." This view is confirmed by some sections, by Mr. D. Sharpe, in the eighth volume of the Journal of the Society (p. 127, &c.), in which the clayslate is clearly shown in the same anomalous position. In two of these sections, as at Stonehaven, a mass of trap intervenes between the clayslate and the red sandstone, and in one instance Mr. Sharpe ascribes to this igneous rock the peculiar position of the clay-slate in relation to the mica-slate. Subsequently he seems disposed to assume that "the trap-rock runs along the whole line of the Highland border," in order to explain what he well describes as the perplexing and apparently contradictory position of the slates (p. 130). Though there are strong grounds for admitting the existence of this more or less continuous line of trap, yet it does not seem sufficient to explain the phænomena. These appear to me to be not a mere upturn of the clayslate, abutting against the mica-slate along a line of fault, or changing its dip by a synclinal axis, as in Mr. Sharpe's sections, but a complete inversion of the series, with the newer rock dipping under the older. Such an overturn of an enormous mass of strata implies some far more powerful agent than the small mass of trap seen along the junction, and one situated in another region, or to the north, not to the south, of the inverted beds†.

In reference to the junction of the clayslate and red sandstone, the present boundary-line appears to be the result of a great fault elevating the region to the north. Along this fault the various masses of trap noted have burst out, and dykes of great extent, and approximately parallel, are known in many places in the red sandstone. The small portion of materials which the northern mountains have furnished to the sandstones and conglomerates at their base shows that these mountains could not then have formed a line of coast exposed to the action of the sea. In the south of Scotland where the red sandstone rests horizontally on upturned Silurian strata, which evidently formed dry land at the period, the old line of coast may almost be traced by the rounded boulders or angular fragments of Silurian rocks imbedded in the conglomerates. In this and other parts of the north the conglomerates are not thus connected with the primary strata; and their chief components are derived from other sources. This diversity of origin is strikingly shown by comparing the newer drift deposits covering the extremity of the Grampians, and derived from their detritus, with the sandstones and conglomerates at their base. Both are evidently similar formations, deposited almost in the same place, though at widely distant epochs in the earth's history; but how very distinct are their mineral cha-

* Geology of Scotland, p. 169.

† The change in the mineral nature of the rock along these divisional planes proves that they mark successive strata, and are not, as has been stated, planes of cleavage. Although the foliation of the gneiss and mica-slate is, in general, approximately parallel to the stratification, yet this is not always the case, and these two well-marked and very distinct structures—stratification and foliation—ought not to be confounded.—J. N., Oct. 13, 1855.

racters! The older strata, dark reddish-brown masses, with boulders of quartz, sandstone, felspar-porphyry, and claystone-traps;—the newer deposit, yellowish-grey in colour, and full of rounded fragments of granite, gneiss, mica-slate, and hornblende and serpentine rocks. Evidently the two deposits represent the detritus and destruction of entirely different lands. So diverse is their aspect and imbedded boulders, that we are almost forced to the conclusion that the materials of the red sandstones have been derived, not from the strata on which they rest, and which formed the sea-bed of the period, but from other rocks constituting the shores of that sea and the valleys of the great rivers that flowed into it.

The highly inclined position of the sandstone may be ascribed in part to the action of the trap-rocks seen both in the section and also further south on the coast. Their extent does not, however, seem sufficient to explain the whole amount of the elevation; and I am inclined to think, that, in part, at least, it is owing to the inversion and consequent expansion of the metamorphic strata. The same powerful agency compressing the strata is also needed to explain the singular fractures and indentations of the boulders in the conglomerate. When these effects were produced, the strata now seen on the surface must have been covered up by an enormous thickness of rock (subsequently removed by denudation), and thus subjected to that degree of temperature required to soften such of the boulders as have received an impression from their less fusible neighbours, and to re-cement those that were broken by the pressure.

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6. *Notice of some* Raised Beaches *in* Argyllshire.

By Commander E. J. Bedford, R.N.

(Communicated by Sir R. I. Murchison, V.P.G.S.)

(The publication of this paper is deferred.)

[Abstract.]

Two of these raised beaches are in the Lunga Islands, one of them in Lunga Proper, the other in North Fullah. Their present altitude was calculated to be 40 feet 8 inches above high water mark. A third was found in Kerera Island, and has the same height as the former. These were illustrated by highly finished sketches by the author, which also indicated the position of other raised beaches, in Oronsay at 38 feet 6 inches in elevation, in the south-western angle of Jura at 34 feet 8 inches, and at Loch Tarbert, in Jura, at 42 feet 1 inch, and 105 feet 5 inches.

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7. *On* Sand-worn Granite *near the* Land's-End.

By R. W. Fox, Esq.

(Communicated by Sir R. I. Murchison, V.P.G.S.)

On a recent visit to the Land's-End, I noticed some striking evidences of the influence of drifting sand in wearing away the surfaces of hard granite rocks.

A little to the northward of Land's-End Point is Whitsand Bay, the shore of which is covered with pulverized shells mixed with minute grains of quartz, forming together a sand of dazzling whiteness. The hill which rises behind this bay is clothed with very short herbage, springing from a thick stratum of similar sand; and it is partly intersected by a ravine or glen, increasing in width and depth as it descends rapidly in a W.N.W. direction to the bay or beach; and a little stream runs through the middle of it. The steep sides of the glen, instead of being covered with herbage, consist of fine white shelly and quartzose sand, like that on the beach, and numerous granite rocks appear above the sand, many of them rising only a few inches out of it, with nearly plane surfaces, sloping with the sand. Other masses of granite rise many feet above the sand; but all the rocks are worn, and more or less polished, on those surfaces which are inclined in any degree towards the beach, whereas their opposite sides, facing towards the head of the glen, whether sloping or vertical, are neither polished nor worn. It is evident that the dry sand, driven by the currents of wind rushing up through the glen, has produced these effects; and, moreover, owing to the directing influence of the glen on the wind passing through it, all the granitic surfaces which are more or less inclined towards the beach are striated or furrowed parallel to the direction of the glen,—that is towards the W.N.W., except where the direction of the latter is a little changed, and there that of the furrows is changed with it.

When the wind blew with only a moderate force up through the glen, the surface of the sand was observed to be set in quick motion before it; but the tendency of the sand to slide down the slopes into the stream limited its further accumulation.

The loose stones on the sand, however hard, have their edges rounded off by the drifting sand, just as if they had been long exposed to the action of water in motion, whereas the stones and granite-rocks at and near the head of the glen, and on other parts of the hill, are not polished, furrowed, or rounded like those exposed to the action of the drifting sand.

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8. *Remarks on the* Brown Coal *of the* North *of* Germany. By Professor Beyrich. Communicated, with Observations, by W. J. Hamilton, Esq., Pres. G.S.

Having received from Professor Beyrich a letter, in which reference is made to the Brown Coal of North Germany, and of which the following communication is an extract, I think it right, for the purpose therein mentioned, to lay it before the Society.

"A serious error has crept into your last paper respecting our Brown Coal formations *, occasioned, as it appears, by a not sufficiently clear statement in Plettner's Memoir on the Brown Coal of

* Anniversary Address, 1855, Quart. Journ. Geol. Soc., No. 42. p. lxxix.

Mark Brandenburg. You take such a lively interest in the progress of the knowledge of our North German tertiary formations, and have so successfully laboured at the work yourself, that I would entreat you to correct this error in your Quarterly Journal, in order to prevent its adoption in your English literature, as well as to obviate the propagation of an incorrect view in Germany.

"You state, that in North Germany there are two distinct Brown-coal formations:—1. The oldest, which at Egeln, near Magdeburg, is overlaid by the marine sands parallel with the *Système Tongrien inférieur* of Dumont. 2. A younger formation, which overlies the Septaria-clay. Now, it must be observed, that neither Plettner nor myself, nor any other German geologist, have ever stated that the Septaria-clay was under the Brown Coal (viz. that of Mark Brandenburg). You will at once be convinced of this, if you refer to the Journal of the German Geological Society, vol. iv. p. 453, and look at the general view of the order of stratification which Plettner has given as the result of his observations. The superposition of the Septaria-clay over the Brown Coal was first clearly established by borings in the neighbourhood of Sörzig near Köthen, of which I published an account in my Appendix to 'Our knowledge of the Tertiary formation in Mark Brandenburg,' in Karsten's Archives for 1847. In no spot east of the Elbe has any marine, or indeed conchiferous tertiary deposit been hitherto found either above or below the Brown-coal deposits; so that we are by no means justified in assuming in North-Eastern Germany the existence of two distinct Brown-coal formations, of such different periods as would be the case, if our Brown Coal overlaid the Septaria-clay. For the present we must believe that all the Brown Coals of North-Eastern Germany are older than the oldest North German marine tertiary deposits."—[E. B.]

This correction of Professor Beyrich's is a very important one. On referring to Plettner's above-mentioned memoir, I find that he has there stated that the Septaria-clay is the youngest (jüngste) formation in the Brown-coal fields of Mark Brandenburg, instead of underlying the Brown Coal, as I had originally read the passage, not having had an opportunity of visiting the country myself. The consequences of this alteration in the order of stratification are most important. There is a break in North-Eastern Germany and especially in Upper Silesia in that connected system of superposition of strata which I had believed to exist from the Westeregeln beds upwards to those of the Vienna basin; and I am bound to admit, that the possibility of the Marine tertiaries of Weinheim, Egeln, and Hesse Cassel being Upper Eocene, rather than Lower Miocene, is hereby considerably increased. We have still to look for that continued sequence of deposit which would, in my opinion, have proved the connexion of the tertiaries of North Germany with the younger deposits of the Vienna basin. The exertions of so many able geologists who are now engaged in the investigation of these tertiary beds, will, I trust, soon lead to a satisfactory conclusion. In the meanwhile I have been unwilling to withhold from the Society the possible modification of the views I endeavoured to maintain, or the correction of an error into which I may have unintentionally led them.—[W. J. H.]

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9. *On the Origin and Formation of the* RED SOIL *of* SOUTHERN INDIA. By Dr. W. GILCHRIST, Surgeon H.E.I.C. Madras Presidency.

(Communicated by Sir R. I. Murchison, V.P.G.S.)

VARIOUS opinions have been entertained regarding the nature and origin of the "Red Soil," which constitutes the surface-formation of several extensive tracts of India*; and believing the subject to be one on which geologists wish for further and more exact information, I steadily kept it before my mind during the prosecution of a public duty entrusted to me, of opening up a line of road through one of these Red-Soil tracts; and the opportunities thus offered, by sections, &c., have afforded me some interesting facts respecting the character of the Red Soil, its origin, and the probable mode of its deposition.

The characters of the Red Soil.—The Red Soil of Southern India is very variable as to thickness. It varies, according to my observations, from 25 feet to a few inches. Of the thickness of about a foot, I have traced it constituting the surface-soil over a tract of several square miles, the bed-rock below the water-worn stones which occur in its lowest portion being granitic gneiss (of which also these stones consist), generally in a friable state, from disintegration.

In regard to mineral composition, the Red Soil in its purest state consists mainly of quartz with peroxide of iron, and a small quantity of carbonate of lime (in consequence of the presence of which, it generally effervesces more or less when a mineral acid is thrown on it); more or less alumina also is contained in it generally. Quartz and peroxide of iron are invariably found as ingredients, and frequently these only are found to constitute the deposit; but hornblende, granite, &c., rounded into gravel, and of various degrees of size, are frequently found as part of the formation. Different localities present different mixtures, as might be expected in a deposit which, previously to final deposition, had been moved to and fro by water.

It may be added, that, agriculturally speaking, the Red Soil is fertile: it is also much used by the natives of India for constructing the walls of their huts, and even in the better sort of native houses it is used instead of mortar (of lime and sand) for plastering the interior. The oxide of iron and quartzose sand exert a mutually binding or hardening power, so that, when completely dry, the mixture is as hard as the native-made bricks, perhaps more so.

I am not prepared to speak as to the relative geological age of the

* [For a notice of the Red Soil of the Nágpur District, see Quart. Journ. Geol. Soc., No. 43. p. 354.—ED.]

Red-Soil formation, and have made repeated search in it for organic remains, but without success.

The Origin of the Red Soil.—The Red Soil of Southern India is derived from the disintegration of the ferruginous hornblendic rocks so abundant and conspicuous in Peninsular India. The portions of these rocks that have resisted the decomposing agents under the influence of which the more easily decomposable parts have given way constitute ridge-like ranges of hills, extending in a direction nearly N.W. and S.E., continuously or in detached hills; but in the latter case, the individual hills have a common compass-direction. These hills, in consequence of their dark colour, contrast strongly with the lighter-coloured adjoining surfaces, above which they do not rise higher than 500 feet, seldom more than 200 or 300 feet. Their declivities are steep and rough, consisting of blocks of rock, of from one to six feet of cubic contents, and of parallelopipedal or spheroidal shape. At the lower part of the declivities, the interstices between these blocks are more or less filled up with reddish soil; but the ridges of the hills consist only of the blocks (the interstices being unoccupied with soil), heaped together in a confused manner.

With the exception of about half an inch or so inwardly from the surface, these blocks consist of dark-blue, confusedly crystalline, tough, hornblendic rock; and this nearly disintegrated crust is of a reddish colour, but of a more yellowish hue than the colour of the red soil.

These hills are unmistakeably of a volcanic origin, and have broken up the previously existing granitic gneiss, with which, in colour, they strikingly contrast, and intersecting the undulatory or hilly surface of which they are frequently seen stretching in straight lines as far as the eye can reach.

In making sections on the lower parts of the declivities of these hills, or cutting into surfaces nearly level with the adjoining ground, in order to make a level line of road, some of the following varieties of lithological structure in these trap-rocks have presented themselves:—

(*a*) A jointed structure; the fragments having a more or less rhomboidal shape (concretionary rhomboids), and frequently in a state of partial disintegration, sometimes quite decomposed; colour red, though not so dark as that of the red soil. Occasionally this structure occurs with the centres of the individual rhomboidal concretions consisting of fresh undecomposed rock, surrounded with decomposed cases more or less thick.

(*b*) Spheroidal masses of concentric structure, more or less decomposed at surface, but with centres of fresh rock, extremely tough, and in size varying from one inch to one or two feet or more in diameter. The interstices between these spheroidal concretions or nuclei vary considerably, from one inch to two feet or more; the interstices occupied with red earth or soil*.

* I find at Rothesay (1854) a trap-rock, on the western side of the dam of Lochfad, exhibiting exactly the appearance of the variety *b*, above described. On

(*c*) The above-mentioned two kinds of nuclei, more or less intermixed, but with smaller interstices, occupied with red earth.

The above varieties of condition of the ferruginous hornblendic rocks sufficiently indicate that they are more or less composed of a paste or matrix, relatively more easily decomposable than the contained concretionary nuclei. This paste, decomposed, has furnished the Red Soil. When *in situ*, it has not the full red hue of that soil, on account of its containing all the insoluble ingredients of the original rock ; amongst these is alumina, the presence of which, from its white colour, diminishes the depth of red due to the peroxide of iron so largely contained in the red soil. The alumina is in a highly pulverulent state, and, in consequence, is longer held in suspension in water than the other ingredients of the rock, and thus is generally separated by being transported to a greater distance than the other materials, when the debris is subjected to the transporting influence of water in motion.

This separation can be easily performed artificially, and the natural operation is to be seen going on in brooks running amongst or over the decomposed rock : the bright red soil is deposited in the less rapid parts of the stream, while the more buoyant alumina is carried further away.

The deposition of the Red Soil.—Very frequently the red soil of Southern India rests on granitic gneiss. That this granitic floor has been the bed of a sea or lake is amply demonstrated by the water-worn stones of granite, quartz, &c. which sections through the red soil down to this granitic floor brought to light. I had often seen these water-worn stones cropping out at the bottom of the nearly perpendicular red-soil banks of brooks, but concluded they were due to the action of the water of those brooks ; but, when excavating through red soil at distances from water-courses, I found that, on reaching the granitic bed, it was rare that between it and the red soil a layer of water-worn stones was not found : observations made over a considerable tract of country, and miles apart, fully proved that even the present elevated table-land of the Mysore, Southern India, has been at one time under water, of which these widely-spread water-worn stones are indubitable proof.

Thus, while the stratum on which the red soil is generally found to rest is shown to have been under water, the movement of which

a nearly perpendicular bank, about 8 feet high and some 300 or 400 feet long, there crop out spheroidal nuclei, varying from a few inches to about 3 feet in diameter, and of concentric structure : they are distributed at distances from one to several feet apart, in a brownish earth, which is the debris *in situ* of the more easily decomposable portion of the trap. If a stream of water were to run over this partially decomposed trap, the loose earth in which the concretionary spheroidal nuclei are at present imbedded would be washed away to form a deposit in the Loch, if the stream run into it, while the nuclei would present a confused assemblage of rounded stones, and the interstices of those at the top of the bank would be empty. Thus on a small scale we should have realized that which, on the wide-spread surface of Peninsular India, has in bygone ages taken place on a gigantic scale.

is proved by its having rounded the loose stones* under its influence, the red soil itself contains satisfactory internal evidence of its being an aqueously transported formation. On washing away the finer red ferruginous particles, by putting some of the soil in a vessel with water and stirring, subsequently renewing the water until it comes off clear, the residue, as seen through a magnifying glass, will display its water-worn character. It is in fact a *gravel*, consisting, in different localities, of hornblende, quartz, &c., mixed up in various proportions, with some carbonate of lime, and rounded and water-worn. Occasionally I have seen strata of coarse water-worn pebbles in the red soil itself; and, on the first occasion of observing this, it occurred to me to wash the red soil itself as above stated. Ingredients foreign to the original composition of the ferruginous hornblende-rock, of which the red soil is the debris, will not always be found in the soil itself, particularly if the deposit has several feet of depth; but those portions of it that are in near or actual proximity to the water-worn stones interposed between the granitic floor and the red soil most generally contain more or less of the hornblendic and granitic debris in the shape of gravel.

The conclusion, therefore, at which I have arrived, after extensive and repeated observations over some hundred miles of country, regarding the origin and character of the Red Soil, is that it is the water-spread debris of the ferruginous hornblendic rocks of Southern India, which were under water either during or subsequent to decomposition. The rough dark ridges of the hornblendic hills, as at present seen, are the remains of the less decomposable nuclei of the rock, piled on each other, after the matrix in which they were originally enveloped has been decomposed and washed away.

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10. *On the connexion of the* Umret Coal-beds *with the* Plant-beds *of* Nágpur; *and of both with those of* Burdwan.

By the Rev. S. Hislop.

[Communicated by J. C. Moore, Esq., Sec. G.S.]

In the observations on the Jurassic Formation of the Nágpur Territory, which I had the honour to submit to your Society, I showed that it consisted of four members in the following descending order†: A, thick-bedded coarse ferruginous sandstone with a few stems of trees; B, laminated sandstone, exceedingly rich in vegetable remains: C, clay-shales, of various colours, in which are found the traces of reptiles and worms; and D, limestone, which within our area is generally crystallized from its contact with plutonic rocks. At the time of penning these remarks, not having had an opportunity of inspect-

* These stones are for the most part granitic gneiss,—evidently detached pieces of the underlying rock.

† *Vide antea*, p. 369.

ing any of our Indian coal-measures, I was inclined to regard them as the equivalents of our argillaceous strata marked c; but having recently enjoyed this privilege, while out on a mission tour with my friend the Rev. R. Hunter, I propose to communicate the modifications which have, in consequence, been wrought on previously-formed views.

Our tour extended about 120 miles N.N.W. of the city of Nágpur, —a distance which carried us past the carbonaceous strata near Umret, as far as the bituminous shales at the south base of the Pachma*d*i or Mahádewa Hills. These localities had both been visited by Dr. Jerdon and Lieut. Sankey in 1852, and the results of their investigations have been laid before your Society*.

The coal-field of Umret is about five miles north of the village, near a small hamlet dignified with the name of Bari, or Great, Barkoi, to distinguish it from Chhoti, or Little, Barkoi, which lies three-quarters of a mile to the south. Leaving Umret, the traveller passes over granite for about a mile, when he begins to ascend trap-hills, which continue, with only a slight reappearance of plutonic rock in the low ground near Tawari, until within three-quarters of a mile of Chhoti Barkoi, where they end in an abrupt descent, at the foot of which there emerge beds of sandstone, that constitute the surface-rock to the rivulet at Bari Barkoi. This stream has cut a passage through the sandstone, and laid bare the dark-coloured strata underneath, which are seen to dip at an angle of 5° to the W.S.W.,—the direction in which the water flows. The exposure displays the following succession: overlying sandstone, about 50 feet thick; coal, 1½ or 2 feet; argillaceous shale, 3 feet; bituminous shale, 1 foot; arenaceous and micaceous shale, 3 feet; and white sandstone, depth unknown.

On observing the strata, and the order in which they occurred, I remarked to Mr. Hunter, that the shale would probably turn out to be the representative of the fissile sandstone, abounding in fossils, that is so well developed at Kámpti, Silewá*d*á, Bokhárá, Bharatwá*d*á, &c. In hazarding this conjecture, I took it for granted that the overlying rock was the common sandstone of this country, which is for the most part traversed by iron-bands. Search having been made, the iron-bands, though not of the typical character, were discovered. So far the hypothesis was confirmed.

Additional light was thrown on it by examining the circumstances under which the argillaceous and bituminous shales are met with at the Mahádewas. The sandstone forming the mass of that mountain-range must be about 2000 feet thick, and presents a line of bold mural crags, extending E. and W. for upwards of twenty-five miles. The front of the precipice is towards the south, while the strata dip at an angle of 5° to the north, or, more correctly, N.N.E. However much the thickness of these arenaceous beds exceeds that of the ferruginous sandstone in the immediate neighbourhood of Nágpur, there can be no doubt that both rocks are the same, as both possess the same iron-bands, which I consider positive evidence of identity,

* Quart. Journ. Geol. Soc. vol. x. p. 55.

when they do occur; though their absence may not be conclusive as to dissimilarity. Under the sandstone, there are about 8 feet of green shales, becoming more micaceous and laminated below, and succeeded for about 3 feet by bituminous shale, which disappears under the surface of the ground. Unlike Barkoi, there is no seam of coal to be seen, but the tendency to it in the bituminous shale is manifest enough; and, indeed, this latter bed, as I shall endeavour to show, when I come to speak of the organic remains, is palæontologically a part of our Indian carboniferous strata.

Here then at Barkoi and the Mahádewas, as well as near Nágpur, we have the same thick-bedded iron-banded sandstone overlying in the last-mentioned locality more fissile strata of a somewhat similar material; but at the former two places, superposed on argillaceous and carbonaceous or bituminous shales. Are then the *lower* beds also of the same age in all three localities? Of the contemporaneity of the inferior strata at Barkoi and the Mahádewas there cannot be two opinions; but as those in our immediate neighbourhood differ in colour, and to a considerable extent in composition, some hesitation may be felt in including them in the identification. It may be supposed that there is a deficiency in the one district, which is supplied in the other.

Now it may help to remove doubt to mention that, even in this vicinity (Nágpur), where the lower strata are generally of a whitish hue, they present in their higher portion a certain quantity of clay, which becomes less and less as we descend, until at last, as in the underlying beds at Barkoi, we arrive at pure sand. And to complete the analogy in regard to composition, it may be added, that in a particular spot at Bokhárá, six miles N. of Nágpur, the higher laminæ now referred to exhibit not only the argillaceous mixture, but an approximation to the carbonaceous colour, being quite brown through the amount of comminuted vegetable matter which they contain.

But for direct proof of identity in age, an appeal must be made to the fossil contents of the strata under comparison. At Barkoi we found the following genera: *Glossopteris* and *Cyclopteris*, with *Phyllotheca*, *Vertebraria*, and other stems, and a variety of fruits or seeds. At the Mahádewas, during the very hurried visit which we made to that locality, we discovered *Glossopteris*, *Phyllotheca*, *Vertebraria*, and fruits or seeds; besides which, I believe, our friend Mr. Sankey had previously brought to light specimens of *Pecopteris*, *Sphenopteris*, and *Trizygia*.

In regard to the Barkoi plants, I think there is scarcely one that cannot be specifically matched with some one from the laminated argillaceous sandstone in the vicinity of Nágpur. Of the genus *Glossopteris*, the bituminous shale furnished several species; but among them there is not one that strikes me as not having been observed before in our arenaceous strata. The *Cyclopteris* of Barkoi exactly agrees with that of Bharatwá*d*á, both being oblong-cuneate, and characterized by the same venation. The most abundant *Phyllotheca* at Barkoi, is one with 10 sulci, which is also the one most frequently discovered near Nágpur. Of *Vertebraria*, there does not appear to be more than a single species, though Royle* has formed a *V. radiata* from a transverse section of the stem of his *V. indica*, and M'Coy† has added another species, *V. australis*, from N. S. Wales, because there is a slight difference in the radiations of his transverse section from those of Royle's.

Taking the *Vertebraria* found at Barkoi as belonging to the only species hitherto discovered either in India or Australia, it is satisfactory to ascertain, that it is just as abundant in all the localities of our sandstone as in the coal-formation of Barkoi. Besides the *Vertebraria*, there is another stem common at Barkoi, which has its exact counterpart nearer Nágpur. It is undescribed, may be distinguished by its nearly opposite leaf-scars, and occurs plentifully in the laminated sandstone of Silewá*d*á. The fruits or seeds from Barkoi I have not at present the means of comparing with those of Kámpti. One of them, however, may be easily recognized as identical with a fruit or seed lately met with at Bharatwá*d*á.

Between the vegetable remains of the Mahádewas and those of our laminated sandstone, a like comparison might be instituted. If, for example, Mr. Sankey's *Pecopteris* from that locality agreed, as my memory suggests, with one figured by M'Clelland‡, then it must have corresponded with one that occurs at Kámpti. The *Vertebraria*, both at the Mahádewas and near Nágpur, might be proved to be identical, and a general resemblance pointed out in regard to *Glossopteris*, *Phyllotheca*, and the fruits or seeds. But after the statements of the previous paragraph, it is scarcely necessary to enlarge.

From the above numerous coincidences, it may be inferred that our laminated sandstone is the equivalent of the carbonaceous and bituminous shales in the north of this territory. It follows, as a matter of course, that the position of the coal-measures is among the beds immediately underneath the ferruginous sandstone (A).

* 'Illustrations of the Botany, &c. of the Himalayan Mountains.' When I formerly referred (Journ. No. 43. p. 371, &c. and MS. account of the fossil plants) to this remarkable genus of plants, I had not in my possession a specimen from the Indian coal-shales. The recent examination of many such has served to increase in my mind the conviction that its character has been misunderstood. Its smaller branches are somewhat slender and apparently winged. Sometimes they are found lying along the plane of the laminæ,—at other times running across it. When a branch is discovered in the former situation, it is found to be split in two halves, with the wings that lie in conformity with the lamination stretched at their full breadth, while those that lie at an angle with it are, as it were, foreshortened. In this case there is no trace of radiation. But when a branch is found running across the laminæ, as often happens, all the wings have equal room to retain their form, and hence the radiated appearance. The number of the radii or wings differs in specimens which I have examined from the same locality, and, as I believe, in portions of the same plant. A similar want of uniformity in this respect is perceptible in the specimens figured by Royle. That there is any such thing as dichotomous-veined foliage between the radii, does not appear from the shale specimens that have fallen under my notice. On the contrary they seem to be wholly destitute of leaves. But there is every reason to think that our sandstone specimens possess these appendages, and that they are of a narrow linear shape like those of the *Phyllotheca*.

† Ann. and Mag. of Nat. Hist. vol. xx. p. 147.

‡ Report of Geological Survey for 1848–49.

If we look beyond this province, we shall find this view amply confirmed. The account given by Dr. Walker* of the discovery of fragments of coal at Kotá, in the Nizam's dominions, would lead to the belief that the carbonaceous and bituminous shales which he noticed were above the highest bed of argillaceous limestone. But whether this may have been the case or not, is of little consequence; as all I contend for is, that they are near the base of the iron-banded sandstone,—a position which must at once be assigned them, when we take into account their relation to the surrounding hills at Kotá†. The succession at Duntimnapilly‡, according to the same writer, seems to have been—anthracite, carbonaceous sandstone, and micaceous sandstone. What the rock, 15 feet thick, above the anthracite was, he does not mention. But it is worthy of remark, that the carbonaceous and micaceous sandstone into which the anthracite passes downwards, bear a great resemblance to the strata underlying the coal-seam at Barkoi, and appear to coincide with the 8 feet of laminated sandstone mentioned by the late Dr. T. L. Bell in his detailed description of the rocks bored through at Kotá. It is to this lamented officer that we owe the best materials for comparing the coal-measures on the banks of the Pranhitá with those in the north of Nágpur. The section with which he has furnished us is: sandstone (iron-banded), from 50 to 500 feet; argillaceous limestone 9 feet; bituminous shale three-quarters of an inch; then argillaceous limestone, bituminous shale and limestone again, which passes into the laminated sandstone alluded to above. Without quoting further from this list of strata, which has already been published in the Journal§ of the Society, I may mention that the *bituminous* shale at Kotá, though to a considerable extent interstratified with argillaceous limestone, &c., is found only in the upper half, while *argillaceous* shales and limestone preponderate in the lower half. Limestone, according to the most recent information received from Dr. Bell, was the lowest rock reached after passing through 27 feet of red clay-shale.

Again, at Palamow, the first beds that Mr. Homfray‖ came upon under a mass of sandstone, 150 to 200 feet thick, were shale and coal, resting upon 30 feet of sandstone, in which we may again trace a similarity to the coal-field at Barkoi. Such also is the order of the strata at Singrá, as given by Mr. Homfray. Dr. Carter, in his admirable 'Summary of the Geology of India¶,' shows that Jacquemont found small layers of anthracite between the strata of compact limestone which immediately underlie the Panná sandstone. According to Franklin**, in all the glens connected with the Panná range, particularly in that of the Bágin River, black bituminous shale crops out from beneath the sandstone. Mr. Osborne's obser-

* Beng. Asiat. Soc. Journ. vol. x. p. 342.
† Quart. Journ. Geol. Soc. vol. x. p. 374, and *note*.
‡ Beng. Asiat. Soc. Journ. vol. x. p. 344.
§ Quart. Journ. Geol. Soc. vol. viii. p. 231; vol. ix. p. 351; and vol. x. p. 374.
‖ Beng. Asiat. Soc. Journ. vol. x. p. 374.
¶ Bomb. Br. Roy. Asiat. Soc. Journ. No. 19. p. 204.
** Asiat. Res. vol. xviii. part i. p. 103.

vations* prove that under the sandstone of Umla Ghat there is shale with exudations of petroleum, which is succeeded below by alternate beds of sandstone and shale, limestone lying under all.

Thus we see that south, north, and east of this territory, as well as within its limits, the carbonaceous and bituminous shales may be said immediately to underlie the ferruginous sandstone. It is difficult to comprehend the Burdwan coal-field in our comparison, for it seems to lie in a basin, and the carboniferous strata rise to the surface without any superincumbent sandstone. But the connexion, which cannot be established lithologically, may be rendered very manifest by the evidence of fossils. Species of *Trizygia*, *Vertebraria*, *Glossopteris*, and *Pecopteris* are common to the shales of Burdwan and those of the Mahádewas. And, although Dr. M'Clelland has professedly figured no *Phyllotheca*, or Calamite, as he would name it, from Bengal, yet there can be little doubt that what he calls *Poacites minor* † is identical, wanting the joint, with one of our Phyllothecas found both at the Mahádewas and Kámpti, and specifically distinguished by the possession of 8 sulci. I am not certain, though I am disposed to think, that the *Poacites muricata* ‡ of the same author is the unfurrowed stem, with nearly opposite leaf-scars, described above, p. 558, as common in the shale of Barkoi and the laminated sandstone of Silewá*d*á. The breadth and rigid appearance of our specimens are exactly the same as in M'Clelland's figure, and there is occasionally on them a fine longitudinal striation; which might be taken for the venation of an endogenous leaf.

Subjoined is the succession, from above, of our Indian Freshwater § Oolitic Formation, according to the view taken in this paper.

I. *Upper Sandstone Series; called by Dr. Carter the "Panná [Punna] Sandstone."*

In general, coarse and thick-bedded; sometimes friable, and white, variegated with red blotches; at other times hard and of a rusty colour, traversed by iron-bands. Contains a few stems of trees about the base. Thickness at Nágpur 25 feet; at the Mahádewa Hills upwards of 2000 feet.

II. *Laminated Series; the same as Dr. Carter's "Kattrá Shales."*

1. Either arenaceous, carbonaceous, or bituminous. The arenaceous strata more or less mixed with clay and mica; laminated and abounding in fossils above, and gradually becoming coarser, thicker-bedded, and more destitute of organic remains below. The carbonaceous or bituminous shales are the equivalents of the laminated fossiliferous sandstone just mentioned. Though occasionally alternating with argillaceous limestone, they for the most part pass into micaceous or coarse sandstone. Thickness from 300 feet, in the Nágpur territory, to 2000 feet in Bengal.

* Beng. Asiat. Soc. Journ. vol. vii. p. 843.

† Geol. Survey, Tab. xvi. fig. 4, with the description at p. 55.

‡ Ibid. Tab. xiv. fig. 6.

§ I here say nothing of the Oolitic strata in Cutch, as they are obviously marine.

2. Argillaceous shales, green, red, blue, and more rarely white, in some localities alternating with argillaceous limestone. Contains the traces of reptiles and worms. Thickness about Nágpur 80 feet, though much greater in the Bhandárá district to the east.

3. Limestone, sometimes compact, but often crystalline and dolomitic. Near Nágpur 100 feet, at Moodelaity 310 feet thick.

From the above arrangement of the laminated series, it will be seen there is a difficulty in disposing of the limestone. Beds of it in some districts of India alternate with our No. 2, and even with No. 1. At Moodelaity, where the latter appears to be wanting, the whole mass of it is said to overlie the argillaceous shales. I have followed the order as it is within this territory, where the limestone is most frequently crystalline, while the red shale, lying above it, has suffered no change from heat. This I am disposed to consider the typical order of succession among our "Freshwater Oolites." At Kotá, though the calcareous and bituminous beds are interstratified to a certain extent, yet the greater part of the latter are found above, and of the former below. Newbold, who gives us the superposition at Moodelaity, embodies his views of the order of stratification throughout Southern India in these words:—"The limestone occupies, with few exceptions, the lowest position in the sections afforded by the great lines of drainage of these tracts, and in places where the superincumbent strata have been stripped off. Next in order of superposition come calcareous shales, mingled with much argillaceous matter, then argillaceous shales and slates, sandstone, siliceous and arenaceous schists, quartzose rock, and sandstone conglomerate*." In some parts of Bundlekhand the limestone occupies a high position: but, as we have had occasion to notice before, at Bágin the bituminous shale lies above the greater part of it. In the coal-fields of Bengal calcareous strata appear to be wholly wanting.

To complete the catalogue of our Indian Jurassic Formation, I might here add—

III. *Lower Sandstone Series.*

This is developed at Moodelaity and in Bundlekhand, and has received from Dr. Carter the name of the "Tárá Sandstone;" but, as it does not occur within our area, except perhaps in the form of gneiss, mica-schist, and other metamorphic rocks, underlying our crystallized limestone, I forbear to enter on the consideration of it at present.

[*Note.*—The age of the Bengal Coal-fields is treated of by Prof. Oldham, Journ. Asiat. Soc. Bengal, No. 6, 1854, p. 619; Edinb. New Phil. Journ. New Ser. vol. ii. p. 210; and by Dr. Carter, 'Summary of the Geology of India,' p. 41.—Ed.]

* Roy. Asiat. Soc. Journ. vol. viii. p. 160.

11. *On some* Minute Seed-vessels (Carpolithes ovulum Brongniart), *from the* Eocene beds *of* Lewisham. By J. D. Hooker, M.D., F.R.S., F.G.S. &c.

[Plate XVI.]

Of this remarkable and beautiful little fossil three or four specimens have been detected in the Eocene clays of Lewisham, by the late Rev. H. de la Condamine, and one of them in so perfect a state that I have had little difficulty in making out the details of its structure. They occurred associated with freshwater shells in the "*Planorbis* bed" at Counter Hill, and are alluded to in Mr. Prestwich's valuable memoir on the "Woolwich and Reading Series" of the London Tertiaries, Quart. Journ. Geol. Soc. vol. x. pp. 119 and 156 (see also Pl. 3. fig. 4).

A few other vegetable remains were found associated in the same bed with this *Carpolithes*, but none that throw any light upon its affinities. Amongst these are two kinds of Dicotyledonous leaves, together with the pinnæ of a Fern not differing in venation from the existing genus *Asplenium**, and the remains of Monocotyledonous leaves. To the same formation, however, Mr. Prestwich has referred some fragments of coniferous and other Dicotyledonous woods, and a Fir-cone, referable apparently to the existing genus *Abies*†. Dr. Mantell also, in his 'Geology of Sussex,' has figured some vegetable remains alluded to by Mr. Prestwich as apparently agreeing with some of the Reading species, of which latter a beautiful series of forms, chiefly of leaves of Dicotyledonous trees, are given at Pl. 4 accompanying the Memoir before mentioned‡. The whole assemblage appears to indicate that the climate of the period during which they flourished did not materially differ from that of England at present; of which Mr. Prestwich's conclusions, drawn from the contemporaneous animal remains, had already afforded abundant evidence: the same may be said of the plants with which this species has been found associated in France, as described in M. Brongniart's paper hereafter to be alluded to.

I have been particular in detailing the above facts, because, though so perfect in condition, I am quite unable either to refer *Carpolithes ovulum* to any known family of plants, or to determine its affinities approximately; and, though I have laid the specimen and my analysis before those of my friends who are most distinguished for a profound knowledge of structural and systematic Botany, they have not been able to suggest any recent Natural Order under which it should be classed. This is the more remarkable, from the fact that there are no characters in the Dicotyledonous leaves mentioned above that preclude their being referred to living genera, and the same may be said of the Fir-cone and the Fern leaflet, whilst the *Mollusca* and *Entomostraca* have been referred by Mr. de la Condamine, Mr.

* Quart Journ. Geol. Soc. vol. x. p. 156. pl. 3. fig. 6.

† *Ibid.* p. 156. pl. 3. fig. 3.

‡ See also *ibid.* p 163.

Prestwich, Mr. Morris, and Mr. Jones to living genera, with few exceptions.

Before entering upon the subject of its affinities, I shall describe the genus, premising, however, that I have assumed it to be Cryptogamous, and have employed a corresponding terminology.

Genus CARPOLITHES. *Sporangium* coriaceum, oblongum, basi hilo notatum, apice mamilla conica poro pertusa instructum, uniloculare, saccum sporuliferum continens. *Saccus* membranaceus, hyalinus, reticulatus, loculo conformis, basi lato sessilis, fundo sporangii tantum adnatus, cæterum liber, apice conicus, poro instructus. *Sporæ* majusculæ, oblate-sphericæ vel discoideæ, centro depressæ, 3-multilobæ, e sporulis cuneiformibus radiatim dispositis conflatæ. *Sporulæ* subtilissime striolatæ; striis radiantibus.

1. CARPOLITHES OVULUM, Brongn. Descript. Géologique des Environs de Paris, t. 11. f. 6.

Hab. Terra argillacea fluviatili Eocena ad "Counter Hill," prope villam "Lewisham," Comitate "Kent;" invenit beat. *Rev^dus^ Dom. H. de la Condamine.*

Sporangium atrum, carbonaceum, longit. $\frac{3}{10}$ unc., diametro majore $\frac{1}{5}$ unc., compressum, verosimiliter distortum: parietes coriacei, e stratis plurimis cellularum formati, superficie creberrime areolati, opaci; margine altero acuto, altero subincrassato et vasis lignosis scalariformibusque percurso; mamilla conica terminali basi disco elevato circumdata. *Saccus* internus hyalinus, humectatus hygrometricus, e membranis duabus tenuissimis arcte accretis formatus; areolis cellularum transverse oblongis, apicem conicum versus minoribus et valde conspicuis. *Sporæ* majores $\frac{1}{600}$ unc. diametro, minores $\frac{1}{1000}$ unc., omnes centro translucidæ, pallide flavæ.

For the reference of this fossil to Brongniart's *Carpolithes ovulum* I am indebted to Mr. Morris's extensive and accurate acquaintance with the literature of Palæobotany, as well as with the plants themselves, he having recognized both this and the *Folliculites,* which I shall next describe, on my showing him my drawings and analyses.

The *C. ovulum* was first noticed in Cuvier and Brongniart's 'Description Géologique des Environs de Paris,' as having been found associated with tertiary freshwater fossils. M. Brongniart hesitated whether to consider it as a seed or a monospermous pericarp, and very doubtfully suggests a possible affinity with *Nymphæaceæ.* This alliance is not, however, alluded to under *Nymphæaceæ* in his later 'Tableau des Genres de Végétaux fossiles,' and is, I presume, abandoned.

It is remarkable that the additional knowledge we now possess of this fossil should throw no more direct light upon its affinities. Even if we discard the idea of its being a sporangium and of cryptogamic origin, the terminal mamilla is very peculiar, and the definite aperture at the apex of the internal sac is hardly analogous either to the micropyle in the testa of a seed, or to any opening in the membrane enclosing the albumen. The arrangement of the cells of which the internal sac is formed is also peculiar, for they gradually diminish in size towards the terminal pore, and evidently indicate that the latter performs some important office.

The spores themselves are very numerous, though the sac was not at all full of them. The Rev. Mr. Berkeley, to whom I showed them *in situ*, and who most carefully went over my analysis, was quite unable to suggest any other explanation of their origin than that they really were the reproductive organs of the fossil; though equally impressed with myself by the phænogamic character of the whole, and quite unable to compare the spores with those of any cryptogamic plant known to him.

From the opacity and brittleness of the walls of the sporangium, I was unable to obtain good sections at all points; but it seems to consist chiefly of a dense, compact cellular tissue, traversed on one side (where there is an evident thickening) by a bundle of vessels passing from the base to the terminal mamilla. The cells of the outer surface are denser, and have thicker walls, than those of the inner, and are further perforated by canals passing from cell to cell; the prominence of these cells gives the outer surface its reticulated appearance. The inner surface again is lined with much larger, oblong, hexagonal cells, with short transverse bars on their walls. The scalariform vessels of the vascular bundle closely resemble spiral vessels, but are not in a sufficiently perfect state for an accurate analysis; they are accompanied by fusiform cells, and tubes, apparently of pleurenchyma. The elevated disc surrounding the base of the terminal mamilla is irregular in outline, and may be the remains of a membrane that once covered the apical pore; the mamilla itself appears to be composed of but one stratum of cells, but this is doubtful.

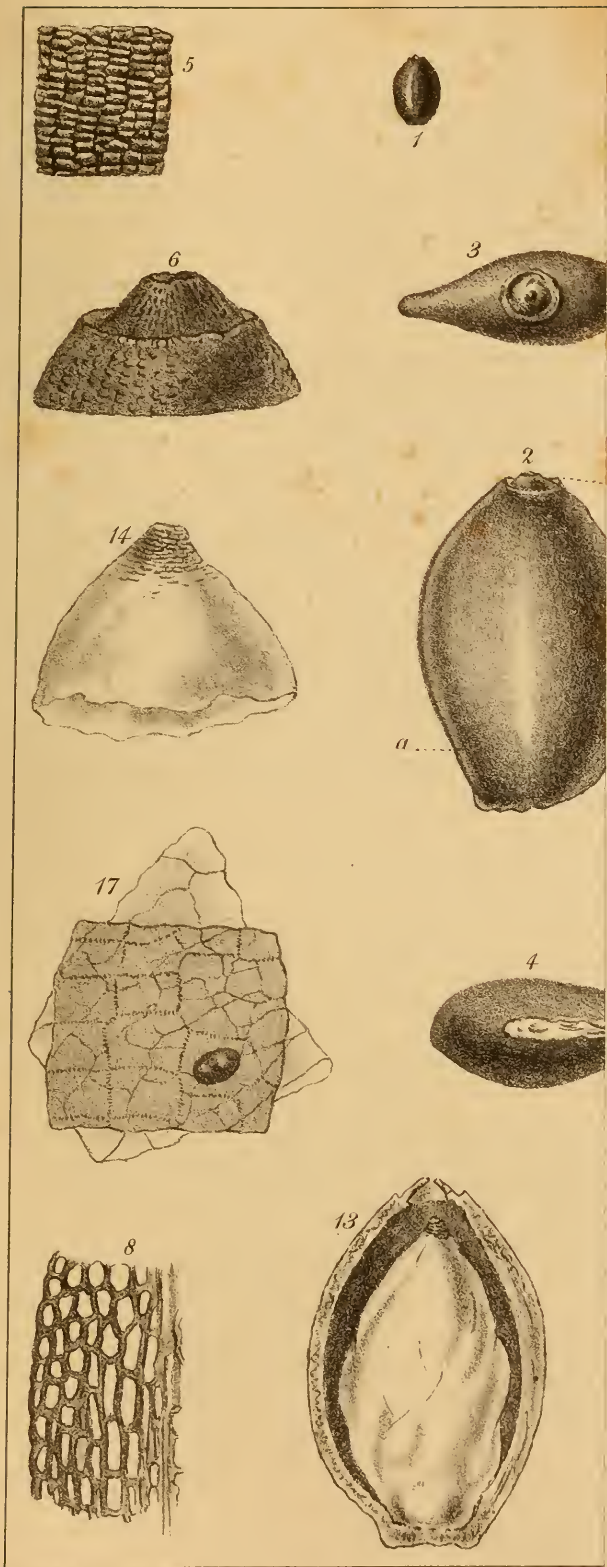
The sporular sac is a singularly beautiful structure, being as transparent, and apparently as perfect, as when fresh, absorbing moisture and expanding under it; it is soluble in boiling nitric acid, but I failed to produce any reaction upon it or upon the spores with iodine or sulphuric acid. It is easily ruptured, and appears to be formed of two layers of excessively delicate cellular tissue, whose areolæ are not conformable to one another, except at the apex of the sac; the latter is conical, and no doubt once occupied the cavity of the mamilla of the sporangium, from which it has become retracted after the dispersion of the majority of the spores, and the consequent collapse of its walls.

The spores are amber-coloured, and the depressed central areola is sometimes occupied by an opaque or transparent mass: the delicate radiating striæ on the wedge-shaped sporules have suggested the generic name of *Rhytidosporum**, should it be found advisable, when the structure of other *Carpolithes*† is better known, to separate this from them.

Except for the presence of the spores in the sac of this specimen,

* From Gr. ῥυτὶς, a wrinkle, and σπόρον, a spore.

† As at present limited, *Carpolithes* is an artificial assemblage of organs of fructification.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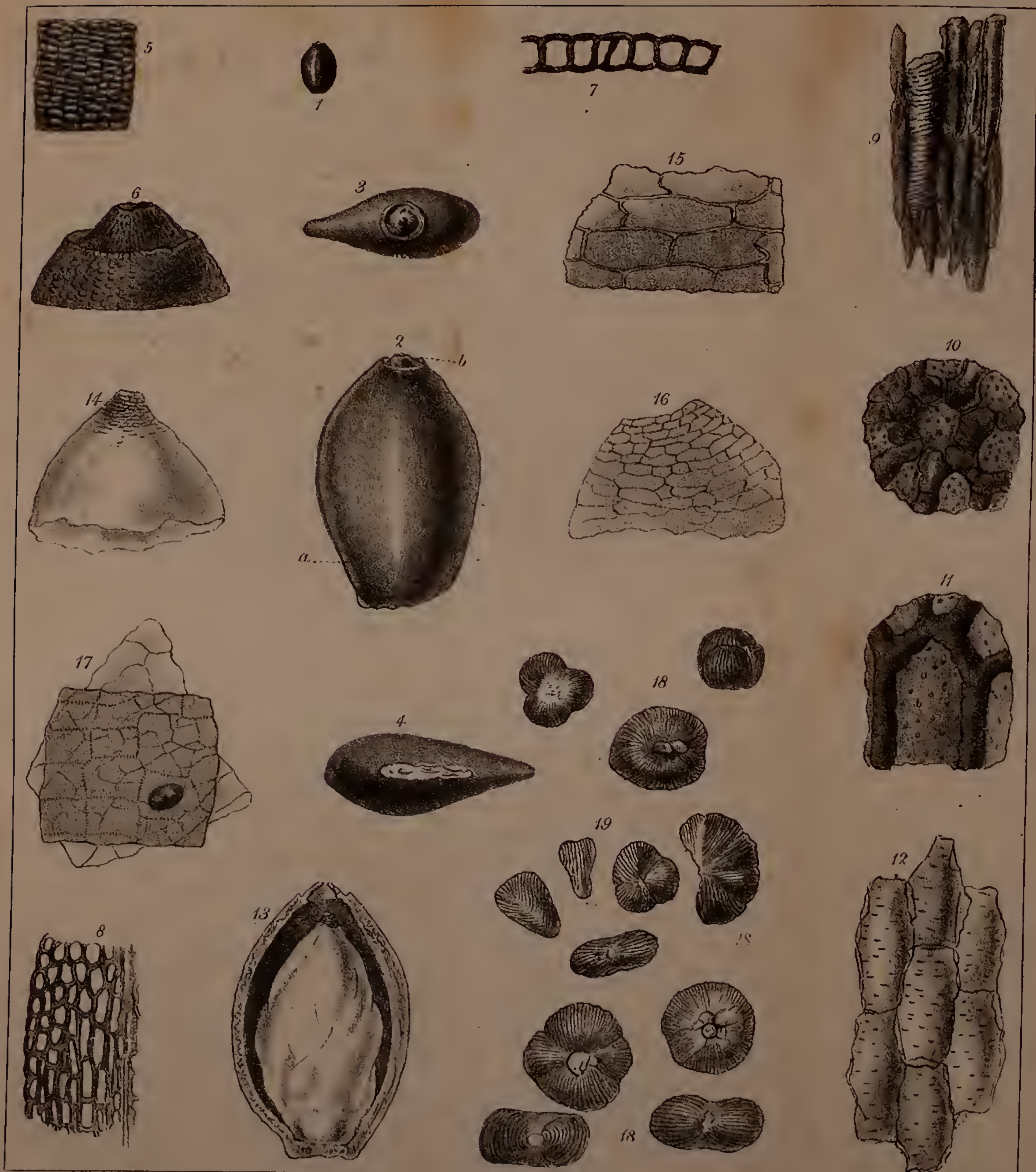
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I should have had little hesitation in referring it to Phænogamous plants, and there is much that recalls the structure of the seed of *Magnoliaceæ*. In *Magnolia* itself the seed consists of a crustaceous testa (with a fleshy outer coat), perforated at the micropyle, and traversed along one side by vascular cords; it further contains a delicate membranous sac, almost identical, in microscopical structure, in situation, and in mode of attachment to the testa, with that of *Carpolithes ovulum*; but there is not, upon the membrane of the *Magnolia* seed, the defined apical pore that there is in this fossil, nor does it contain any contents analogous to what I have here described as spores.

In the present state of our knowledge, if the striated bodies in the sac are to be regarded as spores, then *C. ovulum* must be referred to *Cryptogamia*, and it will rank nearer Ferns than any other class; for, though the membranous inner sac more resembles that of Mosses in its structure than any known Fern, the vascular bundle is opposed to that alliance, as is the insertion of the sac, and the form and structure of the spores.

There is a remarkable analogy between the structure of this Counter Hill fossil and the genus *Folliculites*, which I shall shortly describe*, and which is abundant in the Tertiary lignites of the Bovey Tracey Coal-field in Devonshire,—the position and structure of the sac being identical; but the sporangium or outer coat of *Folliculites* dehisces longitudinally, the sac does not open by a terminal pore, and I have found no traces of sporules in the numerous specimens of that genus which I have examined.

DESCRIPTION OF PLATE XVI.

(All the figures except fig. 1 are more or less highly magnified.)

Fig. 1. *Carpolithes ovulum*; natural size.
Fig. 2. The same magnified: *a*. the thickened edge traversed by the vascular cord; *b*. the terminal mamilla and pore.
Fig. 3. The same, looking towards its apex, and fig. 4. towards its base.
Fig. 5. Cellular tissue of the surface.
Fig. 6. Mamilla and terminal pore.
Fig. 7. Transverse section of its tissue.
Fig. 8. Vertical section of thickened edge and vascular cord.
Fig. 9. Portion of cord highly magnified.
Fig. 10. Cellular tissue of the outer surface of the sporangium near the cord, showing the canals in the cell-walls.
Fig. 11. The same from towards the apex of the sporangium.
Fig. 12. Cells of inner wall of sporangium.
Fig. 13. Vertical section of sporangium showing the inner sac.
Fig. 14. Upper portion of sac.
Fig. 15. Tissue of lower part of sac.
Fig. 16. Tissue of apex of sac.
Fig. 17. More highly magnified view of membrane of the sac, showing it to be formed of two. (With a spore attached.)
Fig. 18. Spores.
Fig. 19. Sporules.

* See below, p. 566.

12. *On some small* SEED-VESSELS (FOLLICULITES MINUTULUS, Bronn) *from the* BOVEY TRACEY COAL. By J. D. HOOKER, M.D., F.R.S., F.G.S.

[PLATE XVII.]

THE remarkable fruit which forms the chief subject of the present communication was first brought under my notice by my lamented friend the late Prof. E. Forbes, who pointed out to me specimens of it in the Museum of the Geological Survey, and entrusted me with a couple for examination. Shortly after having made a complete analysis of these, a very fine series of Bovey Tracey peats and lignites was sent to the Museum of the Royal Gardens of Kew, by Dr. Croker, amongst which were numerous specimens of the same fossil in an excellent state of preservation. An examination of several of these has enabled me to add a little to the analysis which I had previously made, and has confirmed it in all essential points.

As was the case with *Carpolithes ovulum* *, there are no fossil vegetable remains accompanying the *Folliculites* that suggest any clue to its botanical affinity. The mass of the lignite appears to be formed of coniferous wood, some in the state of charcoal, and the remainder more or less highly bituminized.

From Dr. Croker's description and accompanying sections †, the main body of the formation seems to consist of

1. A bed of peat containing trunks of trees not now found in the immediate neighbourhood, but which appear to me to agree in microscopical character with the common Maple (*Acer campestre*). These are quite fresh and white, and lie in immediate contact with the surface of the uppermost bed of lignite.

2. The upper layers of lignite are very different, and in them was found a cone, so closely resembling that of a Scotch Fir (*Pinus sylvestris*), that I doubt its being specifically distinct from that plant. The only specimen hitherto discovered appears to have been nearly or fully ripe, and contains winged seeds, also quite agreeing with those of the Scotch Fir. This upper lignite, when microscopically examined, is found to be composed of coniferous wood, and is similar to the lower lignite.

3. Beneath the upper layers of the lignite is a thick bed of ferruginous granitic sand.

4. Ten beds of good coal (lignite), the upper of which are parted by beds of blue clay.

Below the blue clay is the layer containing the *Folliculites*, which are thickly strewed over the surfaces of the laminæ of lignite, and slightly imbedded in them, as if the latter had been soft when the deposit was formed. They lie in all directions, but always on their flat sides, as if they had been floated into the places they occupy; though this by no means follows, as their compressed form may be due to pressure.

Small pieces of resin, similar to the "Highgate Resin," are found

* See above, p. 562.

† See also Parkinson's 'Organic Remains,' vol. i. p. 126 &c.

in the clay, and were probably secreted by the coniferous trees whose wood appears to form the mass of the coal.

The existence of a Pine-cone, so closely resembling that of a tree still existing in Great Britain that it cannot be specifically distinguished from it, would seem to refer the Bovey Tracey Coal-field to the Post-pliocene epoch without any doubt, and is an extremely interesting discovery. This cone is wholly carbonized, and the woody interior of its scales and axis is highly bituminized. The seeds, however, may be easily separated from the cone, and their membranous wings are, though carbonized, quite perfect. From a microscopical analysis of the wood-cells of the cone, I see no reason to doubt that it belonged to the species that yielded the coniferous wood with which it is associated; and I find no character in this wood either that prevents its being referred to the Scotch Fir. It must, however, be borne in mind that this identification is provisional only; for, after a study of a very complete collection of cones of existing Pines in the Museum of Kew, I have found that it is quite impossible to distinguish by the cones alone several species from very distant countries, which are nevertheless amply characterized by their leaves and other organs. So also the cone of the Scotch Fir is not the only one to which that found in the Bovey Tracey lignite might be referred; though I do not think that it agrees better with any other species than with this.

Genus Folliculites, Bronn.

Sporangium oblongum vel lineari-oblongum, compressum, utrinque obtusum, leviter curvum, infra apicem paulo constrictum, longitudinaliter leviter sulcatum, uno latere a basi ad apicem longitudinaliter dehiscens, cavum; cavitas ovato-oblonga, supra basin paulo constricta, saccum continens. *Saccus* membranaceus, hyalinus, loculo conformis, fundo constricto loculi adnatus, apice attenuatus, rima brevi oblonga lateraliter versus apicem dehiscens. *Sporæ*? minimæ, irregulares, subglobosæ vel oblongæ.

Sporangium crassum, crustaceum, $\frac{1}{4}$ unc. longum, e stratis plurimis cellularum minutarum dense compactarum conflatum. *Superficies* exterior sub lente punctato-areolata; interior strato cellularum majorum vestita, cellulæ oblongæ vel lineares, aliæ transverse clathratæ vel scalariformes, punctatæ, cribratæ vel varie porosæ, parietibus contiguis rectis vel undulatis. *Saccus* internus transparens, e membrana simplici formatus, cellulis compressis transverse oblongis quadratisve areolatus, cellulis versus apicem minoribus et magis distinctis, lineis intercellularibus sub lente maxime augente subtilissime moniliformibus.

Folliculites minutulus, Bronn, Lethæa Geognost. p. 849, pl. 35. fig. 11.

Hab. In terra carbonacea pleiocena?, ad "Bovey Tracey," Comitate "Devon."

The specimens of this fossil agree well with the somewhat rude figure of Bronn's quoted above, which is taken from a specimen found in the Brown coal; but it may be doubted whether they are not also referable to another presumed species, that on which the genus was established, the *F. Kaltennordhemensis*, Zenker (in Leonhard and Bronn's Jahrbuch, 1833, p. 177. pl. 4. fig. A. 3–7), which, however, represents a rather larger and narrower fossil than the present.

The original species of *Folliculites* is the *F. thalictroides*, Zenker (*Carpolithes thalictroides*, Brongniart), a fossil first noticed by the elder Brongniart, in 1810, in a paper published in the 'Annales du Muséum,' vol. xv. p. 382. pl. 33. fig. 17. It is there referred to the vegetable kingdom, though an alliance with Insects is hinted at; the species is a large one. In 1822 it was twice described by the younger Brongniart, who named it *C. thalictroides*, in a paper, by Cuvier and himself, on the Geology of the Environs of Paris, pl. 11. fig. 4 & 5, and in his "Classification des Végétaux fossiles," Mémoires du Muséum, vol. viii. p. 317.

Brongniart was not aware of the dehiscence of the fruit, and considered it to be allied to *Thalictrum*. Two varieties of it are described; one, var. *Parisiense*, from Miocene beds near Paris,—the other, var. *Websteri*, from the Eocene formation of the Isle of Wight. More lately, in his 'Tableau des Genres de Végétaux fossiles,' he considers these as distinct species (*C. thalictroides* and *C. Websteri*), and follows Unger in referring them to *Naiadeæ*, who, he says, is perhaps right in this reference, though they differ very much from any existing genus of the Order (p. 87). Zenker's genus *Folliculites* appears not to be alluded to in the 'Tableau des Genres de Végétaux fossiles' of M. Brongniart, though published sixteen years before that excellent work.

Whatever may be the true affinities of *Folliculites*, I think they are very remote from both *Naiadeæ* and *Ranunculaceæ*. The internal sac is regarded as an arillus by Zenker, a view which appears to me to be untenable; and, if not the membrane of a sporular sac, it is most likely the proper coat of an embryo or albumen.

I have examined about twenty-five specimens of this remarkable fossil, all in a very perfect state as regards the sporangium and enclosed sac, but differing a little in the nature of the cellular layer forming the inner lining of the sporangium. Owing to the very brittle and perfectly opaque carbonized state of the fossil, I was unable to make sections or slices, and the tissues of the inner surface were obtained piecemeal.

The substance of the walls of the sporangium is dense, opaque, thick, and brittle, formed of many rows of densely crowded cells; the outer surface is undulated and minutely dotted; the thickened apex is rounded and vertically striated. The dehiscing surfaces are smooth and polished, and a groove or canal leads from the upper end of the internal cavity to the apex of the fossil.

The membrane lining the inner wall of the sporangium is formed of large turgid cells, having a glistening appearance; they are transparent, membranous, brittle, and of a rich brown colour. The individual cells are oblong, cylindrical, with blunt bases, often produced into a convex sac (8 *a*), and their upper ends frequently terminate in blunt, opaque, prominent cones that stand out from the surface of the membrane. The cell-wall is marked with very faint oblique lines, appearing more like undulations of the cell-wall than a thickening of it or deposit on it. Under a very high magnifying power, the lines marking the junction of the contiguous cell-walls have a beautifully beaded appearance (fig. 8).

Beneath this investing coat of the cavity I occasionally found broken pieces of tissue, represented by figs. 9–13, which approach vascular tissue in character.

The attachment of the sporular sac is by a broad base, that adheres to the somewhat excavated base of the cavity of the sporangium; the apex of the sporular sac is drawn out into a very fine point, which projects into the tubular canal at the apex of the sporangium, and is there united to the cellular tissue lining the latter. The sporular sac finally becomes retracted from this canal, and tears away a portion of its lining membrane with it (fig. 5).

The substance of the sporular sac is extremely delicate, but firm and brittle, transparent and glassy; it does not expand in water like that of *Rhytidosporum* *, but is dissolved in hot nitric acid, and presents no action with iodine.

The very different-looking cellular tissues figured are all evidently referable to one type, but they may have belonged to more than one layer. Some of the longer (fig. 10–13) approach vascular tissue in character; but I was quite unable to detect any stronger evidence of vascular tissue, which, however, may very well be supposed to exist along the edge of the fossil opposite the suture.

The sporular sac, in its origin, insertion, membranous nature, &c., closely resembles that of *Carpolithes ovulum*, but differs in many remarkable points of form and anatomy; thus it bursts by a minute oblong slit below the narrow sharp apex, and appears to be formed of but one layer of very compressed cellular tissue. Under a very high magnifying power ($\frac{1}{20}$ lin. doublet, or $\frac{1}{5}$ inch object-glass), this tissue presents the same beautiful appearance that the lining membrane of the sporangium does, the boundary-lines between the cells being formed of strings of minute spherical bodies of various diameters, and the intermediate membrane is either transversely undulated, or appears so from the presence of excessively fine, parallel, waved lines. What I have regarded as spores were the only contents of the sac in one of the specimens, and consisted of a mass of extremely minute spherical or oblong transparent bodies, of various sizes. In the other specimens the sac was perfect; but its cavity, and that of the sporangium, were filled with fine silt, amongst which I could detect no definite remains of vegetable tissue.

With regard to the affinities of this fossil it is exceedingly difficult to speak. The sporular sac at once suggests an alliance with Mosses, and the traces of vascular tissue in *Carpolithes ovulum*, to which it may be assumed to be allied, with Ferns. There are, however, very grave objections to these affinities for either of the fossils. Thus, as regards

* See above, p. 564.

Mosses, their sporular sac has a very different insertion and origin from that of these plants, being almost invariably traversed by an intruded duplicature of itself, called the columella, and being attached to the walls of the sporangium by a delicate confervoid arachnoid tissue, of which these fossils present no traces.

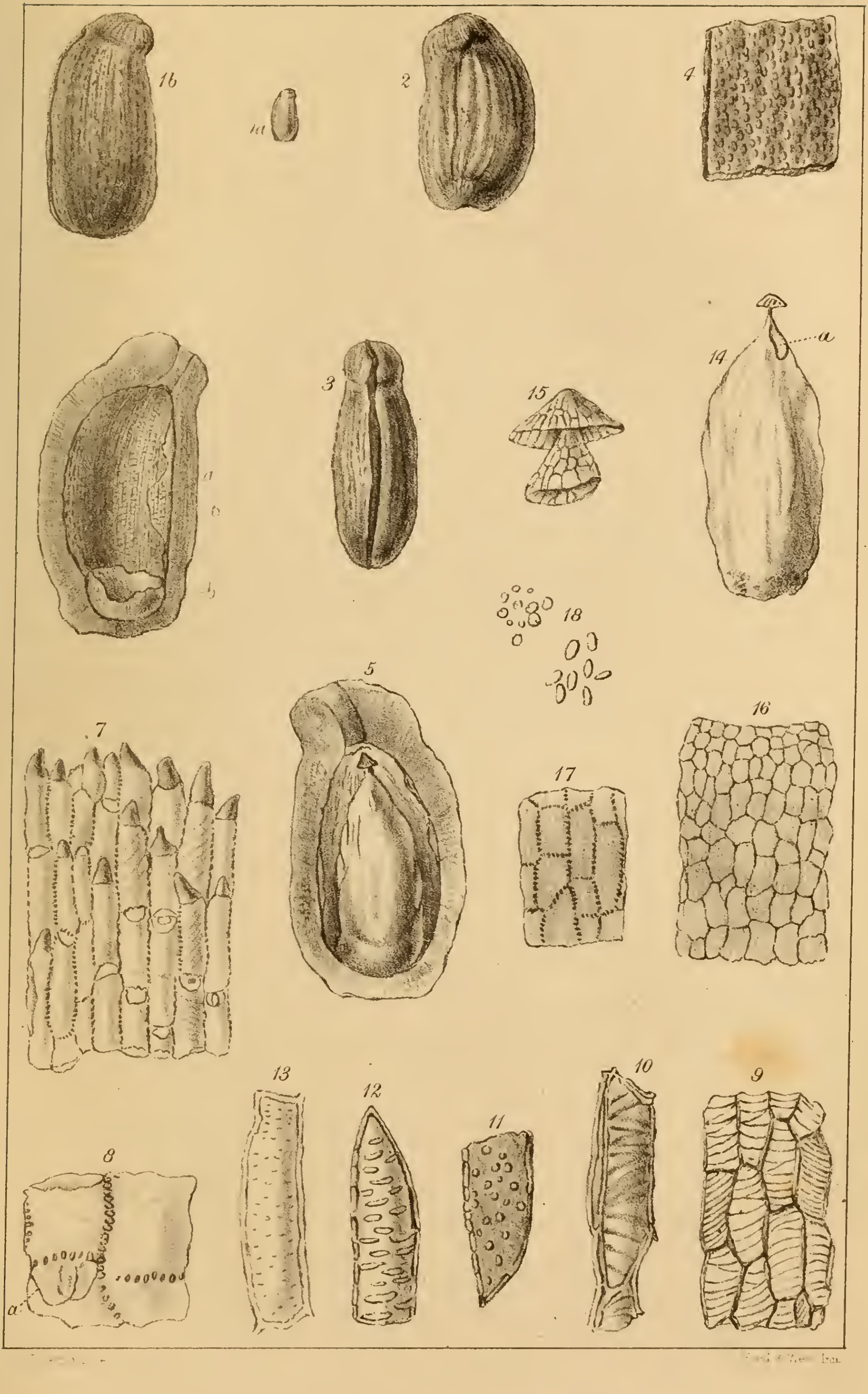
The apical dehiscence of the inner sac of *Folliculites* and the lateral dehiscence of that of *Carpolithes* do not form valid objections to the alliance with *Musci*, though unknown in that Order. The porous and barred cells of *Folliculites* may be considered analogous to the curious cellular tissue of *Sphagnum* leaves; but there is in Mosses no known analogue of the vascular bundle of *Carpolithes*.

Upon the whole I think it probable that these bodies may have belonged to a group of plants more nearly allied to Ferns than to any known living Order, if not absolutely belonging to the Filicoid alliance; and, considering how little we know of these fossils on the one hand, and, on the other, the very great diversity of form and anatomy in the sporangia of Ferns, it appears to me to be unadvisable to found upon these specimens an independent family. Added to this is the fact, that the recent discoveries in the reproductive organs and mode of germination of the Cryptogamic plants generally have thrown a light upon these families, which tends rather to enlarge our views of their limits than the contrary.

DESCRIPTION OF PLATE XVII.

(All the figures except 1 *a* are more or less highly magnified.)

Fig. 1, *a*. *Folliculites minutulus*, natural size; 1, *b*. the same magnified.
Fig. 2. Magnified view of another specimen.
Fig. 3. The same, presenting the dehiscing face.
Fig. 4. Portion of the outer wall of the sporangium.
Fig. 5. Vertical section of the sporangium, showing the position of the sporular sac.
Fig. 6. Vertical section of another specimen, showing the inner lining membrane (*a*) and the base of the sporular sac (*b*), the upper part of which has been removed.
Fig. 7. Portion of the lining membrane, formed of cylindrical turgid cells with often convex bases and conical opaque apices.
Fig. 8. More highly magnified view of a portion of the same, showing at *a* the convex base of a cell.
Fig. 9. Portion of a fragment of a membrane that appeared to line the cavity of another specimen, but which I suspect was originally beneath that figured at 7.
Figs. 10–13. Various cells with dots, perforations, &c. in their walls, or transverse bands, and which appeared to underlie the superficial membrane of the cavity at different parts of the sporangium.
Fig. 14. The sporular sac; showing its acuminate apex with the oval opening (*a*) below it, and above the opening the remains of the membrane that lined the base of the canal at the apex of the sporangium.
Fig. 15. Very highly magnified view of the apex of the sporular sac, &c.
Fig. 16. Membrane of the sac.
Fig. 17. A portion of the same, showing the beaded appearance of the cell-walls.
Fig. 18. Spherical and oblong sporules?



FOLLICULITES MINUTULUS
from Bovey Tracey

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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 NUMMULITIC, CRETACEOUS, *and* JURASSIC TERRAINS *of the* MARITIME ALPS, *near* NICE. By Prof. A. PEREZ.

[Sui Limiti Geognostici del Terreno Cretaceo delle Alpi marittime, per A. Perez. Estratto degli Atti dell' otava Riunione degli Scienzati Italiani in Genova; Sezione di Geologia; Seduta delli 23 Settembre 1846. 8vo. Nizza, 1853, pp. 15.]

IN the writings of Sismonda * and Pareto † the Cretaceous terrain of the Maritime Alps is represented as consisting—its upper part, of the Alpine nummulitic terrain,—and its lower, of the yellow compact limestone of the neighbourhood of Nice and the deposits intermediate to this and the nummulitic rocks. To elucidate this subject, I think it necessary to commence by tracing the arrangement and succession of these strata, referring both to the labours of the above-named geologists, and to the additional observations made by myself.

Nummulitic rocks.—The series of nummulitic rocks, so prevalent in the Maritime Alps, is considerably developed at Mortola, where it was observed long ago by De la Beche ‡, and since described with much exactness by Pareto in his 'Description of Genoa.' Having visited this locality for the purpose of comparing it with those of Pallarea, Fontana Giarrié, Contes, Braus, Villanova (Provence), Berra, Poggetto, and Roccasterone, I could not find any other difference between the nummulitic terrain of Mortola and that of the above-cited places, than what would arise from the greater or less development of the series, or from the absence of one or more of its members. The order, the fossils, the relations, and the characters are identical.

Not wishing to repeat what can be read in the 'Description of Genoa,' I shall not describe the upper part of this terrain, but will confine my observations to its lower portion, which, lying upon the

* Osservazioni Geologiche sulle Alpi marittime e sugli Apennini Liguri. 1841. See also Classificazione dei Terreni stratificati delle Alpi tra il Monte Bianco e la Contea di Nizza; Mem. R. Accad. Sc. Torino, ser. 2. vol. xiii. 1851.—TRANSL.

† Liguria marittima. Descrizione di Genova, art. Geologia; in the "Guide" presented to the Members of the Italian Scientific Association at the meeting in Genoa in 1846.

‡ Trans. Geol. Soc. London, 2nd ser. vol. iii. pt. 1.—TRANSL.

evidently Cretaceous terrain, may show us whether it ought to be united to it or not.

On the Belenda Hill, above Mortola, and in its neighbourhood it is difficult to follow the stratification on account of the irregularities of the surface, the contortions of the strata, and their various foldings. On the top of this hill, however, to the N.E., we can distinguish—1. The cretaceous marly limestone with *Inocerami* and *Hamites*; 2. Overlying nummulitic strata. Conformably on the latter lie, 1st, strata full of fossils, identical with those of the Fontana Giarrié, which are noticed by Bellardi in Prof. Sismonda's Memoir on the Maritime Alps; 2ndly, other strata with various *Nummulites* (as we shall again find at Capo di Mortola); 3rdly, above these, marls and sandstones; and 4thly, macigno and limestones.

These strata are folded back towards the S.E., and are reproduced with their regular development at the Croce di Mortola, where, by a local disturbance, the strata with *Nummulites* are covered unconformably by the fossiliferous strata which we have above noticed.

It is easy to see that this unconformability depends on a local displacement, if we follow the direction of the strata from the Croce di Mortola as far as Capo Omonino, where they dip into the sea near the estate of Grandis. There I noticed the following parallel series of strata, from below upwards:—

A. { 1. The bluish marly limestone with *Inocerami* and *Hamites*; without any trace of *Nummulites* or other fossils common to the overlying beds.

B. { 2. Strata containing *Nummulites* from thirty to a few millimetres in diameter, and gibbous on both surfaces.
3. Strata with whitish fossils (Zoophytes predominating), analogous to those of Fontana Giarrié, Blosasco, Pallarea, &c.
4. Strata containing *Ostreæ* about 20 centimetres in diameter (perhaps the *Ostrea latissima* of Deshayes?).
5. Strata with flat *Nummulites*, about 20 millimetres, more or less, in diameter.
6. Strata containing minute bodies possibly referable to *Nummulina* of D'Orbigny,—flat, circular, thin, and bearing a central tubercle on one of their faces.
7. Strata with small *Lenticulites*, analogous to those of Beaulieu near St. Ospizio.
8. Strata containing a mixture of flat *Nummulites* and of the species referred to in No. 6, &c.

Disseminated in the greater part of these strata [B.] we have the *Spirulea nummularia*, Bronn [*Serpula spirulea*, Lamk.], and other fossils which we cannot here notice, but which will be treated of by M. Bellardi*.

These strata consist of a psammite, more or less brown, and varying in its character.

* See "List of the fossils from the Nummulitic Rocks of Nice," by M. Bellardi, Bullet. Soc. Géol. France, 2 sér. vol. vii. p. 678.—Transl.

I insist then on the perfect agreement of these nummulitic strata amongst themselves (and especially with that containing zoophytes and full of whitish fossils, which at the Croce di Mortola I described as being unconformable by a local displacement), that these inferior strata with *Nummulites* may not be dismembered, nor united with the underlying cretaceous limestone [A.].

This order of the strata is repeated at the Fontana Giarrié with the same fossils.

The same succession is observable at Poggetto, Contes, Roccasterone, &c.; places where I have collected—with MM. Bellardi, Wandenhecke, Caillaud, Dr. Baudoin, Major Charters, and others—more than a hundred species of fossils, the majority of which are referable to supercretaceous forms, according to MM. Deshayes, Defrance, Michelin, and Bellardi. At Blosasco Count Saisi of Nice found a *Nerinæa* in the nummulitic strata; and some cretaceous fossils found in this terrain are noticed in Prof. Pilla's work; but their number is very small.

At Braus only the stratum comparable to that above indicated by No. 2 has been observed. More exact research, however, may enable us to find the others also. I have there ascertained that the nummulitic terrain reposes on the marly limestone with *Inoceramus* quite unconformably,—a fact already noticed by Professor Sismonda, and observed by him and Bellardi at Poggetto, Roccasterone, and La Penne.

The limestone with *Lenticulites* at Beaulieu ought to be collocated with the nummulitic strata of Mortola, of which it represents the strata marked No. 7. And in fact, if this be tertiary, as the Marquis Pareto is inclined to think, with it ought to be arranged the nummulitic series of Mortola and of all the Maritime Alps, from which it cannot be separated:—a fact proved by the marls that cover this limestone, which abound with *Foraminifera* common to the nummulitic marls.

A deposit, moreover, which I visited at the Torrent Lupo, in Provence, ought I think to be referred to the Alpine nummulitic terrain, and should be regarded as analogous to the stratum marked No. 6, both from the fossils which it contains, and from the nature of the rocks which overlie it. In examining these rocks we find a considerable development of marls and sandstones, which call to mind the portions immediately above the nummulitic strata in other parts of the Maritime Alps. Further, these sandstones are here covered by Sub-Apennine tertiaries, with the usual development of bluish marl and of conglomerate.

Cretaceous rocks.—Without the intervention of the Hippurite-limestone with Nummulites, the absence of which at Nice and on the Ligurian coast has been demonstrated by M. Ewald, the Alpine nummulitic terrain generally lies upon a marly limestone, sometimes full of green points, &c., the characters of which have been well described in detail by MM. Sismonda, Pareto, and others. In this no Nummulites have been found; but, on the contrary, the following cretaceous species—

Inoceramus mytiloides.
—— Cuvieri?
Ananchytes ovatus.
Micraster arenatus.
—— cor-anguinum; &c.
Gryphæa columba.
Nautilus triangularis.
Ammonites varians.
—— Woolgari.
Ammonites Rhothomagensis.
—— Mantelli.
—— falcatus.
—— Fleuriausianus; and others.
Scaphites æqualis.
Baculites baculoides.
Turrilites costatus.
—— Gravesianus; and others.

This is a mingling of the fossils of the white and the chloritic chalk, contained in numerous strata constituting a well-developed terrain, which ought, indeed, from its uniform characters and the relations of its parts to be regarded as single and indivisible.

At the geographical limits of this terrain we find cropping out two strata of sandstone (of a green colour from the grains of glauconite abundantly disseminated in the rock), which separate it from the underlying compact yellow limestone.

These two strata of green sandstone are naturally disconnected from this terrain,—1stly, by the distinct separation at their line of contact; 2ndly, more especially by the fossils that characterise them.

The first of these strata contains at the Madonna di Laghetto, the plain of Eza, and the Rayet near Monte Calvo the characteristic *Ammonites* of the Gault: the fossils are,—

Ammonites Lyellii.
—— mammillaris.
—— Roystianus.
—— Delaruei.
—— interruptus.
Ammonites Beudanti.
—— latidorsatus.
Discoidea subuculus; and others.

The second stratum affords characteristic lower neocomian fossils. It is to be recognized by the little flattened oval oolitic grains of hydrated iron; and is characterized at Monte Calvo, S. Lorenzo di Turbia, the Fosse di S. Ospizio, Toretto, Col di Revello, &c., by the following fossils:—

Ammonites Astierianus.
—— cryptoceras.
—— difficilis.
—— Leopoldinus.
—— heliacus.
—— Ixion.
Ammonites radiatus.
—— angulicostatus; and others.
Crioceras Emerici.
Belemnites dilatatus.
—— subfusiformis; and others.

These two strata almost always occur in separate localities; they have a development of from one to a few metres, and lie conformably on the compact yellow limestone.

Major Charters has visited some of these localities, and, to my satisfaction, has arrived at the same conclusions.

Jurassic rocks.—Beneath these green sandstones lies the dirty-yellow compact limestone, more or less dolomitic, which forms the flanks and the crest of the principal mountains above Nice, and along a considerable tract of country in Liguria to the West.

This limestone is considerably developed; and, without overstepping the truth, it may be estimated at above 1000 feet in thickness.

The agents which have metamorphosed it—sometimes into gypsum, sometimes into dolomite—have not so obscured its stratification but that it may be seen with difficulty in a few places.

To M. Sismonda's reasoning on the original cause of the production of the gypsum of this limestone, I will add a fact of some weight; namely, the alteration which the rocks of the chloritic chalk lying above this limestone have undergone in the gypsum pit of S. Rosalia, where, although very much deranged and altered, they can still be recognized; and I note this fact as opposed to the conclusions which might be drawn from the perhaps not too exact observation of M. Tchihatcheff, who described his having seen the gypsum lying in strata above the compact limestone at Monte Morone.

The disturbances which this terrain has suffered render it somewhat difficult to recognize the order and arrangement of its parts.

It appears to me possible to divide it into three portions;—the uppermost is characterized by numerous *Zoophytes* (as at the Faro, where it is soon covered up by the neocomian sandstone);—the middle division is very dolomitic, and especially contains *Nerinæa*;—the lowest contains the majority of the *Ammonites*, of which the following is a list:—

Ammonites biplex.
—— multiradiatus.
—— tortisulcatus.
Ammonites flexuosus.
—— Kœnigii.
—— subfascicularis.

To the above list may be added others which are referable to the section "planulati," but the species of which are not recognizable. Other fossils* are:—

Belemnites (indeterm.).
Nerinæa Wisurgis, *Rœm.*
Terebratula perovalis, *Sow.*
Terebratula globosa, *Sow.*
—— maxillosa, *Sow.*

Also several *Echinodermata*, which are regarded as jurassic by M. E. Sismonda, who has also collected from this limestone some indeterminable fragments of an Apiocrinite and a Pentacrinite.

These fossils were collected at the foot of Monte Calvo in the Valley of S. Andrea, at the foot of the hill of Rovello, at S. Ponzio, at Monte Albano, and at the hill of Turbia near S. Lorenzo. In some of these localities we collected them in company with Major Charters.

The supposed absence of jurassic fossils in this limestone,—its having analogous mineral characters with the neighbouring rocks of the Cheiron, and other reasons derived from position,—and especially the [presumed] affinity of some of its fossils with the neocomian, were the reasons that induced M. Sismonda to regard it as neocomian, and to remove it from the jurassic series, with which De la Beche and Buckland† had placed it. Some geologists indeed are still inclined to take this view.

* I am indebted to Baron von Buch for the determination of the jurassic Ammonites, and to M. Bellardi for that of the other fossils of this terrain.

† Trans. Geol. Soc. 2 ser. vol. iii. p. 183 *et seq.*—Transl.

The fossils that favoured this opinion are,—

The *Ammonites subfascicularis*, D'Orb.; found by Sig. Prof. Cav. Sismonda in several localities in the county, and by me in the Valley of S. Andrea, together with *A. tortisulcatus*, D'Orb. This species was afterwards referred by D'Orbigny to the jurassic series.

Ammonites virgatus; cited by Sismonda with some doubt*.

An *Aptychus*; determined by M. Bellardi as the *A. Didayi* (Coquand); but in this fossil M. Bellardi afterwards found some differences from the true *A. Didayi* in the number and direction of the costæ, on comparing it with a well-preserved individual of that species.

Ammonites Ixion, *Belemnites dilatatus*, *B. pistilliformis*, and *B. subfusiformis*; these were really found in the greenish neocomian sandstone, which some would unite with this limestone, which occurs in the same localities.

General inferences.—Reasoning upon what I have here brought forward, it appears to me possible to arrive at the following conclusions:—

1. That the macigno in the Maritime Alps is always superior to the nummulitic strata.

2. That the nummulitic terrain in the different localities of the Maritime Alps above cited is identical in age and character, if not in development.

3. That of the fossils which it contains, the greater part are Eocene, some are peculiar to it, and some are Cretaceous.

4. That it is perfectly distinct in its characters from the cretaceous strata on which it reposes,—sometimes unconformably; and consequently that it cannot be classed with them.

5. That the Hippurite-limestone with Nummulites may sometimes possibly be in contact with the nummulitic terrain in the South of France, and in other places, but that the two groups have no character in common, except the presence of the genus *Nummulites*,—and not the species, as was supposed by Prof. Pilla.

6. That, if a few fossils be sufficient to characterize a deposit, a larger number are more decisive; whence it follows that, taking into account the numerical proportion of species, the Alpine nummulitic terrain should be referred to the eocene and not to the cretaceous period, very few fossils referable to the latter having as yet been discovered in the localities above-mentioned, and some even of these are doubtful.

7. That the Alpine nummulitic terrain ought from its characters and fossils to be classed as intermediate between the cretaceous and the supracretaceous, as MM. Pilla and Leymerie think; or at least it should be united with the tertiary series as a lower member, but quite detached from the chalk, as M. Michelin has suggested.

8. That the marly limestone with *Inocerami*, *Am. Mantelli*, *Am.*

* Notizie e schiarimenti sulla costituzione delle Alpi piemontesi del Prof. Sismonda, p. 89.

varians, *Gryphæa columba*, &c. ought to be regarded as the upper cretaceous terrain, to distinguish it from the gault, which I shall designate middle chalk; and from the neocomian, which forms the lowest portion of the cretaceous series.

9. That the Gault, although little developed, constitutes a terrain of itself, and represents the middle chalk of the Maritime Alps.

10. That the Neocomian terrain finds its representative only in the greenish sandstone characterized by lower neocomian fossils.

11. That the compact yellow limestone not so characterized, and subjacent to the lower neocomian, is Jurassic; a conclusion rendered necessary by the jurassic fossils found in it.

12. That the Cretaceous terrains of the Maritime Alps* are limited above by the marly limestone with *Inoceramus*, *Hamites*, &c., and below by the greenish neocomian sandstone, both inclusive.

[T. R. J.]

On the Metamorphism *of* Rocks. By M. J. Delanoue.

[L'Institut, 1854, p. 285. Leonhard u. Bronn's N. Jahrb. f. Min. u. s. w. 1854, p. 731.]

The author disapproves of the immoderate application of the hypothesis according to which silica, natron, and even felspar have been driven out from the interior of the globe to silicify and felspathize not only the strata lying in their immediate vicinity, but even single beds of rock intercalated between others,—or according to which magnesia has penetrated this or that rock, or converted a part of a limestone into dolomite. He does not deny the outbreak of molten rocks from the interior of the earth, and the effect of their heat on the sedimentary rocks at the point of contact, whereby the latter may have been calcined, and reaction may have taken place among their constituent parts, or many of them may have been volatilized. Thus "the volcanic rocks are formed by the *surfusion* of the felspathic rocks; anthracite and graphite by the heating or calcining of fossil plants, &c. But there is no proof that the porphyries must give up alkalies, or the serpentines carbonated magnesia to rock-masses broken through by them. Thus in the Ligurian Alps the serpentines have upraised limestone strata, almost without altering, or at least only fracturing them. Nowhere do we see proofs of the integral chemical change of the whole of a rock or series of rocks."

* The region which bears the general name of "Maritime Alps" extends west and east from near Colmar in France to Capo di Noli, a distance of about 90 miles (English); and to the northward it has a width, on the parallel of Cuneo, of about 50 miles.

The principal maps of this district are two.—1. The great Trigonometric Survey, "Carta Topografica," on a scale of $\frac{1}{30,000}$th of nature: the result of operations described in two elaborate volumes 4to. This map occupies ninety (engraved) sheets, and must be an excellent basis for geological survey. 2. A reduction of the great map to a scale of $\frac{1}{250,000}$, in six sheets. (" Carta degli Stati di sua Maesta Sarda, in terra ferma; opera del Real Corpo di Stato Maggiore; incisa, etc. 1841.") The scale of this reduced map is very nearly 4 miles to an inch (English).—Transl.

It appears far more natural to admit that the elements of the metamorphic rocks already existed in them, and have not been introduced. Certain sedimentary dolomites and limestones have evidently undergone a fusion and subsequent crystallization (St. Gothard). Chiastolite, Felspathic-granites [?], and many other silicates may have at any time been produced by the intense heating of sedimentary rocks in which their constituent elements were already present. Felspar crystals originate where the sedimentary rock contains the aluminous alkali-silicates of the pyrogenous rocks from the destruction of which it has been formed.

The author indicates a new origin for felspar by the wet method. This soluble combination, which is formed in the laboratory by the precipitation of alumina with the natron-silicates, occurs also in the clays, in spite of the solubility of the soda, and must have necessarily been precipitated in the earliest times from all the ancient seas so rich in kali- and natron-silicates. The presence of these alkali-silicates has given rise to the immense quantity of quarzites, jaspers, and flint-rocks, which are so abundant in the oldest formations.

These quarzites, jaspers, felspars, &c. have been precipitated chemically with all sediments, and their predominance in certain places of the sedimentary rocks has rendered them so homogeneous and hard, that recourse has been had to the hypothesis of an extensive metamorphic felspathization:—as for instance in the case of the greywacke of the Vosges. [T. R. J.]

On Childrenite*. By C. Rammelsberg.

[Poggendorf's Annal. lxxxv. p. 435, &c.; and Leonh. u. Bronn's N. Jahrb. f. Min. u. s. w. 1854, p. 322.]

This mineral occurs in a vein in the George and Charlotte Mine near Tavistock in Devonshire, with spathose iron, quartz, and copper-pyrites. It is also stated to have been found near Callington in Cumberland. Form, rhombic octohedron; the side angles, according to Brooke, =97° 50′, the sharper terminal angles =120° 30′ [? 102° 30′], the blunter 130° 20′. Combinations, several. Colour, yellowish and blackish brown, and blackish. Transparent. Lustre, brightly vitreous. Hardness =5. Powder, yellowish. Specific gravity, from 3·247 to 3·28. Composition:—

Phosphoric acid	28·92
Alumina	14·44
Oxydulated iron	30·68
Oxydulated manganese	9·07
Magnesia	0·14
Water	16·98
	100·23

Formula:—$(2\dot{R}^4\overset{\cdot\cdot}{\overset{\cdots}{P}}+\overset{\cdots}{Al}^2\overset{\cdot\cdot}{\overset{\cdots}{P}})+15H$. [T. R. J.]

* See also Brooke, Quart. Journal of Science, vol. xvi. p. 274; and Brooke's and Miller's Mineralogy, p. 521.—Transl.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

Mineralogical Researches *in the District around* Arendal *and* Krageroe *in* Norway. By David Forbes, F.G.S., A.I.C.E., and Tellef Dahll, Cand. Min.

[Mineralogiske Iagttagelser omkring Arendal og Krageroe, &c.; abridged from the Norske Magazin for Naturvidenskab, vol. viii. part 3, 1854.]

This paper is the first of a series of observations on the mineralogy of the line of coast connecting the towns of Arendal and Krageroe in Norway, and contains notices of several new minerals, as well as additions to the mineral geography of this district.

Some points connected with the development of minerals in connexion with the granitic rocks appear of sufficient interest to warrant an abstract of this part of the paper, without going into the more purely mineralogical details which form the bulk of the communication.

The district itself is composed entirely of the older rocks, principally gneiss, which shows itself in many varieties. The general strike was found to be from 60° N.W. to E. and W., or about parallel to the main line of coast.

The dip was extremely variable, and at all angles from 13° up to 90°, S.E. to S., and up to S.W.

Mica-gneiss was found most normal in Dybvaag, consisting there of red orthoklase, grey quartz, and black mica.

Felspar and mica became more sparingly distributed towards Krageroe, and there hornblende and quartz were found more prominent, and often as distinct rocks; on the other hand, nearer Arendal, felspar was much more abundant, and was generally present as potash-felspar, whereas at Krageroe soda-felspar was the more common.

The results of these researches appear to prove that the occurrence of minerals in these rocks is due almost exclusively to the appearance of granite, which therefore formed a special subject of investigation, and is divided into two classes:—

A, when occurring as veins, or imbedded in the course of strata.

B, as nodules or irregular masses.

It was found that this classification was not only consistent with the external form of the granitic masses, but was also visible in their internal structure and mineral contents; since the former of these varieties was seldom found to contain extraneous minerals, whereas the latter was generally rich in such.

With regard to the first of these classes, reference can be made to the paper itself, with its illustrations*, from which it would appear that this granite shows itself in veins of all sizes, cutting through, or imbedding itself in, the gneiss, and generally possessing a much finer grain and more confused development than the other variety.

The second class is treated more in detail, as being particularly favourable to the development of extraneous minerals. The first symptoms of the appearance of such granite seem to be where there is seen here and there in the crystalline schists small nodules of white quartz, of reddish-grey orthoklase, or of yellowish-white oligoklase, of a greater size than the particles composing the rock itself.

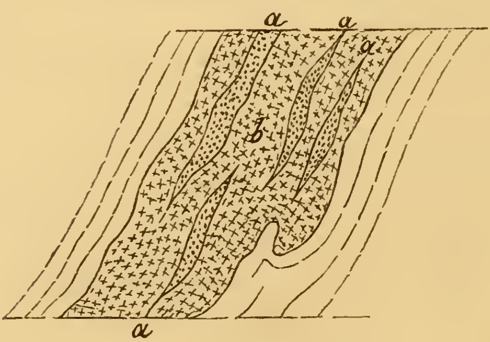
Still further developed, as can be seen at Grönholmen, Flougstadöen, &c., these nodules are composed of one or both species of felspar, along with quartz and mica, in particles varying in bulk up to the size of the fist; the laminæ of the gneiss bend round the nodules, like the woody fibre surrounding a knot in timber.

When the size of these nodules increased, it was found that the particles of their constituent minerals also became larger, less intermixed with each other, and of better crystalline development; and further, that extraneous minerals were found more frequently present in proportion to such increase of size.

The appearances presented by such granitic masses, with their progressive development, will be better seen from a few of the illustrations which are here subjoined.

Fig. 1 is a horizontal plan of part of an irregular granitic mass in

Fig. 1.—*Ground-plan of a granitic mass, with quartz-nodules, in gneiss at Kalvesund.*

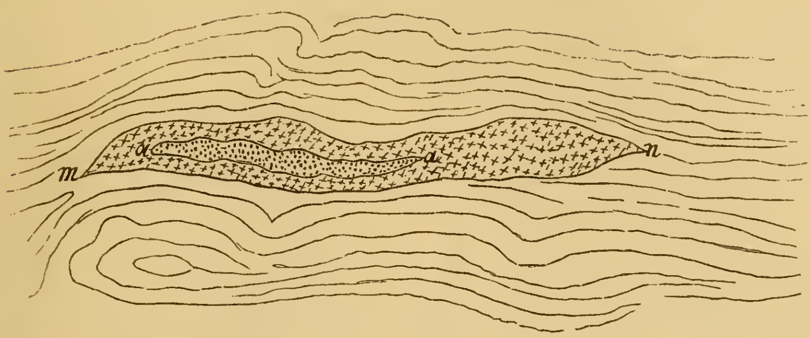


the gneiss at Kalvesund. Lenticular masses of quartz (*a*, *a*) are here seen surrounded by a mixture of orthoklase and mica.

At Flougstadöen also is seen a similar case (fig. 2), where a nodule of quartz (*a a*) is surrounded by a mixture of the same com-

* In Plate III., Norske Mag. f. N. vol. viii. part 3; some of the figures of which are here reproduced as woodcuts.—Transl.

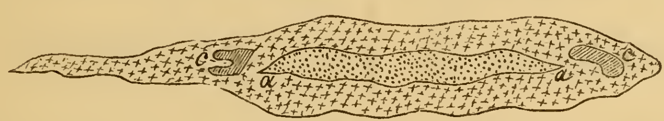
Fig. 2.—*Ground-plan of a granitic mass, with a quartz-nodule, in gneiss at Flougstadöen.*



position as before, and the whole forms an irregular mass (*m, n*) in the gneiss, and disturbs the foliation of this rock.

Fig. 3 is a sketch drawn on an island near Ebo, where, as before, *a, a,* is a lenticular quartz nodule, surrounded in this case by a mixture of white oligoklase and chloritic mica, which also encloses the fragments *c, c,* evidently portions of the hornblendic gneiss which forms

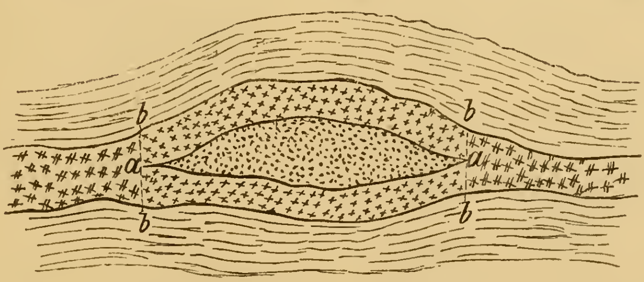
Fig. 3.—*Ground-plan of a quartz-nodule in a granitic mass, with fragments of the enclosing rock, from near Ebo.*



the surrounding rock ; several minerals are found here.

On a much larger scale than any of these, fig. 4 represents the section of the quartz quarry at Buoien ; here we have a large mass of quartz, *a, a,* which is quarried for technical purposes, surrounded

Fig. 4.—*Section of a Quartz Quarry at Buoien, showing a lenticular mass of quartz enveloped with granitic rock imbedded in gneiss.*



by a sheath of rock, which, within the lines *b b, b b,* is composed of orthoklase, with a few large plates of black mica. At the point of contact with the quartz, the orthoklase is often found in large and sometimes defined crystals of several cubic feet contents.

Beyond the lines *b b*, *b b* the orthoklase is less developed, becomes mixed with about as much oligoklase and quartz, and then forms a graphic granite, which at other parts, by the addition of mica in small plates, puts on the appearance of ordinary granite.

Orthite, Zircon, Malakon?, Oerstadite?, Apatite, Yttrotitanite, Magnetite, &c., were found here.

The finest representation given of the structure of such granitic masses is shown in the vertical section of the felspar quarry at Helle near Næskilen (fig. 5). The scale may be judged of from the section itself, which at the highest point is about 15 feet. The felspar is here quarried for technical purposes.

On the surface is seen a covering of gneiss, not more than from 1 to 2 feet thick, showing a regular and nearly perpendicular foliation; below this we have on the one hand (*a*) orthoklase graphic granite, and on the other (*b*) oligoklase graphic granite.

Still lower, the constituent minerals of the granite, viz. quartz (*r*), orthoklase (*o*), and mica (*x*), are developed on an immense scale; the mica, even, being in plates of enormous size and of many square yards area. The masses of quartz and orthoklase here found sometimes show traces of crystalline faces.

Underneath the whole we have graphic granite (*m*), going over to ordinary granite of a fine grain.

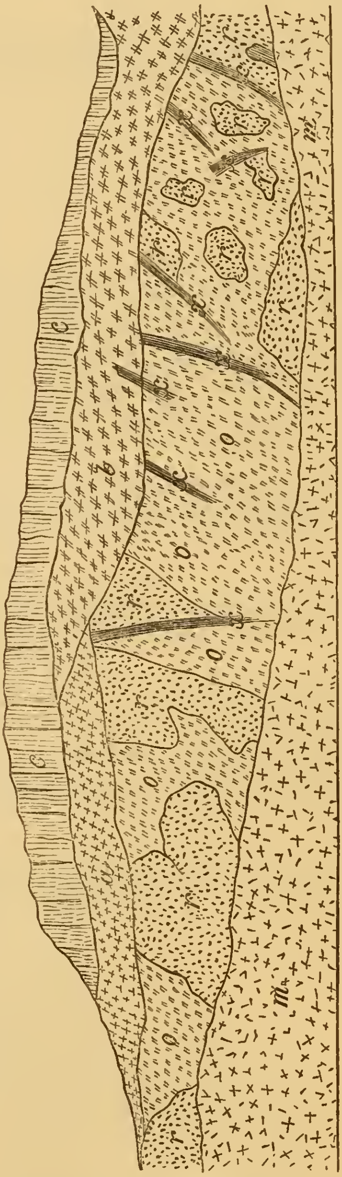


Fig. 5.—*Section of a Felspar Quarry at Helle.* Height of section 15 feet.

a, graphic granite with orthoklase.
b, graphic granite with oligoklase.
c, *c*, gneiss.
m, graphic granite passing into ordinary granite.
x, mica.
o, orthoklase.
r, quartz.

Several minerals occur here, and amongst others may be mentioned two new minerals called Alvite and Bragite, as well as Orthite in crystals and masses up to the size of 14 to 15 lbs.

From the observations made in various parts of this district it would appear that the mica present in such granite has a very determinate relation to the occurrence of extraneous minerals, which were almost invariably found either in close connexion with, or often imbedded in, the plates of mica. It was likewise remarked, that the quartz, when in contact with large plates of mica, became of a smoke-brown colour, which otherwise it was never found to possess; also that the felspar often became of a darker colour, and was then generally accompanied by some rarer mineral.

Various observations seem to prove that both the felspar and the mica have crystallized before the quartz; the mica-plates apparently floating about in a solution from which the quartz had subsequently crystallized.

Beyond the abstract here given, the remainder or greater part of the communication treats of the minerals separately, with regard to locality, mode of occurrence, crystalline character, and chemical constitution; and is of such length that reference on these points must be made to the paper itself. It may be mentioned, however, that four new minerals, called Alvite, Tyrite, Urdite, and Bragite, are announced; the chemical examination of which shows the presence of very rare chemical elements; also that three of them contain a considerable amount of water, notwithstanding their being situated in granite of igneous origin. [D. F.]

On the Echinodermata *of the* Hils-Conglomerate *in* North-Western Germany. By A. von Strombeck.

[Leonhard u. Bronn's N. Jahrbuch f. Min. u. s. w. 1854, p. 641–656.]

Among the characteristic fossils of the Hils-conglomerate in the Northern Hartz and in Hilse, the *Echinoidea* are some of the most important, partly on account of peculiarity of form, and partly from their abundance; and as yet they have not received sufficient attention. Hence it happens that geologists, though well acquainted with the rich variety of the Neocomian *Echinodermata* of Switzerland and France, remain still in doubt with regard to the place of the Hils-conglomerate (although indeed A. Roemer, in his work on the Chalk-formation, has already referred it to its true geological horizon). For this reason M. v. Strombeck was induced to determine with precision the species from the Hils-conglomerate; more especially as he possessed for comparison some good suites of Neocomian fossils from Neuchâtel, Ste. Croix (Jura Vaudoise), Mont Salève near Geneva, Censeau (Dep. Jura), Escragnoles (Var), Castellane (Basses Alpes), &c., with which he was favoured by geologists living near those localities; and further, since M. Desor, one of the best authorities on the *Echinoidea*, had lately revised the Hils-conglomerate species in M. v. Strombeck's collection, some of which were represented by fifty and more specimens. The determinations may therefore be considered as correct.

At the same time M. von Strombeck in this paper furnishes some remarks on the Lower Cretaceous beds near Brunswick; his intended memoir on this subject requiring more time for its completion.

The whole of the Hils-conglomerate does not contain fossil Echinoderms. In the fullest development of the Conglomerate, where it does not pass into one bed, the upper part contains no trace of Sea-urchins, although it has many fossils common also to the lower portion. The *Echinoidea* are confined to the older part. Here there are in one and the same horizon two different *facies*, passing however one into the other; the one is full of *Spatangoidæ*; the other in its typical development exhibits only *Cidaris* remains.

The *Spatangoidæ facies* occurs in the Brunswick district, on both sides the Asse (Berklingen, Gross-Vahlberg, Gevensleben, between Denkte and Wittmar, &c.),—on the Oesel (particularly at the spot called Busche),—on the Fallsteine (Achim and Wetzleben),—and between Goslar and Harzburg on the northern side of the Hartz.

The *Cidaris facies* is seen on the southern brow of the Elms (Rautenberg, near Schöppenstadt),—on the heights near Apelnstadt and Salzdahlum, between Brunswick and Wolfenbüttel,—on the Oesel (Kissenbruch sand-pit),—and near Schandelah.

When the Hils-conglomerate is not divisible into upper and lower, it either contains no *Echinites*,—as at Bohnencamp near Querum, not far from Brunswick (here the Neocomian sandstone of the Teutoburger Wald, described by F. Roemer, appears to belong),—or only the *Cidaris*, as at Elligserbrink, not far from Delligsen in Hilse.

With regard to its stratigraphical position, the Hils-conglomerate in the Northern Hartz lies on the jurassic strata (the lower, middle, or upper, according to the several localities), and in the Hildesheim district it rests on the Wealden. It is generally overlaid by a thick mass of clay, which in its fullest development presents the following members, from below upward:—

1. Clay with the fossils of the Speeton Clay, as cited by Phillips,—but leaving out the Gault forms, &c.

2. Clay with *Belemnites semicanaliculatus*, Blainv. (according to D'Orbigny), and *Ammonites Nisus*, D'Orb.;=the Gargas-marl = Aptian.

3. Lower Gault Clay, poor in fossils; locally replaced by a littoral formation, the Subhercynian Lower Quader-sandstone.

4. Upper Gault Clay with *Ammonites auritus*, Sow., *Belemnites minutus*, Lister. (See Zeitschr. d. Deutsch. Geol. Gesellsch. vol. v. p. 501.)

Still higher are variegated marls [flammen-mergel], pläner, and lastly argillaceous and sandy marls (the latter with *Bel. mucronatus*) of the age of the White Chalk.

The clays nos. 1 to 4 were comprehended in the term "Hilsthon," given by A. Roemer before it was known that any of them possessed a distinct and characteristic fauna, the publication of which M. von Strombeck reserves to himself. The rich fossiliferous bed at Elligserbrink, 4 to 12 feet in thickness, which Roemer likewise included in it, is, as above mentioned, decidedly Hils-conglomerate.

M. von Strombeck proceeds to describe (pp. 463–652) the species of *Echinodermata* peculiar to the Hils-conglomerate, and to point out their synonymy, alliances, and localities.

The following are the species of *Echinoidea* that have been found in the Hils-conglomerate and determined with precision.

	Comparative abundance.	From the Middle Neocomian (*Marnes d'Hauterive*) of the country around Neuchatel.	Cited by A. Gras from the Lower Neocomian of d'Orb. (*Marnes d'Hauterive*) of the Dép. de l'Isère.	Cited by Marcou from the *Marnes d'Hauterive* of the neighbourhood of Nozeroy (Dep. Jura).
Toxaster complanatus (*Gmel.*), *Ag.*	cc.	...	...	...
Holaster Hardyi, *Dub.*	cc.	...	...	...
Dysaster ovulum, *Ag.*	r.	...	...	...
Pygurus Montmollini, *Ag.*	rr.	*	...	
Nucleolites Olfersii, *Ag.*	c.	...	...	...
—— Gresslyi, *Ag.*	r.	...		
Pyrina pygæa, *Desor*	c.	...	...	...
Holectypus macropygus, *Desor*	r.	...	...	...
Diadema rotulare, *Ag.*	r.	...		...
—— Bourgueti, *Ag.*	rr.	...		...
Cidaris punctata, *Roem.*	cc.	†		...

All these species, except the last one, occur together more or less frequently; but exclusively in the lower Hils-conglomerate. The last species (*Cidaris punctata*) is rare in the same localities, but is extremely abundant where the beds contain no other Urchins.

M. D'Orbigny has recently divided the Neocomian into two stages,—the lower, or Neocomian proper,—and the upper, or Urgonian. The Swiss geologists again divide the lower portion into two members,—the lower and the middle Neocomian, represented by the Marnes d'Hauterive and the yellow limestone ‡ which underlies it.

According to a letter from M. Desor, the Lower Neocomian is characterized by *Toxaster subquadratus*, *T. Campichei*, and *Pygurus rostratus*; the upper, by *Toxaster oblongus* and *Pygurus productus* §. It may be that the separation between the lower and the middle Neocomian is only local; it is certain, however, that the Hils-conglomerate has not as yet afforded any of the lower or of the upper

* [This species, which M. v. Strombeck states he has not received from Neuchatel, has certainly been found in the Marnes d'Hauterive of Ste. Croix (Jura Vaudoise).—E. R.]

† [This species is found in the Neuchatel district in the Upper Neocomian (étage urgonien).—E. R.]

‡ [M. v. Strombeck speaks of this rock as being palæontologically equivalent to the Marnes d'Hauterive; but this is incorrect, as the fauna is very different. M. Desor has proposed for this lower stage the name *Valangien*, and is about to describe the fauna, which contains a great number of new species.—E. R.]

§ [In M. v. Strombeck's paper the two species of *Pygurus* are inadvertently misplaced one for the other.—E. R.]

Neocomian species of Echinoderms. On the contrary, as may be seen by the foregoing Table, nearly all the species are found in the Marnes d'Hauterive, both in the Dépt. de l'Isère, and in the French Jura and Neuchatel; and by consulting the works of Leymerie, the same will be found to hold good for the Basin of the Seine.

Thus are these Echinites found to indicate a particular geological horizon; the Marnes d'Hauterive of Switzerland and France corresponding to the Hils-conglomerate of Germany. It seems indeed that, even if some of the species occur in the lower Neocomian, none of them passed up to a higher horizon than the Neocomian. The only exception appears to be the occurrence of *Toxaster complanatus* in younger beds up to the Upper Greensand in England (Morris's Catalogue, 1st edit. p. 54*); but it is probable that this exception will be set aside by further examination. The occurrence of this species in the Speeton-clay is at least very doubtful. The Speeton-clay of Brunswick does not contain anything of the kind. Either the Speeton-clay of Yorkshire has not been separated from the lower Neocomian, just as Phillips did not separate it from the Gault, or the *Spatangus argillaceus*, which Phillips figures from the Speeton Clay, is a different species from *Toxaster complanatus*†.

The agreement between the Marnes d'Hauterive and the Lower Hils-conglomerate, as shown by their other organic remains, is thus supported by an additional argument,—the identity of the Echinoideal fauna. But we must not forget that this same Neocomian exhibits in different localities very different *facies*, such as Marcou has described it at Nozeroy, and as it occurs in the Hartz.

[E. RÉNÉVIER and T. R. J.]

On the GEOLOGY *of the* NORTHERN VORARLBERG *and the* NEIGHBOURING DISTRICTS. By A. ESCHER VON DER LINTH.

[Mémoires de la Société Helvétique des Sciences Naturelles, vol. xiii.; and Bibliot. Univ. de Genève, Arch. Sc. Phys. et Nat. Sept. 1854, p. 67 &c.]

THE position of the Alpine rocks regarded as belonging to the Keuper has been often the subject of discussion, especially since the environs of S. Cassian in the Tyrol have furnished a large number of fossils. M. Escher's memoir treats especially of this difficult subject, and contains also a description of the general succession of the numerous rock-masses which constitute the eastern portion of Switzerland and the western part of the Tyrol. The memoir is the result of traverses made in this little-known Alpine region in 1851.

M. Escher indicates in the following Table the order of the strata, commencing at the top. This general view is established on the numerous sections accompanying the memoir.

* [This is corrected in the 2nd edit. 1854.—T. R. J.]

† [With regard to this species, the late Prof. E. Forbes remarks (Mem. Geol. Surv. Dec. IV. t. 5. p. 4), "I can find no evidence whatsoever of the occurrence of the true *Toxaster complanatus* in the British strata. Very distinct Sea-urchins, members of no fewer than four different genera, have been intended by that name in British lists."—E. R.]

Molasse	1.	Upper freshwater. Marine. Lower freshwater.
Eocene	2.	Flysch.
	3.	Nummulitic beds.
Cretaceous	4.	Limestone of Sewen.
	5.	Gault.
	6.	Urgonian.
	7.	Neocomian.
Jurassic	8.	Upper ? Jurassic.
	9.	Middle Jurassic.
?	10.	Fucoidal schists.
Lias	11.	Marly limestone with *Ammonites Amaltheus*, &c.
	12.	Red limestone with hornstone.
Trias	13.	Limestone with *Megalodon scutatus*.
	14.	S. Cassian beds.
	15.	Dolomite (fossils at Esino, Lake Como).
	16.	Schists with *Halobia*.
	17.	Letten-kohle.
	18.	Muschelkalk (Lombard Alps).
	19.	Bunter-Sandstone (Regoledo).
	20.	Verrucano.

In reviewing this series of strata, the author commences with those which are sufficiently characterized to serve as a geological horizon. These are the two members of the Lias, Nos. 11 and 12. This group is well developed in the Vorarlberg and the Tyrol, and particularly in the Spullers Alps, to the north of Klosterle on the Arlberg road, and at Elbigenalp in the valley of the Lech.

The stratum No. 11 is that which M. Schafhäutl has termed the Fleckenmergeln. It contains some Fucoids and coaly matter, and attains a thickness of 400 feet. It has yielded the following fossils :—

Ammonites radians, *Schl.*
A. falcifer ?, *Sow.*
A. annulatus, *Schl.*
Ammonites torulosus ?, *Schübl.*
A. Desplacei ?, *D'Orb.*
A. heterophyllus, *Sow.*

These are referable, according to M. D'Orbigny, to the *Etage Toarcien.*

Ammonites planicosta, *Sow.*
A. margaritatus, *Montf.*
A. Valdani, *D'Orb.*
Ammonites Regnardi, *D'Orb.*
A. Henleyi, *Sow.*
A. fimbriatus, *Sow.*

These characterize the *Etage Liasien.*

Orthoceras (Melia, *D'Orb.*).
Inoceramus Falgeri.

It appears that there is a *mélange* of fossils in this bed.

The *red limestone with hornstone*, No. 12, consists of red marly concretionary limestone, with red and green nodules of hornstone, and varies in thickness from 20 to 100 feet. The silex sometimes forms layers which, in the lower part, alternate with limestone a great number of times. These beds, which appear to be the equivalent of the Lias of Adneth (Salzburg), contain fossils referable to the *Etage Sinémurien*, viz.—

Ammonites Bucklandi, *Sow.*
A. Conybeari, *Sow.*
A. Turneri ?, *Sow.*
Nautilus aratus, *Schl.*
Belemnites brevis, *Bl.*

Consequently, although as yet neither *Plagiostoma giganteum* nor *Gryphæa arcuata* have been found in them, these beds without doubt belong to the Liassic epoch.

In the Spullers Alp there are beneath the preceding beds *Schists* (No. 10) similar in external character to Flysch. These are marly schists and sandstone, containing debris of plants, flakes of mica, and impressions of *Fuci*, and have a thickness of 500 to 600 feet. Without positively deciding the question of the age of this rock, M. Escher places it in the lower jurassic series, because it has not yet afforded either the greenish sandstones* or the Helminthoids which usually characterize the Flysch. Its Fucoids also have considerable analogy to those of the Lias.

The *middle jurassic*, No. 9, is represented by a whitish limestone to the south of Vils. It contains

Terebratula spinosa, *Phill.*
T. concinna, *Sow.*
Terebratula pala, *Buch.*
T. antiplecta, *Buch.*

The *Upper Jurassic Limestone* (Jurakalk von Au), No. 8, is met with in the Bregenzer Wald, between Au and the Mellau Valley, where it forms the anticlinal of Canisfluh. The fossils are few; two of the Ammonites are allied to *A. biplex.*

The *Cretaceous beds* occur on the borders of the Alps between the Rhine and the Ill, and at the Grünten, near Sonthofen. They resemble those of eastern Switzerland. The author mentions the *Etage Néocomien* A, D'Orb. (1500 feet in thickness), with *Toxaster complanatus*; and the *Etage Néocomien* B, or *Urgonien*, of D'Orb., = Schratten-kalk of Studer, or Caprotina-limestone. The latter is whiter in colour than the former; it contains

Orbitolina lenticularis, *Bronn*; near Feldkirch, the Grünten, &c.
Caprotina ammonia, *D'Orb.* Grünten.
Plicatula asperrima ?, *D'Orb.* Grünten.
Janira atava, *D'Orb.*; at Sentis.
Ostrea.
Nerinæa.
Pentacrinites.

The *Greensand* (*Etage Albien*) = Turrilite-Sandstone, 100 feet thick, has a variable lithological constitution. Fossils are abundant, and are identical with those of Fis and the Perte du Rhône.

Lastly, the *Seewer-kalk*, or the Inoceramus-limestone of Seewen (200 feet thick), represents probably the *Etage Cénomanien*, *E. Turonien*, and *E. Sénonien* of D'Orbigny.

M. Merian has found on the Lüner-gratt, between Prättigau and the Lüner-see, a boulder full of fossils belonging to the *Gosau formation* (*Etage Turonien*).

The *Nummulitic formation*, surmounted by the *Flysch*, occurs in this region, and is separated from the upper Seewer-kalk by a marl (100 feet thick) with *Ostrea Archiaciana*, D'Orb. This is the marl which, according to Murchison ('Alps, Carpathians,' &c. pp. 186, 193, 201, &c.), presents a lithological passage from the Cretaceous into the overlying Nummulitic rocks.

The *Molasse* is divisible into two groups of freshwater formation, separated by a marine deposit. Between Sibratsgfäll and Bregenz the gravels of the Nagelfluh consist of limestones, and contain little or none

* [We suppose that under this denomination the author refers to the Dioritic sandstone known as the "Grès de Taviglianay."—Ed. B. U. Gén.]

of the granite and porphyry so plentiful in the Swiss Nagelfluh. The Nagelfluh alternates with the sandstones and marls of the Molasse; thus proving, contrary to M. von Buch's opinion, the contemporaneity of the two groups,—the Nagelfluh being merely a coarse-grained sandstone.

Having described these more modern formations, M. Escher reverts to the rocks below the Lias; commencing with No. 13, the limestone with the *Megalodon scutatus*, Schaf., which is known also as the "Dachstein-bivalve." This large shell has been wrongly identified with the *Cardium triquetrum* of Wulfen. It occurs in a whitish granular limestone in association with Corals.

The next is the *St. Cassian group*, No. 14, which has a thickness of from 30 to 200 feet, and abounds with fossils; such as

Bactryllium striolatum, *Heer.*	Cardita crenata, *Goldf.*
B. deplanatum, *Heer.*	Cardium Rhæticum, *Mer.*
Spirifer uncinatus, *Schaf.*	Avicula speciosa, *Mer.*
Ostrea.	A. Escheri, *Mer.*
Spondylus obliquus, *Münst.*	Gervillia inflata, *Schaf.*
Pecten Falgeri, *Mer.*	Natica alpina, *Mer.*
P. Lugdunensis, *Mich.*?	Oliva alpina, *Klipst.*

It is difficult, however, to determine as yet whether this group is a marine equivalent of the Upper Keuper of Germany, or whether the Keuper is incomplete in Germany, not possessing these deposits which in the Alps occur between the Keuper and the Lower Lias. The same may be said of the Megalodon-limestone.

Beneath the above-mentioned rocks is *Dolomite*, No. 15, having a thickness of 1500 feet. This forms the bare and sterile mountain-tops of the Vorarlberg.

From the analyses made by M. Landolt (tables of which are given by M. Escher), it appears that, with regard to the magnesia, this rock presents many varieties. At one extreme we find

12·23 Carb. of magnesia }
84·47 Carb. of lime } and at the other { 49·37 Carb. of magnesia
{ 49·89 Carb. of lime,

as the constituent proportions. The analyses made with respect to the stratigraphical position of the specimens seem to show that the lower part of the dolomite is more highly charged with magnesia than the upper portion.

M. Escher is of opinion that there is more than one dolomitic series; since the St. Cassian group in the Vorarlberg is underlaid by dolomite, whilst the same group at St. Cassian itself is overlaid by dolomite. There also occur great bands of dolomite in the groups Nos. 16 and 17. Hence it is evident that the succession of the groups beneath the Lias is less precise than that of those above.

In the Rells Valley, at the Triesnerkulm, and the Col de Virgloria, the dolomite rests on a red sandstone and a quartzose conglomerate, which have long been classed with the Grauwacké, but are now in the map of Switzerland* recognized as Verrucano. At other places the dolomite rests on Nos. 16 and 17, which evidently belong to the Trias.

* Carte géologique de la Suisse; by MM. Studer and Escher v. d. Linth, 1853.

The *Halobia-schist*, No. 16 (Lettenkohle), consists of black marl-slates, and affords the following fossils:—

Bactryllium Schmidii, *Heer.*	Ammonites globosi.
B. Merianii, *Heer.*	Halobia Lommellii, *Wissm.*

It contains also gypsum (in the Rellsthal), granular dolomites, and nodules of marly limestone enclosing *Pecten*, *Cardinia*?, and *Melania*?

A series of *Quartzose Sandstones and Black Slates*, No. 17, hardly admits of separation from the preceding; it appears even to alternate with it; hence the author is of opinion that Nos. 16 and 17 may represent alternations of freshwater and marine deposits; the latter being freshwater, and No. 16 marine. This group may be parallel with the Letten-kohle of the Keuper: it presents the following fossils:—

Equisetum columnare.	Cycadites.
Pterophyllum longifolium.	Calamites arenaceus.
P. Jægeri.	

These, together with its lithological characters, refer it to the Keuper, and a fish-tooth, which M. von Meyer considers to belong to a Triassic fish, supplies additional evidence. This series is developed in the Rellsthal, at Vadans, the Triesnerkulm, Dalaas, Bludenz, &c.

The *Muschelkalk*, No. 18, appears only in the Lombard Alps. It is characterized by

Bactryllium canaliculatum.	Myophoriæ.
Encrinites liliiformis.	Ceratites.

The *Bunter Sandstone*, No. 19, is seen at Regoledo, where it contains *Voltzia heterophylla*, Bronn, and *Æthophyllum speciosum*, Schimper.

The *Verrucano* is very variable in composition. The chief mass consists of a conglomerate, sometimes fine and sometimes coarse, of pebbles of quartz, often coloured by oxide of iron. In the Rellsthal, schists represent this series; sometimes argillaceous, and sometimes micaceous schists; and near Vadans micaceous schist occurs in red sandstone (at Hindelang, Vorderjoch, and Thannheim). The red sandstone is the oldest sedimentary rock of the district.

The *metamorphic rocks* are numerous in the Vorarlberg. The following are the principal varieties. Black slates, often found beneath the great dolomite. Talcose schist (Rhæticon, Valleys of Samnia and Gamperton). Gypsum. Talcose rocks with garnets, similar to those of Nuffenen. White limestones with hornblende. Dolomite. Gneiss (Geisspitz, &c.). Spilite (between the Samnia and Gamperton Valleys).

From the author's observations it appears that in the central part of the Grisons the rocks have a northern direction, and also in the Paznaun Valley. Near Kappl, however, they appear to have a west direction.

In conclusion, it appears that the Coal-formation, represented, according to M. Heer, by the anthracite, extending in the French, Savoy, and Swiss Alps as far as Mont Tödi, is not represented in the Vorarlberg and the country to the south. It re-occurs in the Stang-Alp in Styria. It is probable therefore that, at the period when the carboniferous rocks were deposited in the districts where they now occur, the Vorarlberg formed an island, the dimensions of which it is difficult to determine. The researches of M. Escher are not equally conclusive as to whether it was land at the Permian epoch and during the commencement of the Trias. At the period of the formation of the St. Cassian beds and the Lias, however, the district had long been covered by the sea.

The absence of strata more modern than the Lias and Dolomite indicates that since the deposition of these the surface has remained uncovered by the sea. The terrestrial area of the period in question extended on the west about as far as where the Rhine now flows; since further in that direction the Jurassic rocks occur in full development. To the south it extended to the borders of Lombardy; in fact, there are not found any fossils younger than the liassic between the central Grisons, the Lake Como, and the Valley of Camonica. The southern limit is difficult to fix.

In the western part of Switzerland, as far as the Lake of Lucerne, there has been no violent dislocation between the Jurassic and the Cretaceous groups, these being parallel in their disposition. The passage from the Cretaceous to the Eocene has also been tranquil. The absence of Eocene beds in the Chain of the Vorarlberg and the Sentis makes it appear that at the Nummulitic epoch there was in this region an archipelago, the islands of which were distributed in a totally different manner to the existing arrangement of the mountain-tops of the region, observation having shown that most of the summits of the highest limestone-range of Switzerland, from the Tödi to the Wildhorn, are formed of nummulitic rock.

Between the deposition of the Flysch and that of the Molasse there was a disturbance of the surface which converted the chain of the Alps into a continental region; a condition which prevented the Molasse from being deposited in the interior of the Chain; this fact was recognized long ago. Lastly, the most recent, and perhaps one of the greatest of the revolutions that have affected this region, is that which took place after the deposition of the Upper Freshwater Molasse (which is upraised at Saint-Gall, on the borders of the Lake of Zurich, and at the Schnebelhorn), and before the formation of the Lignites of Uznach, Durnten, and Aix-en-Savoie. If, however, M. C. Meyer, by his researches, definitely classes the Marine Molasse as Miocene, and connects it on one side with the Molasse of the South of France, and on the other with the tertiary Vienna basin, there still remains some doubt as to the exact age of the Upper Freshwater Molasse, which has a thickness of not less than 1000 feet.

The mammalian remains found in the three stages of the Molasse do not denote any difference of age; and the researches of M. Heer indicate such minute differences, that he is disposed to regard the

Œningen deposits (superposed on the Upper Freshwater Molasse) as belonging to the Miocene period. It results then that the greatest disturbance affecting the Swiss and Vorarlberg region has taken place between the Miocene and the Drift periods.

M. Escher adds a Supplement relative to his researches on the Trias in Northern Lombardy; and supplies detailed sections of several localities on the borders of Lake Como, in the Val Brembana, Val Trompia, &c.

M. Heer's description of Plants and Insects of the Trias and Lias, illustrative of M. Escher's researches, follows.

The work is furnished with valuable Tables of the fossils of the Lias,—of the geological formations in the Vorarlberg and in Lombardy, showing the collated observations of Emmerich, Schafhäutl, von Hauer, Escher, &c.,—of the distribution of the fossils in the St. Cassian beds of different localities, &c.; and it is illustrated with eight 4to Lithograph Plates of the fossils of the Lias, the St. Cassian beds, Muschelkalk, Keuper, and Bunter-Sandstone, and with two large plates of Sections, besides several woodcut diagrams in the text.

[T. R. J.]

On the Cephalopoda *of the* Hallstatt beds. By F. R. von Hauer.

[Proceedings of the Imperial Academy of Sciences of Vienna, Dec. 7, 1854.]

M. von Hauer described 17 new species of Cephalopods, viz. 14 *Ammonites*, 2 *Nautili*, and 1 *Orthoceras*. These were for the most part discovered by Dr. Fischer, of Munich, in the environs of Aussee in Northern Styria; and increase the number of Ammonites previously known as belonging to these strata by nearly one-half.

None of the species at present known beyond the Alpine Range are found amongst the numerous specimens collected by Dr. Fischer; nor is this surprising, since the results of recent investigations entitle us to consider the Hallstatt beds to be an upper Triassic deposit, wanting beyond the Alps,—or perhaps represented elsewhere by the Keuper, which is so poor in marine fossils, and especially destitute (as far as our present information goes) of Cephalopods.

The features of this Cephalopod-fauna of the Hallstatt beds correspond exactly with the geological position assigned to them. It forms a connecting link between the faunas of the Secondary and Palæozoic periods, including genera known to belong to the most ancient deposits, as for instance, *Orthoceras*, completely evolute *Nautili*, and *Ammonites* with smooth lobes and saddles, together with *Ammonites* of the *arietes*, *heterophylli*, and *ceratitæ* families, exhibiting an evidently jurassic type.

The Hallstatt beds have also afforded two Corals (described by Prof. Reuss, in connexion with M. von Hauer's memoir); one of them belonging to the genus *Isastræa*; the other being a *Fletcheria*, a genus which has been thought until now to be peculiar to the Silurian strata. [Count Marschall.]

On the Gasteropoda *and* Acephala *of the* Sandling Marble. By Dr. M. Hörnes.

[Proceedings of the Imperial Academy of Sciences, February 15, 1855.]

This is a notice by M. Hörnes on the *Gasteropoda* and *Acephala* discovered in the Marble beds of Sandling, near Aussee, by Dr. Fischer, Physician to the Duke Maximilian of Bavaria. The Cephalopods occurring in the analogous strata of Hallstatt have been described by M. von Hauer*, the Corals by M. Reuss†, and the Brachiopods by M. Suess‡. The other molluscs of this Fauna, however, were but very little known before Dr. Fischer had recently succeeded in extracting from this hard marble 30 species of molluscs, nearly all previously undescribed, and one of them being the type of a new genus, named *Platystoma* by Hörnes.

The fauna of this group, comprising about 70 species of Cephalopods (among them are some of gigantic size), bears a peculiar facies, quite distinct from that of any extra-Alpine European deposit. Some forms resemble palæozoic types, whilst others exhibit a decidedly jurassic character. The Hallstatt and Sandling limestones present a distant resemblance to the St. Cassian series, and, like the latter, may be supposed to be a local deposit confined to the Alpine district. [Count Marschall.]

On the intimate Structure *of* Minerals, *as exhibited by the action of* Hydrofluoric Acid. By Prof. Leydolt.

[Proceedings of the Imperial Geological Institute of Vienna, December 12, 1854.]

In this communication Prof. Leydolt gave an explanation of the method which he had invented to demonstrate the intimate structure and composition of crystallized and non-crystallized inorganic substances by submitting them to the corrosive action of diluted Hydrofluoric Acid ; the planes and cavities produced by the action of this menstruum on the surface of the substances submitted to it being immediately connected with the crystallographic system to which they belong, and with the position of the axis.

Prof. Leydolt exhibited several varieties of Rhombohedric Quartz treated in this manner. Complete crystals of this mineral, which had been exposed to the action of the acid, show on the edges of their hexagonal pyramids small planes, situated sometimes on their left, and sometimes on their right side. These planes, produced on plates cut perpendicularly to the crystallographic axis, may be subservient to the recognition whether any crystal of quartz is a binary combination of two individuals turning right or left, even when no difference is to be discovered by investigation of the optical phænomena. Prof. Leydolt has applied to the etched surfaces produced by his mode of operating the method invented by Sir David Brewster

* See above, p. 22. † Ibid.
‡ See the Anniversary Address, in this No., p. lxvi.

to reproduce the interferential colours of mother-of-pearl, of Barton's "Iris-button," &c. By covering the etched surfaces with a thin layer of isinglass, he obtains impressions fit for microscopical examination, both by transmitted and by reflected light. Similar impressions taken on the etched surfaces of arragonite, iron-pyrites, and other minerals were also exhibited. [Count Marschall.]

On Tertiary Fossils *from* Belgrade. By Dr. M. Hörnes.

[Proceedings of the Imp. Geol. Instit. Vienna, December 12, 1854.]

A suite of fossils and rock-specimens forwarded by Prof. Pancic from the environs of Belgrade were found by M. Hörnes to agree with the organic remains and mineral deposits of the Vienna basin. M. Hörnes thinks the arenaceous clays near Radowitza, south of Belgrade, to be equivalent to the tertiary strata of Baden near Vienna, or to those of Lapugy in Transylvania. The deposits of Tasmajdan, Knezevac, and Vischnitza were regarded as belonging to the Leitha-limestone; and those of Mokrilug and Belaboga, together with the hill on which the fortress of Belgrade is built, were referred to the Cerithium-beds.

Notwithstanding the geological information on the environs of Belgrade resulting from the researches of MM. Boué and Viquesnel, a more complete knowledge of the probably abundant fossil fauna of the district is highly desirable. The late M. Fuchs forwarded to M. Partsch a drawing of a *Caprina*, which goes to confirm M. Viquesnel's statement that Belgrade is situated at the foot of a cretaceous range surrounded by tertiary deposits.

[Count Marschall.]

On Clinochlore *and* Mica. By Col. N. von Kokscharov.

[M. Haidinger's Report, Imp. Geol. Instit. Vienna, November 7, 1854.]

The name "Clinochlore" has been given by Mr. Blake to a mineral species from Westchester, Pennsylvania, which exhibits two optical axes. Lieut.-Col. Kokscharov, by carefully measuring the angles of the crystals in the variety from Achmatowsk (Ripidolite of Kobell, Chlorite of G. Rose), found these angles in concordance with the optical phænomena observed in this mineral.

M. Kokscharov also, by exactly measuring the angles of complete crystals of Mica, brought from Mount Vesuvius by M. Abich, has proved their forms to belong really to the Orthotypic System (as M. de Senarmont had supposed), although they bear the character of Macrodomous Orthotypes generally occurring among augitic crystals. [Count Marschall.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Brachiopoda *of the* Kössen Strata *in the* Tyrol. By Edward Suess, Assistant in the I. R. Museum of Mineralogy.

[Denkschrift. Kais. Akad. Wissensch. Mat. Nat. Cl. vol. vii. part 2, pp. 29–65, with 4 lith. plates*.]

My object in this Memoir, which investigates the mode of appearance of a special animal group in certain strata of our mountain ranges, is firstly to make a palæontological comparison and parallelism between these strata and foreign localities,—then to describe the peculiar forms of Brachiopods that are met with in these particular deposits.

The generality of our public, especially the palæontologists, are but imperfectly aware of the geological constitution of our Alps. The strata called here "*inferior lias*" are in many points very different from their homonyms in England or Suabia.

I think the explanation of the term "*Koessen Strata*" will be the best introduction to this Memoir. Although this term is adopted by the generality of our Austrian geologists, and notwithstanding we may in a short time expect to see these strata and their relations illustrated by our excellent geologist, Fr. von Hauer†, it will not be out of place here to give a general view of the geographical extension of these strata and to explain the evidence of this group being a member of the inferior lias and not of the muschelkalk. We may assert these conclusions to be, in the first place, due to palæontological researches; and, their results having been confirmed by recent geognostical investigations, the group may be regarded as occupying a well-determined position in the geologic series.

When Austrian geologists began to give names to peculiar strata in order to establish a terminology independent of the changes or conflicts of theoretical views, the name of "Koessen Strata" was applied to black or dark-grey limestones, often marly or interstratified with

* See also 'Sitzungs-berichte d. mat. nat. Classe d. Kais. Akad. d. Wiss.,' March 1853, vol. x. p. 283; Escher von der Lith, on the Vorarlberg, Mém. Soc. Helv. vol. xiii., and Quart. Journ. Geol. Soc. No. 42, Miscell. p. 16; F. von Hauer, on the Hallstatt Cephalopoda, *ibid.* p. 22; M. Hörnes on the Sandling fossils, *ibid.* p. 23.

† See Jahrb. K. K. Geol. Reichsanst. 1853, pp. 715, &c.

marl, and differing from the much deeper black limestones of the variegated sandstone (now called "Guttenstein Strata" by Fr. von Hauer) by their want of lamination, and by the abundance of fossils, especially of Brachiopods and other Bivalves, contained in them. Hence the name of "Koessen Strata" was applied to the Gervillia- and Avicula-limestone near Bad Kreuth, described by Von Buch (Abhandl. d. Berlin. Akad. 1827, p. 82), to the lias limestone of the Mertlbach (Gaisau) as represented by Messrs. Sedgwick, Murchison, and Lill de Lilienbach in the last author's second section, and especially to the whole formation called Gervillia-strata by MM. Emmrich and Schafhäutl.

The comparison of the numerous fossils soon proved these Koessen beds to be part of the lias; and subsequent palæontological researches introduced a great change in the limits originally assigned to the above term. Rocks, apparently quite similar as to their exterior aspect, were shut out on account of their aberrant palæontological character, and others, of completely different petrographical character, but concordant by their fossil contents, were comprised in the Koessen group. I will now attempt a brief sketch of the separate members of the group : the study of the whole cannot fail to show that an exact investigation of fossils is only the sure foundation for a correct knowledge of our calcareous Alps.

I. *Koessen Strata, properly so called.*

Synonyms:—Upper St. Cassian, t[4], Escher and Merian; Gervillia Limestones, Emmrich; Gervillia Limestones and Slates of the Whetstone Formation, Schafhäutl.

These strata are generally black, and differ, by the characters above mentioned, from the Guttenstein strata which belong to the muschelkalk. Other similar black limestones, containing Brachiopods of the upper lias (Hierlatz strata), *e. g.* those of the Stambachgraben near Goisern, must be carefully separated from them.

The genuine liassic Brachiopods contained in these strata are,—*Spirifer rostratus*, Schloth., *Sp. Muensteri*, Dav., *Terebratula cornuta*, Sow., and *Rhynchonella obtusifrons*, Sss. Of other genera I quote for the most part on Von Hauer's authority,—*Nucula complanata*, Phill., *Pinna folium*, Young and Bird, *Lima gigantea*, Sow., *Pecten liasinus*, Nyst.

According to M. Stur's investigation, these strata near Schloss Enzesfeld are in close connexion with a yellowish-brown limestone, containing, together with the same species of Brachiopods, a notable number of lower liassic remains of genera rarely met with elsewhere in the Koessen strata. Such are, as Von Hauer kindly communicated to me, *Ammonites bisulcatus*, Brug., *Amm. obliquicostatus*, Ziet., *Amm. Kridion*, Hehl., *Amm. Moreanus*, d'Orb., and *Pleurotomaria expansa*, Goldf.

The numerous localities which afford the above-mentioned Brachiopods are sufficient to point out the extraordinary geographical range of these strata. Without reckoning the localities recently discovered in Switzerland as far as the neighbourhood of the lake of Geneva, the closer investigation of which is of the greatest interest, we are quite warranted in tracing the Koessen strata from the Brandner Ferner on the frontier of Vorarlberg to the immediate vicinity of Vienna. They extend undoubtedly from 27° to 34° long. along the northern declivity of the Alps, the line joining the most distant known localities being above 100 geographical miles in length.

The localities where the Brachiopods have been found are distributed in the following manner. The most eastern are close to the great break in the Alpine accessory zone between Vienna and Gloggnitz (Gumpolts Kirchen, Helenathal and Siegenfeld near Baden, Hirtenberg, and Enzesfeld); there are others more to the west near Härnstein, and the richest are in the upper valley of the Piesting, as far as the Klosterthal (Walleg, Oed, Mandlinger Wand, Kitzberg near Pernitz, Frohberg near Weidmansfeld). To the northward there are some in the environs of Kleinzell (near the Unterer Hebenbauer), and to the southward at the Fadner-Kogel near Buchberg; westward, at the Türnitzer Högerkogel, and also in the environs of Maria-zell (Grash in the Hallthal, Bürger-Alpe). As Von Hauer observes, the above-named localities are limited northward by the curved tract of variegated sandstone which marks the rupture of the extreme northern *wave of elevation* (Aufstauungs-Welle). M. Czjzek found them only at one place in the region of the variegated sandstone, viz., at Ratterbash near Frankenfels. The Koessen strata on the northern declivity of the Alps are divided into an eastern and a western region by the advance of the variegated sandstone, from which they are almost entirely excluded nearly as far as the central Alpine mass. After all, I do not think such limitation of any particular importance, as it could possibly have originated subsequently to the deposit of these rocks and on account of the position of the central axis; and the more so, since no striking palæontological or petrographical difference has been pointed out between the eastern and the western portion.

As all the above-quoted localities are at a considerable distance from the central mass, we may conclude that the Koessen strata are wanting in the mountain masses which in the Valley of the Enns form the great fracture accompanying the crystalline rocks. They are not met with near the mass of the Dachstein, nor probably in any of the mountains of the vicinity (Sarstein, Grimming, &c.). Generally the localities are very much scattered in this portion of the Alps; and are just sufficient to point out the connexion of the richest extreme eastern and western localities along the northern declivity.

Brachiopods characteristic of the Koessen strata are found at the Schafberg (between the Vonmauer and the München-See), near Aussee (Scheibenweisenweg to the Moosberg), near Salzburg (Schobergraben near Adneth, Merlbach near Gaisau), and at the Baukengraben (Steier).

The environs of Unken and Loper, so diligently investigated by MM. Emmrich and Peters, exhibit Koessen strata at several places; and further west lies Koessen, the typical locality. The exact place is in the Klamm between Koessen and Reit, on the Austrio-Bavarian frontier. The researches of MM. Emmrich and Schafhäutl, and a collection from this country kindly communicated to me by M. Schlagintweit*, prove that these strata exist around Woessen and Hochfellen (north and north-east of Koessen), also at the Wendelstein, near the mineral bath of Kreut, near the Gruberalpe at the Salzberg (von Buch), at the foot of the Hohe Kramer and of the Zugspitz, at the Wetterstein, and in the Leuctasch valley. MM. Emmrich and Schafhäutl have published several notices of these localities.

From these points a considerable number of localities extend through Tirol, Vorarlberg, and the canton of Grison; in some of them MM. Escher von der Linth and P. Merian have recently found the same fossils as those which are regarded as the most characteristic of the Koessen strata around Vienna. These well-ascertained localities are connected by others, where isolated fossils have been found, but which I do not mention here, as the above enumeration is quite sufficient to prove the continuity of the whole line. The rich localities in the Vorarlberg and in the valley of the Lech may undoubtedly find their proper place among this series; so that the Koessen strata may be considered as a formation extending from west to east between the Brandner Ferner and Gumpoltskirchen near Vienna.

We know far less about the southern declivity of the Alps; but the Dachstein limestone, which also belongs to the Koessen group and plays so important a part in the central chain, being highly developed there, we may expect that the continued researches of the Imperial Geological Institute will there discover still more distinct traces of the Koessen strata.

The Museum at Innsbruck contains fossils, collected between the Rauchkofel and Lienz, which are considered by M. von Hauer to belong to the Koessen series; similar fossils are also said to have been found by MM. Escher and Merian in the environs of the Lake of Como in the Val Brembana, Val Seriana and Val Trompia, and they may be supposed to exist too in the Val di Amone near Roveredo. Dr. Lavissaro communicated to the Imperial Geological Institute a series of silicified fossils, imbedded in a dark grey siliceous limestone; among these were *Spirifer rostratus*, *Sp. Muensteri*, and an undeterminable *Rhynchonella*; *Spirifer rostratus* is found at Tremona in a black marly limestone (Studer, Geolog. d. Schweitz, vol. i. p. 481). The Lyceum of Bergamo also has communicated a fossil not distinguishable from *Gervillia inflata*, from the black limestone of Monte Misma.

II. *Starhemberg Strata and Dachstein Limestone.*

The Starhemberg Strata consist of yellowish or reddish limestone, intercalated as thin layers in the Dachstein limestone. Their fauna is quite identical with that of the Koessen Strata; only two or three very rare species are known which have not yet been found also in the latter formation. The Brachiopods appear in very great

* See Quart. Journ. Geol. Soc. vol. x. p. 348.

numbers, but, some *Rhynchonellæ* excepted, only as single shells; so that their determination is extremely difficult. This circumstance and the appearance of the rock in the form of thin and often-repeated layers in the massive Dachstein limestone justifies the opinion, that the Starhemberg Strata have been formed of loose materials carried by partial currents from a coast abounding in shells into the open sea. Nevertheless a more careful inquiry shows sometimes extensive local beds of a star-coral, also met with in the Koessen strata, which form the lower limit of one of the intercalated Starhemberg beds. This phænomenon is particularly evident at the typical locality in the Piesting valley, in front of the castle of Starhemberg, westward of Piesting; so the Starhemberg strata might perhaps be considered more correctly as "colonies" belonging to the Koessen strata. Few localities, and these very distant from each other, are known at present; yet their petrographical and palæontological characters are very constant. The most eastern are near Hirtenberg and around Piesting (south and westward, at Salzmann's, near the cottage called Teufel, in front of Starhemberg, &c.). They occur to the westward near Tonion in the Mürz valley; then, after a long interval, near the Grimming in the Enns valley, and finally at Kirchholz near Adneth. They are also to be met, but without any fossils, on some intermediate places, *e. g.* in the Dachstein Mountains. Perhaps we know so little at present about these certainly extensive strata only because, owing to their position in the Dachstein limestone, the places where they come to the surface are situated on inaccessible cliffs.

The Dachstein limestone (Megalodus limestone of Schafhäutl and Escher) having, with only one and that not yet well-determined exception, furnished no Brachiopods, I shall only briefly refer to it. It is known to form a very important portion of our mountain-masses, and to extend, together with the Koessen strata, from the western frontier of Vorarlberg to the vicinity of Vienna. It is recognized at many localities in the southern Alps, *e. g.* the valley of the Adige near Trient, where it appears most distinctly.

We do not confine the denomination of Dachstein limestone to the upper strata, containing the Dachstein bivalve; on the contrary, we extend it to the whole mass of white, yellowish, or greyish limestones occupying sometimes the whole interval from the uppermost members of the trias up to the upper lias, and exhibiting in their fossiliferous intercalated layers a fauna agreeing with that of the Koessen strata. In the Dachstein Mountains, the whole group forming the subject of this memoir is exclusively represented by the Dachstein limestone and its intercalated beds.

Some of these intercalated layers offer particularities singular enough to deserve a detailed exposition. Those containing *Rhynchonella pedata* are the most apparent among them. A series of localities, extending from the Hohewand near Wiener-Neustadt to the Tannerkopf and the Königsbach Alpe in Bavaria, have acquainted us with strata which, although very variable in their petrographical aspect, are connected by a singular particularity, containing, as far as they are at present known, no other fossil but *Rhynchonella pedata*, often in such numbers that it forms the principal mass of the rock.

The position of these strata is not yet satisfactorily investigated: as they appear at the Werflinger Wand in the midst of the Dachstein limestone district, we may provisionally place them among the lias. They are of a bluish grey at the Hohe Wand,—white and yellowish near both Lahngang Lakes,—generally black, and the *Rhynchonellæ* in them frequently silicified, near Aussee; near Hallstadt they appear of a greyish-white colour and are interrupted with brick-red and yellow layers.

The so-called Lithodendron limestones are white, and do not seem to be separated from the including Dachstein-limestone by any striking petrographical character, so that in future they may be united with it under the designation of fossiliferous layers. They are still unknown in the eastern portion of our Alps, and the only localities for them with us are the western slope of the Loser near Aussee, and the Weisse Wand near Unken. The only Brachiopods they contain are *Spirifer Muensteri*, at both localities, and with it *Rhynchonella cornigera* at Unken; besides these, they contain also *Plicatula intusstriata* and a *Pecten*, which seems to be met with also in the Koessen strata. According to M. Peters's investigations, the black Koessen strata near Unken and Lofer underlie the limestone with *Megalodon triqueter*, as they do in Vorarlberg, and this white limestone itself includes the Lithodendron strata; so that these three formations must necessarily be combined in one principal group. Other localities are mentioned in the Bavarian Voralpen; M. Schafhäutl's white oolitic limestones with *Rhynch. cornigera* (Leonh. u. Bronn's Jahrbuch, 1853, p. 299) may possibly find their place among them. All the observations at present known agree in their having been constantly seen at a lower horizon than the black Koessen strata.

Certain strata discovered by M. Emmrich near Unken, and subsequently investigated by M. Peters, but not yet sufficiently cleared up as to their stratigraphical relations, show similar phænomena; they consist of white, yellowish, or reddish limestones quite filled with several species of *Avicula*, which are elsewhere found in the Koessen strata and sometimes frequent in the lias of other countries.

These strata deserve the particular attention of future observers, as their more complete investigation may prove useful in solving several still undecided questions. M. Lipold has brought from the Gois- or Schober-graben, in the Wiesthal near Adneth (one of the richest localities for Koessen fossils), some black and very bituminous slates, containing remains of fishes, and a large quantity of one of these *Aviculæ*, viz. *Avicula contorta*, Portl. Subsequent observations must show how far these strata are connected with the well-known fish-slates of Seefeld. M. Schafhäutl and the Tyrol geologists have placed these bituminous slates among formations which we can only recognize as the equivalents of the Koessen strata.

The Koessen, Starhemberg, and Lithodendron or Avicula strata, although very different in petrographical character, are connected with each other by their fossils; their peculiar faunas being but special modifications of the richer one in the Koessen strata, which embraces nearly all the species of the others. Two abnormal members, viz. the Dachstein limestone and the strata with *Rhynchonella pedata*, are connected stratigraphically with the above-mentioned palæontologically united group. The peculiar stratigraphical relations produced by the intimate connexion of all these subdivisions must be carefully examined. If *e. g.* the black Koessen strata be said to be a formation extending from the Brandner Ferner to Gumpoltskirchen, this assertion does not imply that all the points belong really to one and the same line. M. Peters mentions these beds as occurring near Unken and Lofer between two limestones, both of which ought to be placed with the Dachstein limestone; nor is this surprising after what is known concerning the fauna of the Starhemberg strata; the farther solution of these questions must be left to geological investigations of the localities.

The whole series of these strata lies upon the Hallstatt strata, which contain the fossils of St. Cassian and belong to the Upper Muschelkalk; it is covered by strata containing, in some rare cases, fossils of the upper lias, and having so few species identical with those of the immediately overlying strata, and generally so different from them by the appearance of a rich fauna of Cephalopods and Gasteropods, that we are warranted in considering them as the superior portions of the lias formation. Nor is there any doubt of the age of this group of strata, with respect to their stratigraphical relation. If we indeed admit this group, in which the Dachstein limestone alone has frequently a thickness of several thousand feet, to be an equivalent of the lower lias, we must own that such a development of a subordinate division in the secondary rocks is scarcely to be met with in any other country.

This vast development of single members must be the cause of a great many peculiarities. Wherever the Dachstein limestone appears in such force, the lower strata bear no traces of organic life. The levelling influence of such an enormous deposit, and the decrease of the water-depth depending on it, is evidenced by the appearance of fossils at only some thousand feet above the lowest limit of the Dachstein limestone, *e. g.* in the Echern Thal. The strata with *Rhynchonella pedata* may have corresponded to a rather low horizon.

A consideration of the limits of the contemporaneous seas, as determined by the orographic relations existing at this remote epoch, may be useful for the better comprehension of these facts, taken in their totality. A number of geological maps, *e. g.* the littoral map of the Jurassic Seas, published by Gressly, exhibit the continent of the Schwarzwald and the Vosges, and to the south-westward the central table-land of France, as rising above the level of the liassic deposits. Notwithstanding, we still have no proof of these waters having covered the whole of eastern or south-eastern Switzerland.

M. Studer says, "We enter a new region on the opposite bank of the Rhine ; peculiar organic remains, different from anything we got a notion of from the Dauphiné and Savoy thoughout the northern calcareous zone of the Swiss Alps, compel us to search elsewhere for points of comparison*." One of the most remarkable facts, recently ascertained by M. Escher von der Linth, is the sudden termination of all these formations along the valley of the Rhine, between Chur and the Lake of Constance. The Swiss geologists suppose the inferior oolite of the Calanda to immediately follow rocks of a far older epoch ; the mighty masses of triassic and liassic rocks, so conspicuous on the opposite side of the Rhine, are completely missed on this place ; the correspondence of these phænomena with the discordance between the upper lias and the inferior oolite, as observed in several of our Austrian localites, is very striking ; and perhaps one of the most violent upheavings of the eastern Alps may be referred to this period.

Another mass never covered by liassic waters is what may be called the "Bohemian continent," which comprises not only Bohemia by itself, but also the whole of the granitic and gneiss rocks forming table-lands throughout the larger part of Austria, northwards of the Danube, between Passau and Krems, frequently appearing on this side of the Danube also and near St. Leonhard, not far from Pöchlarn, advancing their southern extremity to a distance of only one and a half geographical miles from the alpine limestone. When treating of the Gresten strata, we shall speak of the necessary influence of so extensive a continental mass on the fauna of the neighbouring seas ; its farther influence on the elevation of the Alpine rocks, and how far the flexure of the northernmost tract of variegated sandstone depends upon its outline, must be cleared up by future investigations.

We cannot leave our subject without some allusion to the crystalline rocks of the central eastern Alpine chain, standing in immediate relation to the Alpine limestones. At present the question of the existence of a continent above the level of the sea on the place now occupied by these mighty mountains, can scarcely meet with a satisfactory answer. The majority of facts are opposed to it ; at all events it may not have formed a continuous mass ; whoever has wandered through one of the principal valleys, separating the central chain from the Alpine limestones, may easily agree with this opinion. On one side, the crystalline slates, whose rounded slopes are covered with forests, and frequently cut through by parallel secondary valleys, amply provided with water, tower higher and higher up to the mighty masses of the Grassglockner, Anthogel, &c., giving a magnificent background to the whole scenery ; the opposite slope of the valley offers a great contrast by its vertical limestone cliffs, arising suddenly to the height of many thousand feet amidst the variegated sandstones, covered with meadows and dispersed human habitations. These natural walls, rivalling in whiteness the snow that covers the tops, run through a line of several German miles without being interrupted by any secondary valley ; the strata are all broken up, and where should their continuation

* Geol. d. Schweitz, vol. ii. p. 196.

be searched after if not on the opposite side of the central mass*? The fauna of the Koessen strata is no more favourable to the hypothesis of a former continent on the region at present occupied by the Alps, than is the petrographical character of the limestones themselves, which, even on this spot, show a particular degree of purity.

III. *Gresten Strata.*

Black, marly limestones and dark sandstones, with rich coal-beds and liassic fossils, are found in the portion of our Alps nearest to the southern extremity of the "Bohemian continent"; they contain these Brachiopods—*Spirifer rostratus, Sp. Muensteri,* and *Terebratula cornuta,* which species are also found in the Koessen strata, but no other species are common to both groups. Other genuine liassic fossils of the Gresten strata (for the most part determined by M. von Hauer) are—*Mactromya cardioides,* Phill. sp., *Cardinia Listeri,* Sow. sp., *Pholadomya ambigua,* Sow., *Phol. Hausmanni,* Goldf., *Phol. decorata,* Hartm., *Goniomya rhombifera,* Goldf. sp., *Pleuromya unioides,* Goldf. sp., *Nucula complanata,* Phill., *Pinna folium,* Young and Bird, *Lima gigantea,* Desh., and *Pecten liasinus,* Nyst.; the following are common to the Gresten and Koessen strata—*Avicula intermedia, Nucula complanata, Pinna folium, Lima gigantea,* and *Pecten liasinus.* They contain a rather considerable flora, investigated by MM. Unger and v. Ettingshausen, many species of which are known in the lias or the keuper of other countries.

Generally the Gresten strata are very rich in bivalves, *e. g Myæ*; but, like the Koessen strata, are very deficient in Gasteropods and Cephalopods; yet the rich flora of the first indicates an essential difference, confirmed by closer investigation. The Gresten strata present a certain analogy with the keuper, as far as they bear the character of deposits formed in the neighbourhood of a continent; a supposition strengthened by their rich coal-deposits.

Plants only, and no molluscs, occur in the greater number of localities. I have seen Brachiopods from Rohrbach (north-west of Hainfeld), from Gresten, from the Ferdinand-Stollen at Gaming, and from the Eleonora-Schacht at Grossau; and, farther south-westward, from the environs of Weyer in the Pechgraben, especially near Steinau; and farther to the south-west, from the Fürstenhammer. The ideal line, uniting the two most distant localities, Bernreuth and the Pechgraben, does not exceed ten (German) miles in length.

The researches as yet made are too few to allow of a farther discussion on the relations between the Gresten and the Koessen strata; these are more strictly separated, in palæontological as well in geographical respects, than any of the other groups mentioned in this memoir, nor can their differences be sufficiently explained by the influence of a neighbouring shore, until we find intermedial localities

* No metamorphic rocks, as they appear at the Radstädter Tauern and at other places, are at present known in the corresponding portion of the central mass; so *e. g.* they are wanting at the foot of the Dachstein.

demonstrative of this explanation; as things stand at present, we can merely place them separately.

Prof. Unger was the first who recognized the liassic nature of these strata (Wiener Zeitung, 20th of January, 1845; Leonh. u. Bronn's Jahrbuch, 1848, p. 279); and M. Kudernatsch has given a detailed geological description of them (Jahrbuch der K. K. Geolog. Reichsanstalt, 1852, vol. ii. p. 44).

The time is not yet come to decide about the affinity of these strata with the frequently quoted plant-bearing schists in the western regions of the eastern Alps, which may perhaps prove to be a connecting link between the Gresten and the Koessen strata.

The reports of the geologists who have surveyed this rather limited district agree in representing the Gresten strata as resting immediately on the Guttenstein strata,—a very unexpected circumstance, perhaps to be explained by future observations.

IV. *Relation of the Koessen beds with the St. Cassian beds and the Lias.*

Having detailed the whole of the facts, and enumerated the fossils, which may induce us to rank this group among the lias, I will briefly discuss the reasons given by some geologists for parallelizing some of its members with the St. Cassian formation. The whole series of Koessen fossils gives us but three species identical with those of St. Cassian, viz. *Cardita crenata*, the so-called *Spondylus obliquus* (whose identity seems doubtful even to M. Emmrich), and *Actneonina alpina*, quoted by M. Merian, but without giving its locality. The *Aviculæ gryphæatæ* are found in the lias of England as well as in the St. Cassian strata; and, according to M. Peters, one of our species may probably prove identical with *Avicula contorta*, Portl.

The stratigraphical relations, at least as they exist in Vorarlberg, do not appear to warrant a separation of the Koessen strata from the lias; what we have already said is sufficient to lead us to the conclusion that M. Escher's No. 18 limestone with *Megalodon triqueter* (the equivalent to our Dachstein limestone) and his No. 14 St. Cassian Formation (identical with our Koessen strata) cannot conveniently be considered to be members of different formations. Since the investigation of the Cephalopods of the Salzkammergut, the Hallstatt strata can no longer be doubted to be an equivalent of the St. Cassian formation, nor is there any reason to consider the former as representing only a part of the St. Cassian group.

No locality is at present known where the Koessen group may not be represented, in one way or in the other, between the Ammonitic Upper Lias and the Hallstatt strata. The section referred to by M. Emmrich (Zeitschrift d. Deutsch. Geolog. Gesellsch. 1852, p. 515) as showing the Adneth strata immediately overlying those of the Hallstatt group, is founded on an error of M. Lippold, who has confounded the last-named group with the Adneth strata.

Along the whole northern declivity of the eastern Alps the Koessen strata are most distinctly separated from the Hallstatt group by their palæontological character; not one species common to both has been found throughout their whole extent. As the Koessen strata contain a number of characteristic lias fossils, while the fauna of the Hallstatt strata, at least in its general aspect, comes nearer to the Muschelkalk, we may, with some degree of security, here place the boundary between the formations.

V. *The Koessen Brachiopoda.*

At pages 38-64 of his Memoir, M. Suess describes the Brachiopods on which he founds the palæontological conclusions above detailed. The following table shows their general distribution:—

Kössen Brachiopoda.	Kössen Beds.	Starhemberg Beds.	Lithodendron Limestone.	Gresten Beds.	References.
Terebratula cornuta, *Sow.*	K	S	...	G	Pl. 2. f. 10 & Pl. 3. f. 1–5.
—— pyriformis, *Suess*, n. sp.	K	S	...	...	Pl. 3. f. 6, 8.
—— horia, *Suess*, n. sp.	K	S	...	...	Pl. 3. f. 9.
—— gregaria, *Suess*, n. sp.	K	S	...	...	Pl. 2. f. 13–15.
—— Grestenensis, *Suess*, n. sp.	...	...	...	G	Pl. 2. f. 11, 12.
—— grossulus, *Suess*, n. sp.	...	...	...	G	Pl. 2. f. 9.
Thecidea Haidingeri, *Suess*, n. sp.	K	...	...	...	Pl. 2. f. 16, 17.
Spirigera oxycolpos, *Emmr.* sp.	K	...	...	...	Pl. 1 (20 figs.).
Spirifer rostratus, *Schl.* sp.	K	S	...	G	Pl. 2. f. 8.
—— Muensteri, *Davidson*	K	S	L	G	Pl. 2. f. 1–5.
—— Emmrichi, *Suess*, n. sp.	K	S	...	...	Pl. 2. f. 7.
—— Haueri, *Suess*, n. sp.	...	...	...	G	Pl. 2. f. 6.
Rhynchonella subrimosa, *Schaf.* sp.	K	S	...	...	Pl. 4. f. 5–11.
—— obtusifrons, *Suess*, n. sp.	K	...	...	...	Pl. 4. f. 12.
—— fissicostata, *Suess*, n. sp.	K	S	...	...	Pl. 4. f. 1–4.
—— cornigera, *Schaf.* sp.	K	S	L	...	Pl. 4. f. 13–15.
—— Austriaca, *Suess*, n. sp.	...	...	...	G	Pl. 3. f. 10–15.
Discina Cellensis, *Suess*, n. sp.	K	...	...	...	Pl. 2. f. 18.
Discina, sp.	K	...	...	...	Pl. 4. f. 24.
Rhynchonella pedata, *Bronn*, sp.	Dachstein				Pl. 4. f. 16–23.

[COUNT M. and T. R. J.]

On the VORARLBERG *and the* SALZBERG. By M. E. SUESS.

[Proceedings of the Imp. Geol. Institute of Vienna, Nov. 14, 1854.]

M. E. SUESS, after having visited the Vorarlberg (in company with M. Escher von der Linth and M. Merian) and the Salzberg in the Tyrol, reports that the sedimentary rocks of the Vorarlberg, although agreeing in many respects with those of the Eastern Alps of Austria, differ from them in several particulars. The Spuller's Alpe and the environs of Stallehr and Schroecker are alluded to as examples of this. At these localities rocks palæontologically and lithologically identical with the liassic strata of Adneth and Kössen, and with the variegated marls of the Eastern Alps, rest on sandstones which are notably different from the genuine Werfen strata. At the same places also powerful masses of limestone of the cretaceous period, form a secondary zone, exterior to the liassic rocks, in contradistinction to the conditions obtaining in the Austrian Alps.

The tertiary deposits of the Vorarlberg have been upheaved, like those of Switzerland. M. Escher von der Linth's hypothesis of the Vorarlberg flysch being an eocene deposit is probably correct, both on account of its northern range being between the cretaceous rocks and the molasse, and because its southern range separates the cretaceous rocks from the Alpine limestone proper. The cretaceous group, surrounded by both these lines, is heaved up in a series of regular anticlinals. The largest of these, that of Canisfluh near Au, is fissured to such a depth that lower jurassic rocks are seen coming out from beneath the cretaceous.

Remarkable vestiges of ancient glaciers (already noticed by M. Guyot) occur along the whole course of the Rhine within the Austrian territory, as far as the neighbourhood of Bregenz.

In his excursion to the Salzberg, M. Suess ascertained that at different points there is an alternation of the St. Cassian beds with the sandstone which is regarded by the Swiss geologists as belonging to the Keuper. [Count M.]

Notice of the Occurrence of an Earthquake *at* Schemnitz, Hungary. By M. Russegger, Director of the Mines of Lower Hungary.

[Proceedings of the Imperial Academy of Sciences of Vienna, Oct. 5, 1854.]

On September 16, 1854, at 5 o'clock a.m. (mean time), says the author, I was awakened by a report like that of cannon, which was also heard by all the inhabitants of the building occupied by the Mining Administration, and by the sentinel in front of it. All these persons simultaneously felt a shock and perceived the furniture and other objects suddenly and violently shaken. An inhabitant of the ground-floor thought that a subterranean vault had suddenly fallen in. In the town of Schemnitz itself the shock was felt in the direction of the principal metalliferous vein (Spitaler Hauptgang), and on both sides of this line. It was not felt at Windschacht, situated on the S.W. part of the vein, but its (probably secondary) effects were sensibly felt, though considerably less in force, along the N.E. prolongation of the vein, where it enters the private mining territory of Michaelisstollen.

The shock and report were of greater intensity in the mines than at the surface immediately above the workings in the principal vein. All who perceived the report stated that it seemed to come from underground, and the shock too appears to have acted vertically from below upwards. The supposition that the phænomenon arose from the falling in of abandoned excavations in the mines is inadmissible to any one acquainted with the method by which mineral veins, especially in the Schemnitz district, are usually worked. Moreover, the observations made in the interior of the mines prove that the shock increased in energy with the depth, and reached its maximum at an horizon of 100 fathoms* underground.

Previous to the earthquake in question, another had been felt at Schemnitz on April 6th, 1854, at 6 o'clock P.M. It followed the same line of direction, and was perceived over a larger extent, but it was of less intensity. Its maximum point was also situated immediately beneath the area on which Schemnitz is built; and intense shocks were felt at Windschacht; but they were not at all perceived in the interior of the mines. [COUNT MARSCHALL.]

On the TERTIARY CHELONIA *of* AUSTRIA. By DR. PETERS.

[Proceedings of the Imperial Academy of Sciences at Vienna, Jan. 4, 1855.]

IN his Memoir on the remains of Chelonians in the Tertiary deposits of the kingdom of Austria, M. Peters observes that these fossils, all belonging to the freshwater genera *Trionyx*, *Emys*, and *Chelydra*, may be of great use in throwing light on the mutual relations of the Tertiary freshwater deposits with the seas of that period. Most of these fossils were found in Lower Austria and in the S.W. parts of Styria. One specimen is from the strata of Hammersdorf, near Hermannstadt in Transylvania. Two new species of *Trionyx* (*Tr. Vindobonensis* and *Tr. Stiriacus*), *Tr. Partschi*, Fitz., *Emys Loretana*, Meyer, and a *Chelydra*, closely allied to *Ch. Decheni*, Meyer, are described in M. Peters's Memoir.

[COUNT MARSCHALL.]

On a Recently Discovered METALLIFEROUS DEPOSIT *in* NORTHERN BOHEMIA. By M. VOGL.

[M. Haidinger's Report to the Imperial Geological Institute of Vienna, Nov. 7, 1854†.]

THE Geistergang (Ghost's-vein) is a rich metalliferous deposit discovered at Joachimsthal, in Northern Bohemia, in October 1853. M. Vogl describes it as being formed of decomposed porphyry containing frequent cavities occupied by a talcose substance mixed with capilliform native silver and with black pulverulent oxyd of silver (Silberschwärze). Its metalliferous portion is a compact compound of several species of pyrites, blendes, and metallic sulphurets, especially of cobalt and nickel, among which the silver is found, either native, in shape dentiform or filiform, or in the state of both black and red antimoniferous sulphuret (Rothgiltigerz.)

The vein rests on slate, and is covered by porphyry; it becomes richer as it is closer in contact with porphyry, and attains its maximum richness where it divides into two branches and goes through the porphyry. Farther on, its metalliferous ores diminish gradually as the slate appears more and more in the roof of the vein.

The thickness of one of these branches varies from 3 to 4 inches; that of the other from 3 to 8 inches.

* About 622 English feet.—TRANSL.

† Jahrb. K. K. Geol. Reichsans. 1854, pp. 611, &c.

The richest portion has been worked in a horizontal extent of $4\frac{1}{2}$ fathoms*; it produced $94\frac{3}{5}$ centners† of ore, containing between 700 and 900 marks of silver, and 20 to 23 per cent. of nickel.

The Geistergang during the years 1847 to 1853, inclusive, yielded in total 3249 centners of ore, containing 18660 marks‡ of silver, 227 centners of lead, and 2 centners of copper, representing altogether a value of 387143 florins§, besides the value of the bismuth, cobalt, nickel, and uranium not noted at present in the price-lists of the Mining Administration, although, owing to M. Patera's able practical researches||, these substances may in short time acquire such a degree of commercial and industrial value, that the sums obtained for them may completely pay off the expenses of working the silver.

[Count M.]

On the Geology *of* Lower Carinthia. By Dr. Peters.

[Proceedings of the Imp. Geol. Institute of Vienna, Nov. 7, 1854.]

In presenting a geological map of the western part of Lower Carinthia, which he had examined in the summer of 1854, Dr. Peters observed that this portion of the Alps, comprehending an area of 46 or 47 Austrian square-miles¶, is situated between the masses of crystalline rocks from among which the Hochalpspitz rises, forming the central nucleus of this group, and the older crystalline rocks of the Saualpe and Coralpe, ranging N. and S., and is distinguished from the latter by the absence of a central group, by its peculiar and complex system of valleys, and by the character of its vegetation.

The predominant rock is argillaceous slates, of several varieties, corresponding in strike with those of the Eastern Alps, and undisturbed by the accompanying, locally intercalated micaceous and gneissic rocks.

Sedimentary rocks of ancient date, insensibly passing into clay-slate, appear in the S.E. and N.W. parts of the district. As yet they are not known to contain any organic remains,—excepting the well-known fossil plants of the Stangalpe, which belong to the carboniferous formation,—and their age is necessarily undetermined.

The lower trias occurs only in the S.E. portion. The tertiary formation is represented by lignitiferous plastic clay (Tegel), and by great masses of sand and gravel, occurring even in the highest valleys. The study of these latter deposits throws light on some anomalies observed in the present arrangement of the valleys; for by their aid several river-courses, especially that of the Gark, may be

* The fathom (Lachter) used in the mines of Northern Bohemia = 6·069 Vienna feet; 1 Vienna foot = 1·037 English feet.—Transl.

† The Vienna centner (100lb.) = 123·4601lb. avoirdupois; 3249 centners = 401,130·8649lb. avoirdupois.—Transl.

‡ The Vienna mark ($\frac{1}{2}$lb.) = 0·6730lb. avoirdupois; 18·660marks = 11·418,818lb. avoirdupois.—Transl.

§ The Austrian florin = £0·2 sterling (approximative value); 387·143 florins = £38·714 sterling, 6 shillings.—Transl.

|| See also Jarhb. K. K. Geol. Reichsans. 1854, p. 630, &c.

¶ The Austrian mile = 4·71422 English miles; consequently 1 Austrian square-mile = very nearly 22·1 English square-miles.

subdivided into distinct transverse valleys, whose union into one principal valley has taken place subsequently to the deposition of the gravels and sands. They prove also that the water-courses of the Drave and the Mur were not completely separated at this epoch (which is probably coincident with the limit between the tertiary and the diluvial periods), as rock-fragments derived from the district now drained by the Mur are found in the lateral valleys now opening into the valley of the Drave.

This alternation of areas of hard rock surface and areas of gravel, sand, and clay, the latter offering a great variety of circumscribed cultivatible surfaces, have impressed peculiar characters on the mode of agriculture used in the region described. These deposits are a necessary condition for the existence of the large number of hamlets in several parts of the Alps; nor could the extreme limit of culture have reached without their aid the height of 4700 feet (=4873·9 English feet) above the sea-level. [Count M.]

On the Composition *of the* Vienna Sandstone.
By C. von Hauer.

[Proceedings of the Imp. Geol. Institute of Vienna, Nov. 7, 1854.]

From the chemical researches made by Chev. Charles von Hauer on the matrix by which the quartz granules are cemented together in the "Vienna sandstone," it appears that this cement is identical with that of the "Carpathian sandstone," recently examined by Prof. Zeuschner, and long ago by the late Prof. Hacquet. It is a mixture of the carbonates of lime and magnesia, and of oxydulated iron, varying in quantity from 2 to 80 *per cent.* of the whole mass in different localities, but keeping very constant proportions in each separate stratum. The relative proportion of the carbonates of lime and magnesia varies from 0·7 : 1 to 42 : 1; but remains constant in each separate locality. Lime is generally predominant, but the magnesia and oxydule of iron are never absent. [Count M.]

On some asymmetrical Ammonites *from* Hierlatz.
By M. Fr. von Hauer.

[Proceedings of the Imp. Geol. Institute of Vienna, Nov. 14, 1854.]

In this communication M. Fr. von Hauer described three asymmetrical species of *Ammonites* from the Hierlatz strata.

Two of these, *Am. Suessii* and *Am. abnormis*, have the shell of a normal shape, but the outlines of the lobes are disposed asymmetrically; the dorsal lobe, instead of being separated into two equal halves by the medio-dorsal line, has suffered a considerable change of place in a lateral direction. The lobe-outlines of the third species, *Am. Janus*, belonging to the *Amaltheus* group, are symmetrical, but the right side of the shell is developed quite differently from the left side. *Am. Suessii* has been previously described by Prof. Schafhäutl of Munich, who overlooked the lateral position of the siphuncle, and placed it in the genus *Nautilus*. [Count M.]

On the Liassic Flora *of* Bayreuth. By Dr. Braun.

[Proceedings of the Imp. Geol. Institute of Vienna, Nov. 28, 1854.]

The new genus *Kirchneria*, Braun, is found in the lower liassic sandstone around Bayreuth, and bears a close resemblance to the forms found in the carbonaceous liassic sandstone of Steierdorf in Banat, and described by C. von Ettinghausen*. The analogy of *Kirchneria* with the *Thinnfeldia* of Ettinghausen is very remarkable, notwithstanding that the former is a fern, and that the latter is ranked amongst Conifers. The forms described by Dr. Braun likewise offer considerable analogies with those discovered by M. A. de Zigno† in the Jurassic strata of the Venetian Alps; of these, a fern, on which M. de Zigno has founded his new genus, *Cycadopteris*, bears the nearest resemblance to *Kirchneria*.

Dr. Braun's researches prove that the liassic sandstones of Bayreuth bear a striking agreement with those of Steierdorf in Banat, Fünfkirchen in Hungary, and Lilienfeld, Lunz, and Grossau in Lower Austria, all of them belonging to the same subdivision of the liassic group. [Count M.]

On the Mining District *of* Pribram. By M. Kleszcznski, Mining Surveyor at Pribram.

[Proceedings of the Imp. Geol. Institute of Vienna, Nov. 21, 1854.]

The rich lead and silver veins so extensively worked at the Birkenberg near Pribram, at Drkolnow, and near Bohutin belong to the lower portion of the grauwacke formation which occupies exclusively that portion of Central Bohemia which is situated between Prague and Klattau. Not far from Pribram crystalline rocks, especially granite, range continuously along the grauwacke through Neuknin, Dubenitz, and Sliwitz. Here the grauwacke comprises broad zones of alternating grauwacke and slates, with intercalated subordinate bands of clay-slate and quartzite, frequently passing into the surrounding rocks. The strike is generally S.W. and N.E.; the dip, N.W. or S.E.

The grauwacke of the Birkenberg contains the metalliferous veins, from which a large quantity of argentiferous galena is extracted, together with very fine mineral specimens well known in collections. Veins of greenstone occur both in connection with the metalliferous veins, and independent of them. A clay-bed (called Lettenkluft), running parallel to the grauwacke beds, and dipping N.W. (in an opposite direction to the grauwacke), marks the limit between the grauwacke and the slates overlying it. The metalliferous veins become richer, or separate into several branches, as they approach this clay-bed, and at last are totally cut off by it, no trace of them being found beyond it. It is still a question, however, whether the veins really terminate at the clay-bed, or whether they are shifted

* Abhandl. K. K. Geol. Reichsanstalt, vol. i.

† Leonh. u. Bronn's N. Jahrb. 1854, p. 31; and Quart. Journ. Geol. Soc., vol. x. part 2, Miscell., p. 13.

to a higher or a lower level by a fault. The veins discovered beyond the "Letten Kluft," in the Schreckengebirge, are so different from those worked in the vicinity of Pribram, that the supposition of their being continuations of the latter appears to be unwarranted.

The alluvial deposits in the Litawka Valley are interesting from the fact of their having been profitably washed for gold in the 16th century. The auriferous rock, however, from which the alluvium was derived is still undiscovered. [COUNT M.]

Description of the gigantic ICHTHYOSAURUS TRIGONODON *in the* BANZ *Museum, together with a Synoptical account of the species of* ICHTHYOSAURUS *in the same Collection.* By CARL THEODORI. Fol. Munich, 1854. With 4 large Lithograph Plates illustrating the fossils of the natural size. Pp. 95.

[Beschreibung des kolossalen Ichthyosaurus trigonodon in der Lokal-Petrefacten-Sammlung zu Banz, &c.]

THE remains of the *Ichthyosaurus trigonodon* described in this Memoir, and particularly the almost perfect skull and jaws (6 feet 6 inches in length), are so important and instructive from their great size and good state of preservation, that they were esteemed fully worth the expense of the elegantly printed folio Memoir and the four gigantic lithograph plates (two of them 30½ by 40 inches, and the other two 30½ inches by 8 feet!) by which they have been illustrated at the cost of the Archduke Maximilian, the proprietor of the Banz Museum.

Pages I to XIII of the work contain introductory remarks, a short sketch of the lias formation at Banz, and an account of the finding of the *Ichthyosaurus trigonodon*, the description of the teeth and bones of which occupy the succeeding pages 1–40.

The other species of *Ichthyosaurus* from the lias of Banz which are noticed in this work, with descriptions of some of the most important portions of the skeletons, are the—

Ichthyosaurus communis, *Conyb.*, p. 42.
—— tenuirostris, *Conyb.*, p. 42.
—— —— *var.* sinuatus, *Theod.*, p. 50.
—— acutirostris?, *Owen*, p. 52.
—— hexagonus, *nov. sp.*, p. 55.
—— planartus, *nov. sp.*, p. 57.
—— crassicostatus, *nov. sp.*, p. 60.
—— macrophthalmus, *nov. sp.*, p. 64.
—— ingens, *nov. sp.*, p. 69.

The relative proportions of the several bones of the skull and trunk are further illustrated by two comprehensive synoptical tables.

The Plates I. & II. exhibit two views of the cranium of the *Ichth. trigonodon* of the natural size! Pl. III. is devoted to the illustration of numerous bones of the same species. Pl. IV. comprises characteristic bones of the other species of *Ichthyosaurus* from the lias of Banz. [T. R. J.]

On the Tertiaries *of* Hungary *and* Transylvania. By Dr. Hörnes.

[Proceedings of the Imp. Geol. Institute of Vienna, Dec. 5, 1854.]

During the summer of 1854 Dr. Hörnes made an excursion through Hungary and Transylvania, both for the purpose of adding to the palæontological collection of the Imperial Museum at Vienna, and to collect materials for the completion of his work "On the Tertiary Mollusca of the Vienna Basin." Dr. Hörnes reports that the lithological and palæontological points of similitude between the tertiary deposits of the districts he explored and those of the Vienna Basin are so evident and so numerous that there can be little doubt of their having been contemporaneous.

The sea then occupying the Vienna Basin appears to have been the connecting link between two large contemporaneous seas, one of which covered the Upper Danubian Basin, whilst the other occupied what is now the plains of Central Hungary; nearly in the same way as at present the Sea of Marmora forms the junction between the Black and Ægean Seas.

The tertiary deposits of Korod and Lapugy in Transylvania, of Nemesest in Banat, of Baden, Steinabrunn, and Ottnang in Austria, together with those of Vilshofen in Bavaria, of St. Gallen in Switzerland, and of Montpellier, Bordeaux, and Touraine in France, the faunas of all of which (with some local modifications excepted) present a similar character, may serve to indicate the extent and situation of the extensive sea, which during the tertiary period covered a considerable portion of Central Europe, having an east and west direction.

The locality of Lapugy is remarkable for the richness of its fossil fauna; and some of the shells still retain traces of the coloration by which their surfaces were ornamented during life.

Eocene remains have likewise been found in the lignitiferous deposits of Gran in Hungary. [Count M.]

On the Fossil Crustacea *from near* Verona. By Prof. T. Catullo.

[Proceedings of the Imp. Geol. Institute of Vienna, Nov. 28, 1854.]

Several species of *Crustacea,* viz. *Cancer punctatus,* Desm., *C. Boscii,* Desm., *Platycarcinus Beaumontii,* Edw., and *Pl. pagurus,* Edw., have been previously obtained by Prof. Catullo from the Calcaire grossier of the environs of Verona and Vicenza. The Professor now notices another form, determined by M. Desmarest as *Ranina Aldrovandi,* from the Eocene limestone of Valdonega; and several crustaceans from the slaty limestone in the Valley of Vestina near Monte Bolca, which occur under circumstances similar to those in which the fossil fishes of that locality are met with; the impression of the fossil not being fully obtained except by splitting the fossiliferous beds transversely. The crustacean remains from the Vestina Valley belong to the *Astacini* family, but are too imperfectly preserved to admit of specific determination. The largest and best-preserved specimens among them remind one forcibly of *Palinurus communis,* at present inhabiting the Mediterranean and the Ocean.

[Count M.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On MAGNESITE, *and the* ECONOMIC PRODUCTION *of* SULPHATE *of* MAGNESIA. By M. FOETTERLE.

[Proceedings of the Imp. Geol. Instit. Vienna, Jan. 9, 1855.]

M. FOETTERLE notices a new locality of Magnesite, discovered by him during his geological survey, in the environs of Bruck in Styria. Considerable masses of this mineral occur north of Bruck in a limestone imbedded in crystalline slates. It closely resembles crystalline limestone both in its structure and its white colour.

The angle of the rhombohedron obtained by cleavage is 107° 16′; specific gravity, 3·033; hardness, 4·5, according to Mohs' scale. M. C. v. Hauer found it to contain 99·2 per cent. of carbonate of magnesia, and a very slight quantity of carbonate of iron. When interspersed with minute particles of iron pyrites, it gives 94·7 per cent. of carbonate of magnesia.

Besides the locality just mentioned, three other localities in the Alpine grauwacke, viz. Gloggnitz, Neuberg, and Trieben, afford still larger quantities of Magnesite.

M. Foetterle dwells on the commercial importance of this mineral, as a material for the profitable production of bitter-salt (sulphate of magnesia), in the same manner as, according to M. Delesse, the manufacture of this salt from serpentine has become an extensive branch of industry in France. The serpentine, after having been submitted to calcination for forty-eight hours, is reduced to fine powder, and then treated with dilute sulphuric acid. A somewhat less quantity of the acid is used than would be required to saturate the whole amount of the magnesia in the serpentine. The solution, freed from all heterogeneous substances, is left to crystallize in wooden tubs; and pure sulphate of magnesia is obtained by the second crystallization.

M. Malapert, at Châtre, and MM. Mallet and Lapellier, at Caen, have used with success the method employed in England to obtain this salt from dolomite. The dolomite is treated with 94 per cent. of its weight of sulphuric acid; the filtered solution is freed from the sulphate of lime, filtered again, concentrated, and finally left to crystallize in stone reservoirs. This new branch of industry has enabled France to dispense with the importation of foreign sulphate of magnesia.

[COUNT M.]

On the Coal deposits *at* Marklin, Bohemia. By M. v. Lidl.

[Proceedings of the Imp. Geol. Instit. Vienna, Jan. 9, 1855.]

This deposit, in which sandstone predominates, is, like those of Pilsen and Radnitz, of freshwater origin. The two latter, however, belong to the grauwacke district, while that of Marklin is enclosed on all sides by crystalline rocks (granite and clayslate).

The extent of this coal-deposit, although worked simultaneously by three mining companies, is still but imperfectly known. At present two beds of pure coal, partially capable of coking, have been opened to the depth of from 10 to 14 fathoms [= 20·740 to 29·036 English yards]. Each bed is from 4 to 6 feet [= 4·148 to 6·222 English feet] thick, and they are separated from each other by a shale, 3 feet thick [= 3·111 English feet].

The upper bed of coal is overlaid by rolled pebbles, shales, sandstones with vegetable impressions (among them are many Calamites and but few Ferns), and carboniferous oxide of iron [Kohlen-eisenstein]. At its eastern termination this sandstone contains two coal-beds, scarcely exceeding a few inches in thickness. The lower coal-bed rests on confusedly stratified shales, with *Stigmaria* roots, and on sandstones, with subordinate beds of bluish-grey clay.

The coal is reached by means of a pit, and worked by galleries and pillars. The pumping and raising work is chiefly effected by human labour; one only of the companies having a good steam-engine. The total product of the Marklin mines amounts to 400,000 and more centners per annum [= 494·600 cwt. avoirdup.]. The coal is in request from its cheapness and good quality, and is partly used in the neighbourhood of the mines and in the industrial establishments at Neugedlin, and is partly sent to Vienna and into Bavaria.

[Count M.]

On the Lead-bearing Rocks *of* Lower Carinthia. By M. Lipold.

[Proceedings of the Imp. Geol. Instit. Vienna, Jan. 23, 1855.]

The lead-ores at Unterpetzen near Schwarzenberg, in Lower Carinthia, occur in light-coloured compact limestones, with conchoidal fracture, which occupy the highest summits of the Petzen mountain-range, and have a thickness of 1000 feet [= 1037 English feet] and more. These limestones are divided into beds of one or more fathoms in thickness, striking S.E. and N.W., and dipping N.E. at an angle of from 40° to 50°. They repose on a great mass of dolomites, partly bituminiferous, which are supposed to represent the Guttenstein-strata, as at some places they come out from beneath the red Werfen-slates.

The only plumbiferous stratum is one of inconsiderable thickness, containing the galena in some parts sparsely interspersed, at others in sufficient quantity to be extracted by means of stamping-mills. The richest ore occurs in veins crossing the limestone bed in an

E. and W. direction; they are nearly vertical, and terminate at the upper and lower limits of the metalliferous stratum, which, however, does not differ lithologically from the sterile beds above and below it. Compact galena occurs in these veins or fissures in veinules, up to 3 inches [= 0·259 English foot] thick, or in isolated irregular masses, sometimes of several feet in diameter. It is imbedded in a brownish calciferous clay, in a friable limestone-breccia, or in a mixture of clay and limestone-fragments filling up the above-mentioned fissures. The angularity of the fragments of limestone in the clay and the occurrence of slickensides prove the veins not to have been contemporaneous with the limestone which they traverse. Several such veins are known, running parallel to each other, from S. to N. Most of them do not pass all through the metalliferous limestone, being cut off by faults, throwing them into other strata; so that the working out of these veins becomes difficult. Molybdenate of lead sometimes accompanies the galena. Carbonate of lead is seldom met with.

The fossils as yet found in the metalliferous limestone are undetermined species of *Rostellaria* and *Natica*, and a few *Ammonites* of the *globosi* group, which prove it to be a portion of the Hallstadt-strata or Alpine Muschelkalk.

The plumbiferous strata in question run uninterruptedly for several Austrian miles* in extent, from the Ursulaberg on the Styrian frontier, over the mountain crests of Petzen and Obir, as far as beyond Windiph-Bleiberg; lead-mines being everywhere worked in them.

[COUNT M.]

On the GEOLOGY *of* CARLSBAD, BOHEMIA. By M. v. WARNSDORFF.

[Proceedings of the Imp. Geol. Instit. Vienna, Feb. 27, 1855.]

THE thermal and acidulated springs of Carlsbad are all situated, as is known, on one and the same line, which is generally called "Hoff's Line," from the late E. A. v. Hoff, who first pointed out its existence. M. v. Warnsdorff† states, that this line is coincident with the vein of hornstone, at the upper or superficial limit of which a new spring was discovered in 1852, at a depth of 6 or 7 yards, beneath a layer of peat, a thick bed of sand (with rolled fragments of gneiss), and a reddish clay, 2 to 3 feet thick. This spring issues partly from the fissures of the vein of hornstone, which is here 3 to 4 feet thick, and partly from the fissures of the adjacent rock. The vein itself runs from S.S.E. to N.N.W., dipping south at 70° to 75°. The vein is bifurcate; the upper portion is grey, the lower reddish in colour.

* The Austrian mile = 4·714 English miles.

† M. v. Warnsdorff has previously published some accounts of the geology of Marienbad in Leonhard and Bronn's "Jahrbuch," and in Kratzmann's "New Marienbad Guide;" and his views have recently been discussed in a paper by Haidinger on "the Baryta Crystals deposited by the Water of the Carlsbad Military Bathing-House Spring," published in the Imp. Geological Institute's "Jarhbuch," 1854, p. 142.

The whole of the Carlsbad springs may be regarded as rising in the fissures of this vein,—even the Sprudel, notwithstanding its anomalous situation, indicative perhaps of a fault running along the Alte Wiese and Neue Wiese, and deranging the regular course of the vein.

The author points out, in contradistinction to some recent observations, the notable differences between the fine-grained and the coarse-grained granites, which closely approach each other near the Bernhards-Brunnen.

M. v. Warnsdorff considers that deep excavations in the neighbourhood of the upper limit of the vein would be very unadvisable, and liable to occasion springs to burst through the clay-bed in inconvenient localities. On the other hand, supposing the vein to be continued downwards, immediately beneath the Horner-Berg, between the older coarse-grained granite and the more recent fine-grained granite, springs of very high temperature might be obtained at a depth amounting to only three times the distance of this basaltic mountain by shafts sunk through the fine-grained granite. A vertical shaft would reach the vein at a depth of 120 fathoms [= 248·88 English yards] at the site of the Marksbrunnen; at a depth of 70 fathoms [= 145·2 English yards] at the village of Klein-Versailles.

[Count M.]

On the Geology *of the* vicinity *of* Steierdorf, Banat. By M. J. Kudernatsch.

[Proceed. Imp. Geolog. Instit. Vienna, March 6, 1855.]

The rich coal-deposits of Steierdorf, in Banat, are known to belong to the Liasic group. The old coal-formations were supposed to exist in Banat exclusively in the condition of a small basin, amidst gneiss, near Szekul, 1 Austrian mile [= 4·714 English miles] from Reschitz; but M. J. Kudernatsch has recently discovered a powerful development of genuine Carboniferous rocks in a nearly unknown region of the Military Frontier, E. of Steierdorf. Rich layers of fine lignite, of a pitch-like brightness, are found in the region called Almas, and are as yet unworked.

M. Kudernatsch met with in the liasic strata of Steierdorf a considerable quantity of felsite-porphyries, the eruption of which was probably contemporaneous with the deposition of the liasic shales, as they break through the lower rocks and are stratified conformably with the upper beds.

The cretaceous table-lands around Steierdorf contain extensive deposits of pisiform oxide of iron, originating from the decomposition of marcasite.

The range of massive crystalline rocks eastward of Steierdorf, forming the central mass of the mountainous region of Banat, are composed of large-grained pegmatite, granitite with a trace of potash-mica, granitic gneiss, syenite, amphibolite, serpentine, granulite, &c. The real granites, with potash-mica predominating, seem to be of later date than the granitites, which they cut through in the shape of veins; a circumstance differing from the facts observed in other localities. Along a line of considerable extent the granite is in contact with the cretaceous limestones, which, for a hundred paces beyond the line of junction, bear visible traces of the changes of structure resulting from the contact of the granite; they are saccharoid, frequently dolomitic, and including granules of quartz and even some mica; still, however, they show some vestiges of organic remains. These facts lead to the conclusion, that the eruption of this granite could not have been anterior to the cretaceous period.

[Count M.]

Notice of the Occurrence of an Earthquake *at* Schemnitz, Hungary. By M. Russegger, Director of the Imp. Mining Academy at Schemnitz.

[Proceedings Imp. Acad. Sciences, Vienna, March 8, 1855.]

An earthquake, the third within the space of nine months, occurred at Schemnitz* on January 31, 1855. The shock was accompanied by a noise like the report of a cannon, and was felt in a vertical direction at 35 minutes past 1 o'clock, p.m. It was intense enough to shake the walls of the houses. The maximum of its intensity coincided with the centre of the town; but (as in the previous shocks) it was not followed by further shocks.

The mines were visited immediately after the earthquake, and no breach was found in them; it was ascertained, however, that the commotion had followed the direction of the principal vein (Spitaler Hauptgang), and had reached below the greatest depths which the workings had reached, increasing in intensity from above downwards. In some places there were crevices in the solid rock and the walls of the galleries; but the timber remained unhurt. The cracking of the rock was tremendous, and here and there the currents of air, arising from the commotion, blew out the lamps of the miners, who, believing that the whole mine was crumbling over their heads, were terribly frightened. In some places fragments of rock were displaced and injured the miners.

The circle of commotion above-ground proved the shock to have been central, and not to have followed the direction of a longitudinal fissure. The form of this circle is remarkably coincident with the outline of the inside of the mountain circle surrounding Schemnitz, the outline being traced about the middle of the slope between the bottom of the valley and the tops of the mountains. It has quite the shape of a crater, on the north-east border of which rises the basaltic cone of Mount Calvary.

The depression in which the town of Schemnitz lies may with some propriety be thought to exhibit a crater of elevation amidst a mass of diorite and dioritic porphyry, diametrically traversed by the "Spitaler Hauptgang," with a basaltic outburst (the only one in the immediate vicinity) on its north-east border.

* See the notice of the previous earthquakes at this place, *antea*, p. 36.

The miners being employed at places far distant from each other, it was not possible to determine the form and extent of the subterranean circle of commotion, by means of which it might have been possible to have determined, at least approximately, the depth of the focus of commotion. [COUNT M.]

On some FOSSILS *from the* DOLOMITE *of* MONTE SALVATORE, *near* LUGANO, CANTON TESSIN. By M. FR. V. HAUER.

[Proceedings Imp. Acad. Sc. Vienna, March 15, 1855.]

SINCE L. v. Buch investigated the mountains around the Lake of Lugano, they have been frequently studied by geologists *, and especially the Monte Salvatore. Abbé Stabile of Lugano, however, has been the first to discover a considerable number of determinable organic remains in the dolomite of Monte Salvatore.

These fossils were forwarded to M. Fr. v. Hauer, at Vienna, for examination; and M. Merian has determined them as belonging, for the most part, to known species peculiar to the Muschelkalk. Amongst these fossils, *Halobia Lommellii* and *Chemnitzia tenuis* are remarkable, as previously they were only known to occur in the Hallstatt and Cassian beds, forming the upper subdivision of the Alpine Trias †. [COUNT M.]

Introduction to the Knowledge of Rocks, with reference to their Geological relations and to their practical use in the Arts, Building, and Agriculture. By Prof. A. ERDMANN, Fellow of the Royal Acad. Sciences, Stockholm; Knight Ord. North Star. pp. 207, 8°. Stockholm, 1855. With woodcuts.

[Vägledning till bergartnernas kännedom, o. s. v.]

IN this elementary work on the properties and nature of rocks, the author first notes (chapter 1) the general characters,—crystalline, mechanical, and amorphous; fossiliferous and unfossiliferous. In chap. 2 he reviews their structural conditions; in chap. 3 the various characters of internal and external form,—the former resulting from contraction and from stratification; the latter seen in layers, veins, and masses. Chap. 4 is stratigraphical; and chap. 5 notices the destruction and weathering of rocks. The geological formations and their order of succession are given in chap. 6; and, lastly, chap. 7 comprises the classification and detailed description of the rocks and mineral masses. In this chapter, the author, after remarking that the different rocks often pass one into another, and noticing the difficulty of systematizing the several varieties, divides the rocks into (class 1) those of chemical origin, viz. the quartz, limestone, salt, iron, coal, felspathic, micaceous, amphibolic, pyroxenic, and serpentine groups,—and (class 2) those of mechanical origin, viz. the breccias, conglomerates, sandstones, schists, tuffs, and loose materials.

[T. R. J.]

* Amongst these may be named Breislac, Girard, Lavizzari, Brunner, Merian, &c.

† *Vide antea*, p. 17.

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. XI.